

DATA612, Final Project

Social Network Analysis of the NBA

Michael O'Donnell, CUNY School of Professional Studies

July, 2019

```
In [136]: # import Libraries
import csv
import math
import networkx as net
from networkx.algorithms import bipartite as bi
import matplotlib as plt
import pandas as pd
from matplotlib.pyplot import figure
```

Goal of project: identify important NBA players' networks

Which players have had the most teammates? Which players have strong ties to LeBron James? Which NBA All-Stars have played together?

Today, NBA players change teams often. Players change teams for a variety of reasons, but the most discussed is to team up with other players. This project aims to depict the networks of NBA players' to visualize interesting networks, and speculate upon future player movement.

```
In [192]: # open nba data as a CSV file
nba_data = csv.reader(open("NBA_network.csv"))
nba_data_df = pd.read_csv("NBA_network.csv", header = None)
```

The Dataset:

the data includes player information from 1998-2019. But, this dataset only includes players that were active during the 2018-2019 NBA season. So, Vince Carter and Dwyane Wade are in this dataset because they played last season. But, Kobe Bryant and Shaq are not in the dataset because they did not play last season.

```
In [193]: # create network
g = net.Graph()

# lists of all distinct teams and players
teams = []
players = []

# construct directed graph
for row in nba_data:
    if row[0] not in teams:
        teams.append(row[0])
    if row[1] not in players:
        players.append(row[1])
    g.add_edge(row[0], row[1], weight=1)
```

```
In [264]: #print "nodes in network:", Len(g)
```

```
In [195]: connected_net = list(net.connected_component_subgraphs(g))
#print "size of Largest component:", len(connected_net[0])
```

```
In [196]: # players with the most seasons
print "Players with most seasons:"
print nba_data_df[1].value_counts().head(10)
```

Players with most seasons:

Vince Carter	20
Dirk Nowitzki	20
Jamal Crawford	19
Tony Parker	18
Pau Gasol	18
Tyson Chandler	18
Nene	17
LeBron James	16
Carmelo Anthony	16
Udonis Haslem	16

Name: 1, dtype: int64

```
In [197]: # create an affiliation network of only teams
teamnet = bi.weighted_projected_graph(g, teams)
```

```
In [198]: # create an affiliation network of only players
# this will become our main network..
playernet = bi.weighted_projected_graph(g, players, ratio = False)
```

```
In [199]: # List of the players with most seasons as teammates:
connect_list = list(playernet.edges(data=True))
player_connections = sorted(connect_list, key=lambda tup: tup[2])
player_connections = player_connections[::-1]
print "Players with most seasons as teammates:"
player_connections[0:15]
```

Players with most seasons as teammates:

```
Out[199]: [('Dwyane Wade', 'Udonis Haslem', {'weight': 14}),
('Marc Gasol', 'Mike Conley', {'weight': 11}),
('Dirk Nowitzki', 'Devin Harris', {'weight': 10}),
('Nene', 'Carmelo Anthony', {'weight': 9}),
('Alec Burks', 'Derrick Favors', {'weight': 8}),
('Danny Green', 'Kawhi Leonard', {'weight': 8}),
('Taj Gibson', 'Jimmy Butler', {'weight': 8}),
('Kevin Durant', 'Russell Westbrook', {'weight': 8}),
('Stephen Curry', 'Klay Thompson', {'weight': 8}),
('DeAndre Jordan', 'Blake Griffin', {'weight': 8}),
('Tony Parker', 'Danny Green', {'weight': 8}),
('Joakim Noah', 'Derrick Rose', {'weight': 8}),
('Kawhi Leonard', 'Patty Mills', {'weight': 7}),
('Russell Westbrook', 'Serge Ibaka', {'weight': 7}),
('Danny Green', 'Patty Mills', {'weight': 7})]
```

Measures of Player Centrality

In networks, centrality is critically important. Centrality finds the nodes (players) most central to the network by overall connections (Degree Centrality), closeness to rest of network (Closeness Centrality), or bridges between groups of players (Betweenness Centrality).

```
In [200]: # Look at centrality among players
deg = net.degree(playernet)
deg_list = sorted(playernet.degree, key=lambda x: x[1], reverse=True)
```

```
In [201]: # Look at closeness centrality of players, and teams
import operator
closeness_cen = net.closeness_centrality(playernet)
closeness_list = sorted(closeness_cen.items(), key=operator.itemgetter(1))
```

```
In [202]: # Look at betweenness centrality of players
betweenness_cen = net.betweenness_centrality(playernet)
betweenness_list = sorted(betweenness_cen.items(), key=operator.itemgetter(1))
```

Highest degree centrality:

```
In [203]: cen_list = []

for i in playernet:
    cen_list.append([i, deg[i], betweenness_cen[i], closeness_cen[i]])

centrality_df = pd.DataFrame(cen_list, columns = ['Player', 'Degree', 'Betweenness', 'Closeness'])

centrality_df = centrality_df.sort_values(by=['Degree'], ascending=False)
centrality_df.head(5)
```

Out[203]:

	Player	Degree	Betweenness	Closeness
257	Anthony Tolliver	78	0.016905	0.528529
369	Michael Beasley	70	0.015829	0.507205
411	Jerryd Bayless	69	0.015535	0.506718
154	Omri Casspi	67	0.011010	0.503337
341	Marco Belinelli	67	0.013107	0.505747

Highest betweenness centrality:

```
In [204]: centrality_df = centrality_df.sort_values(by=['Betweenness'], ascending=False)
centrality_df.head(5)
```

Out[204]:

	Player	Degree	Betweenness	Closeness
22	Isaiah Thomas	63	0.017730	0.500000
257	Anthony Tolliver	78	0.016905	0.528529
369	Michael Beasley	70	0.015829	0.507205
411	Jerryd Bayless	69	0.015535	0.506718
182	Shelvin Mack	62	0.013446	0.498584

Highest closeness centrality:

```
In [205]: centrality_df = centrality_df.sort_values(by=['Closeness'], ascending=False)
centrality_df.head(5)
```

Out[205]:

	Player	Degree	Betweenness	Closeness
257	Anthony Tolliver	78	0.016905	0.528529
216	Jose Calderon	64	0.010507	0.514620
460	Channing Frye	58	0.008554	0.510145
183	Jeff Green	62	0.009240	0.507692
503	Gerald Green	63	0.009767	0.507692

Networks to NBA Superstars:

The networks of the top LeBron James, Stephen Curry, and are shown below. Note: the thicker the edge between the players, the more seasons those players were teammates.

```
In [206]: one_season = [(u, v) for (u, v, d) in playernet.edges(data=True) if d['weight']
] <= 1]
two_three_seasons = [(u, v) for (u, v, d) in playernet.edges(data=True) if (d[
'weight']>1 and d['weight']<4)]
four_plus_seasons = [(u, v) for (u, v, d) in playernet.edges(data=True) if d[
'weight']>3]
```

```
In [271]: free_agents = ["Jaylen Adams",
 "Troy Caupain",
 "Tyler Cavanaugh",
 "Joe Chealey",
 "Marquese Chriss",
 "Ian Clark",
 "Jamal Crawford",
 "Mitchell Creek",
 "Dante Cunningham",
 "Sam Dekker",
 "Angel Delgado",
 "Luol Deng",
 "Marcus Derrickson",
 "Cheick Diallo",
 "Tyler Dorsey",
 "PJ Dozier",
 "Trevon Duval",
 "Vincent Edwards",
 "Henry Ellenson",
 "Jawun Evans",
 "Kenneth Faried",
 "Raymond Felton",
 "Jimmer Fredette",
 "Billy Garrett",
 "Pau Gasol",
 "Jonathan Gibson",
 "Brandon Goodwin",
 "Carmelo Anthony",
 "Dwyane Wade"]
```

LeBron James' network below:

```
In [218]: LeBron_network = net.ego_graph(playernet, "LeBron James")
print "nodes in LeBron James' network (total teammates):", len(LeBron_network)
LeBron_cluster = net.Graph(net.ego_graph(playernet, "LeBron James", radius = 1))
print "percent of LeBron's teammates that have played together:", net.average_
clustering(LeBron_cluster)
```

```
nodes in LeBron James' network (total teammates): 40
percent of LeBron's teammates that have played together: 0.89898753272
```

```
In [275]: one_season = [(u, v) for (u, v, d) in LeBron_network.edges(data=True) if d['weight'] <= 1]
two_three_seasons = [(u, v) for (u, v, d) in LeBron_network.edges(data=True) if d['weight']>1 and d['weight']<4]
four_plus_seasons = [(u, v) for (u, v, d) in LeBron_network.edges(data=True) if d['weight']>3]

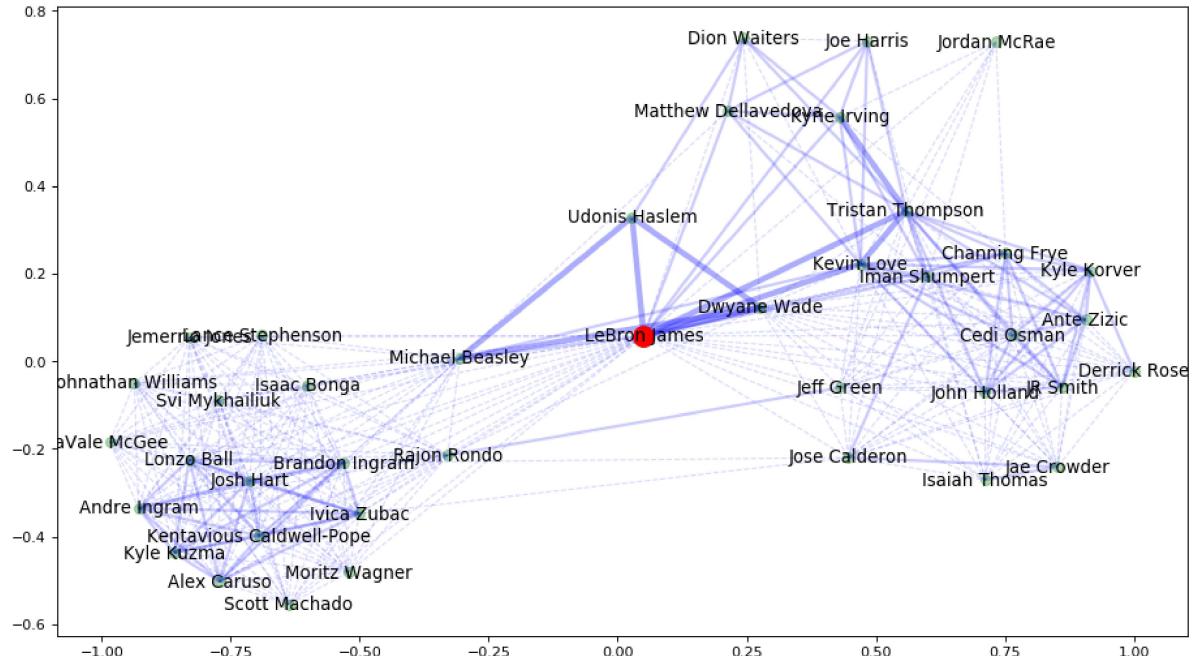
figure(num=None, figsize=(14, 8), dpi=80)
pos = net.spring_layout(LeBron_network) # positions for all nodes

# nodes
net.draw_networkx_nodes(LeBron_network, pos, node_size=50, node_color='g', alpha=0.3)
net.draw_networkx_nodes(LeBron_network, pos, nodelist=["LeBron James"], node_size=200, node_color='r')
#net.draw_networkx_nodes(LeBron_network, pos, nodelist=[free_agents], node_size=90, node_color='y')

# edges
net.draw_networkx_edges(LeBron_network, pos, edgelist=four_plus_seasons,
                       width=4, edge_color='b', alpha=0.32)
net.draw_networkx_edges(LeBron_network, pos, edgelist=two_three_seasons,
                       width=2, edge_color='b', alpha=0.2)
net.draw_networkx_edges(LeBron_network, pos, edgelist=one_season,
                       width=1, alpha=0.14, edge_color='b', style='dashed')

# Labels
net.draw_networkx_labels(LeBron_network, pos, font_size=12, font_weight = 'normal', font_family='sans-serif')
```

```
Out[275]: {'Alex Caruso': Text(-0.771584,-0.502958,u'Alex Caruso'),  
          'Andre Ingram': Text(-0.928544,-0.335483,u'Andre Ingram'),  
          'Ante Zizic': Text(0.906872,0.0950011,u'Ante Zizic'),  
          'Brandon Ingram': Text(-0.531884,-0.231526,u'Brandon Ingram'),  
          'Cedi Osman': Text(0.765256,0.0590652,u'Cedi Osman'),  
          'Channing Frye': Text(0.751209,0.246312,u'Channing Frye'),  
          'Derrick Rose': Text(1,-0.0218549,u'Derrick Rose'),  
          'Dion Waiters': Text(0.243632,0.737163,u'Dion Waiters'),  
          'Dwyane Wade': Text(0.276299,0.122895,u'Dwyane Wade'),  
          'Iman Shumpert': Text(0.600705,0.193139,u'Iman Shumpert'),  
          'Isaac Bonga': Text(-0.601454,-0.0554094,u'Isaac Bonga'),  
          'Isaiah Thomas': Text(0.712198,-0.270991,u'Isaiah Thomas'),  
          'Ivica Zubac': Text(-0.501167,-0.347747,u'Ivica Zubac'),  
          'JR Smith': Text(0.861289,-0.059565,u'JR Smith'),  
          'JaVale McGee': Text(-0.983984,-0.184017,u'JaVale McGee'),  
          'Jae Crowder': Text(0.852109,-0.241161,u'Jae Crowder'),  
          'Jeff Green': Text(0.43063,-0.0603248,u'Jeff Green'),  
          'Jemerrio Jones': Text(-0.830257,0.055342,u'Jemerrio Jones'),  
          'Joe Harris': Text(0.483622,0.731012,u'Joe Harris'),  
          'John Holland': Text(0.711768,-0.0708288,u'John Holland'),  
          'Johnathan Williams': Text(-0.936777,-0.049822,u'Johnathan Williams'),  
          'Jordan McRae': Text(0.733368,0.729141,u'Jordan McRae'),  
          'Jose Calderon': Text(0.446779,-0.219471,u'Jose Calderon'),  
          'Josh Hart': Text(-0.713375,-0.271809,u'Josh Hart'),  
          'Kentavious Caldwell-Pope': Text(-0.694216,-0.399048,u'Kentavious Caldwell-Pope'),  
          'Kevin Love': Text(0.470669,0.222036,u'Kevin Love'),  
          'Kyle Korver': Text(0.91624,0.207393,u'Kyle Korver'),  
          'Kyle Kuzma': Text(-0.859808,-0.436999,u'Kyle Kuzma'),  
          'Kyrie Irving': Text(0.430008,0.558041,u'Kyrie Irving'),  
          'Lance Stephenson': Text(-0.689797,0.0592534,u'Lance Stephenson'),  
          'LeBron James': Text(0.0504205,0.0576707,u'LeBron James'),  
          'Lonzo Ball': Text(-0.830414,-0.224071,u'Lonzo Ball'),  
          'Matthew Dellavedova': Text(0.213338,0.57108,u'Matthew Dellavedova'),  
          'Michael Beasley': Text(-0.306902,0.00656983,u'Michael Beasley'),  
          'Moritz Wagner': Text(-0.522188,-0.481507,u'Moritz Wagner'),  
          'Rajon Rondo': Text(-0.329583,-0.214644,u'Rajon Rondo'),  
          'Scott Machado': Text(-0.637979,-0.555092,u'Scott Machado'),  
          'Svi Mykhailiuk': Text(-0.77271,-0.0891372,u'Svi Mykhailiuk'),  
          'Tristan Thompson': Text(0.558397,0.343438,u'Tristan Thompson'),  
          'Udonis Haslem': Text(0.0278184,0.328915,u'Udonis Haslem')}
```



In LeBron's network above is every active player he has teamed with. Thicker lines represent teammates he has spent more seasons with.

```
In [278]: # free agents in LeBron's network:
print "Free Agents in LeBron's network (above):"
for i in free_agents:
    if i in LeBron_network:
        print i
```

Free Agents in LeBron's network (above):
Dwyane Wade

Stephen Curry's network below:

```
In [219]: Steph_network = net.ego_graph(playernet, "Stephen Curry")
print "nodes in Stephen Curry's network (total teammates):", len(Steph_network)
Steph_cluster = net.Graph(net.ego_graph(playernet, "Stephen Curry", radius = 1))
print "percent of Steph's teammates that have played together:", net.average_clustering(Steph_cluster)
```

nodes in Stephen Curry's network (total teammates): 31
percent of Steph's teammates that have played together: 0.806399484785

```
In [216]: one_season = [(u, v) for (u, v, d) in Steph_network.edges(data=True) if d['weight'] <= 1]
two_three_seasons = [(u, v) for (u, v, d) in Steph_network.edges(data=True) if d['weight']>1 and d['weight']<4]
four_plus_seasons = [(u, v) for (u, v, d) in Steph_network.edges(data=True) if d['weight']>3]

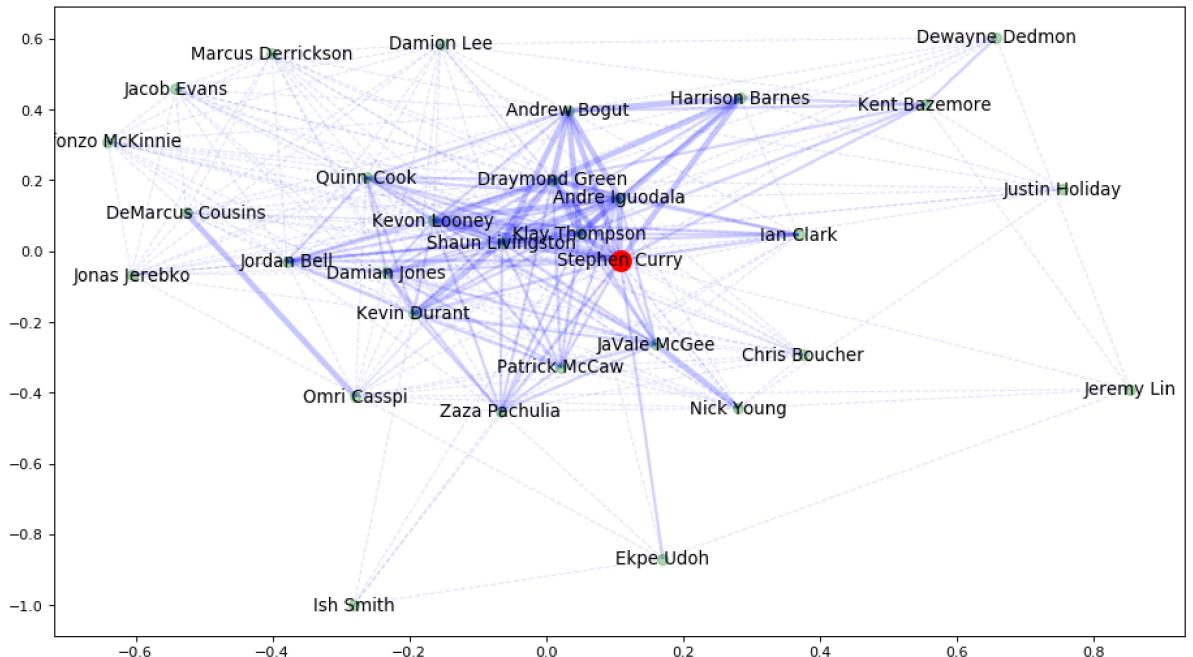
figure(num=None, figsize=(14, 8), dpi=80)
pos = net.spring_layout(Steph_network) # positions for all nodes

# nodes
net.draw_networkx_nodes(Steph_network, pos, node_size=50, node_color='g', alpha=0.3)
net.draw_networkx_nodes(Steph_network, pos, nodelist=["Stephen Curry"], node_size=200, node_color='r')

# edges
net.draw_networkx_edges(Steph_network, pos, edgelist=four_plus_seasons,
                       width=4, edge_color='b', alpha=0.22)
net.draw_networkx_edges(Steph_network, pos, edgelist=two_three_seasons,
                       width=2, edge_color='b', alpha=0.17)
net.draw_networkx_edges(Steph_network, pos, edgelist=one_season,
                       width=1, alpha=0.1, edge_color='b', style='dashed')

# Labels
net.draw_networkx_labels(Steph_network, pos, font_size=12, font_weight = 'normal', font_family='sans-serif')
```

```
Out[216]: {'Alfonzo McKinnie': Text(-0.640774, 0.3099, u'Alfonzo McKinnie'),
 'Andre Iguodala': Text(0.107393, 0.150934, u'Andre Iguodala'),
 'Andrew Bogut': Text(0.0325856, 0.397109, u'Andrew Bogut'),
 'Chris Boucher': Text(0.376311, -0.292239, u'Chris Boucher'),
 'Damian Jones': Text(-0.233253, -0.0609886, u'Damian Jones'),
 'Damion Lee': Text(-0.154403, 0.584976, u'Damion Lee'),
 'DeMarcus Cousins': Text(-0.525961, 0.107838, u'DeMarcus Cousins'),
 'Dewayne Dedmon': Text(0.658094, 0.603344, u'Dewayne Dedmon'),
 'Draymond Green': Text(0.00996148, 0.202388, u'Draymond Green'),
 'Ekpe Udoh': Text(0.171087, -0.86895, u'Ekpe Udoh'),
 'Harrison Barnes': Text(0.284093, 0.43238, u'Harrison Barnes'),
 'Ian Clark': Text(0.369489, 0.0463574, u'Ian Clark'),
 'Ish Smith': Text(-0.280997, -1, u'Ish Smith'),
 'JaVale McGee': Text(0.160444, -0.263032, u'JaVale McGee'),
 'Jacob Evans': Text(-0.541458, 0.458065, u'Jacob Evans'),
 'Jeremy Lin': Text(0.854101, -0.389836, u'Jeremy Lin'),
 'Jonas Jerebko': Text(-0.605967, -0.06722, u'Jonas Jerebko'),
 'Jordan Bell': Text(-0.378816, -0.0292067, u'Jordan Bell'),
 'Justin Holiday': Text(0.754489, 0.174419, u'Justin Holiday'),
 'Kent Bazemore': Text(0.554555, 0.41495, u'Kent Bazemore'),
 'Kevin Durant': Text(-0.19347, -0.17705, u'Kevin Durant'),
 'Kevon Looney': Text(-0.164424, 0.0867089, u'Kevon Looney'),
 'Klay Thompson': Text(0.0492852, 0.0489396, u'Klay Thompson'),
 'Marcus Derrickson': Text(-0.401148, 0.558249, u'Marcus Derrickson'),
 'Nick Young': Text(0.281393, -0.443743, u'Nick Young'),
 'Omri Casspi': Text(-0.2789, -0.410491, u'Omri Casspi'),
 'Patrick McCaw': Text(0.0214164, -0.327356, u'Patrick McCaw'),
 'Quinn Cook': Text(-0.26268, 0.207449, u'Quinn Cook'),
 'Shaun Livingston': Text(-0.0642915, 0.0241401, u'Shaun Livingston'),
 'Stephen Curry': Text(0.108485, -0.0251339, u'Stephen Curry'),
 'Zaza Pachulia': Text(-0.0666394, -0.452903, u'Zaza Pachulia')}
```



Stephen Cury has only played for 1 team, while LeBron has played for 3 teams. Hence, Stephen Curry's network has 1 tight group of players above, while LeBron's network has 2 or 3 tight groups of players.

```
In [279]: # free agents in LeBron's network:  
print "Free Agents in Steph's network (above):"  
for i in free_agents:  
    if i in Steph_network:  
        print i
```

Free Agents in Steph's network (above):

Ian Clark

Marcus Derrickson

Kawhi Leonard's network below:

```
In [220]: Kawhi_network = net.ego_graph(playernet, "Kawhi Leonard")  
print "nodes in Kawhi Leonard's network (total teammates):", len(Kawhi_network)  
)  
Kawhi_cluster = net.Graph(net.ego_graph(playernet, "Kawhi Leonard", radius = 1  
))  
print "percent of Kawhi's teammates that have played together:", net.average_c  
lustering(Kawhi_cluster)
```

nodes in Kawhi Leonard's network (total teammates): 34

percent of Kawhi's teammates that have played together: 0.865691368669

```
In [221]: one_season = [(u, v) for (u, v, d) in Kawhi_network.edges(data=True) if d['weight'] <= 1]
two_three_seasons = [(u, v) for (u, v, d) in Kawhi_network.edges(data=True) if d['weight']>1 and d['weight']<4]
four_plus_seasons = [(u, v) for (u, v, d) in Kawhi_network.edges(data=True) if d['weight']>3]

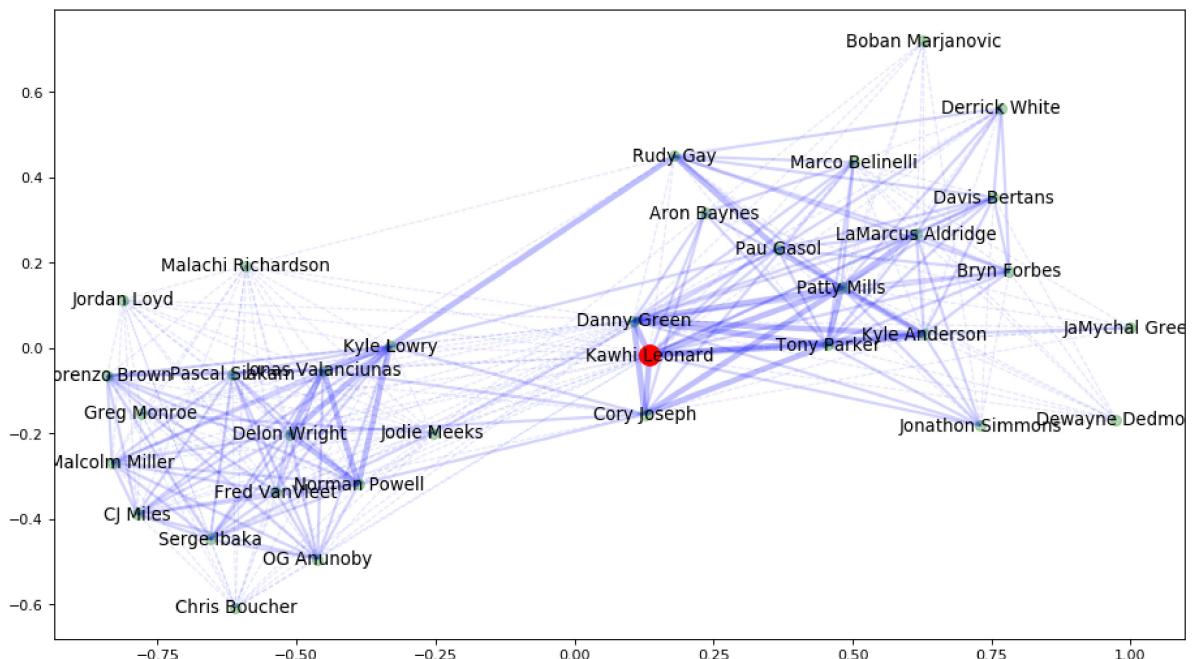
figure(num=None, figsize=(14, 8), dpi=80)
pos = net.spring_layout(Kawhi_network) # positions for all nodes

# nodes
net.draw_networkx_nodes(Kawhi_network, pos, node_size=50, node_color='g', alpha=0.3)
net.draw_networkx_nodes(Kawhi_network, pos, nodelist=["Kawhi Leonard"], node_size=200, node_color='r')

# edges
net.draw_networkx_edges(Kawhi_network, pos, edgelist=four_plus_seasons,
                       width=4, edge_color='b', alpha=0.25)
net.draw_networkx_edges(Kawhi_network, pos, edgelist=two_three_seasons,
                       width=2, edge_color='b', alpha=0.17)
net.draw_networkx_edges(Kawhi_network, pos, edgelist=one_season,
                       width=1, alpha=0.1, edge_color='b', style='dashed')

# labels
net.draw_networkx_labels(Kawhi_network, pos, font_size=12, font_weight = 'normal', font_family='sans-serif')
```

```
Out[221]: {'Aron Baynes': Text(0.234197, 0.316447, u'Aron Baynes'),
'Boban Marjanovic': Text(0.627366, 0.718142, u'Boban Marjanovic'),
'Bryn Forbes': Text(0.781907, 0.179506, u'Bryn Forbes'),
'CJ Miles': Text(-0.786573, -0.389416, u'CJ Miles'),
'Chris Boucher': Text(-0.60966, -0.607358, u'Chris Boucher'),
'Cory Joseph': Text(0.126349, -0.155017, u'Cory Joseph'),
'Danny Green': Text(0.10596, 0.0643723, u'Danny Green'),
'Davis Bertans': Text(0.753946, 0.353111, u'Davis Bertans'),
'Delon Wright': Text(-0.512112, -0.201059, u'Delon Wright'),
'Derrick White': Text(0.767139, 0.561289, u'Derrick White'),
'Dewayne Dedmon': Text(0.974161, -0.168387, u'Dewayne Dedmon'),
'Fred VanVleet': Text(-0.536964, -0.336826, u'Fred VanVleet'),
'Greg Monroe': Text(-0.779211, -0.152725, u'Greg Monroe'),
'JaMychal Green': Text(1, 0.0469944, u'JaMychal Green'),
'Jodie Meeks': Text(-0.255096, -0.198723, u'Jodie Meeks'),
'Jonas Valanciunas': Text(-0.451902, -0.0517996, u'Jonas Valanciunas'),
'Jonathon Simmons': Text(0.729849, -0.18186, u'Jonathon Simmons'),
'Jordan Loyd': Text(-0.811773, 0.112843, u'Jordan Loyd'),
'Kawhi Leonard': Text(0.134761, -0.0167423, u'Kawhi Leonard'),
'Kyle Anderson': Text(0.628556, 0.0319063, u'Kyle Anderson'),
'Kyle Lowry': Text(-0.332212, 0.00397608, u'Kyle Lowry'),
'LaMarcus Aldridge': Text(0.614226, 0.267197, u'LaMarcus Aldridge'),
'Lorenzo Brown': Text(-0.840522, -0.0647107, u'Lorenzo Brown'),
'Malachi Richardson': Text(-0.591346, 0.192831, u'Malachi Richardson'),
'Malcolm Miller': Text(-0.831618, -0.268398, u'Malcolm Miller'),
'Marco Belinelli': Text(0.501489, 0.434717, u'Marco Belinelli'),
'Norman Powell': Text(-0.38843, -0.319135, u'Norman Powell'),
'OG Anunoby': Text(-0.462189, -0.494019, u'OG Anunoby'),
'Pascal Siakam': Text(-0.615164, -0.060441, u'Pascal Siakam'),
'Patty Mills': Text(0.480139, 0.141463, u'Patty Mills'),
'Pau Gasol': Text(0.36571, 0.232064, u'Pau Gasol'),
'Rudy Gay': Text(0.179449, 0.44939, u'Rudy Gay'),
'Serge Ibaka': Text(-0.655236, -0.447495, u'Serge Ibaka'),
'Tony Parker': Text(0.454806, 0.00785988, u'Tony Parker')}
```



Danny Green was part of the trade that sent Kawhi from the Spurs to the Raptors. Thus, Danny Green's node is near Kawhi above, in the middle of two clusters.

```
In [280]: # free agents in LeBron's network:  
print "Free Agents in Kawhi's network (above):"  
for i in free_agents:  
    if i in Kawhi_network:  
        print i
```

```
Free Agents in Kawhi's network (above):  
Pau Gasol
```

Network of NBA All-Stars:

```
In [222]: All_Star_players = ['James Harden',  
                           'Kevin Durant',  
                           'Kyrie Irving',  
                           'Kawhi Leonard',  
                           'LeBron James',  
                           'Anthony Davis',  
                           'Ben Simmons',  
                           'Bradley Beal',  
                           'Damian Lillard',  
                           'Dwyane Wade',  
                           'Karl-Anthony Towns',  
                           'Klay Thompson',  
                           'LaMarcus Aldridge',  
                           'Giannis Antetokounmpo',  
                           'Stephen Curry',  
                           'Joel Embiid',  
                           'Paul George',  
                           'Kemba Walker',  
                           'Blake Griffin',  
                           "D'Angelo Russell",  
                           'Dirk Nowitzki',  
                           'Khris Middleton',  
                           'Kyle Lowry',  
                           'Nikola Jokic',  
                           'Nikola Vucevic',  
                           'Victor Oladipo',  
                           'Russell Westbrook']
```

```
In [223]: for i in All_Star_players:  
    print i, "total teammates in the league:", len([n for n in playernet.neighbors(i)])
```

James Harden total teammates in the league: 47
Kevin Durant total teammates in the league: 37
Kyrie Irving total teammates in the league: 30
Kawhi Leonard total teammates in the league: 33
LeBron James total teammates in the league: 39
Anthony Davis total teammates in the league: 36
Ben Simmons total teammates in the league: 23
Bradley Beal total teammates in the league: 28
Damian Lillard total teammates in the league: 26
Dwyane Wade total teammates in the league: 47
Karl-Anthony Towns total teammates in the league: 22
Klay Thompson total teammates in the league: 29
LaMarcus Aldridge total teammates in the league: 35
Giannis Antetokounmpo total teammates in the league: 29
Stephen Curry total teammates in the league: 30
Joel Embiid total teammates in the league: 27
Paul George total teammates in the league: 30
Kemba Walker total teammates in the league: 26
Blake Griffin total teammates in the league: 41
D'Angelo Russell total teammates in the league: 31
Dirk Nowitzki total teammates in the league: 38
Khris Middleton total teammates in the league: 31
Kyle Lowry total teammates in the league: 43
Nikola Jokic total teammates in the league: 22
Nikola Vucevic total teammates in the league: 37
Victor Oladipo total teammates in the league: 36
Russell Westbrook total teammates in the league: 34

```
In [230]: AllStar_network = playernet.subgraph(All_Star_players)

one_season = [(u, v) for (u, v, d) in AllStar_network.edges(data=True) if d['weight'] <= 1]
two_three_seasons = [(u, v) for (u, v, d) in AllStar_network.edges(data=True) if d['weight']>1 and d['weight']<4]
four_plus_seasons = [(u, v) for (u, v, d) in AllStar_network.edges(data=True) if d['weight']>3]

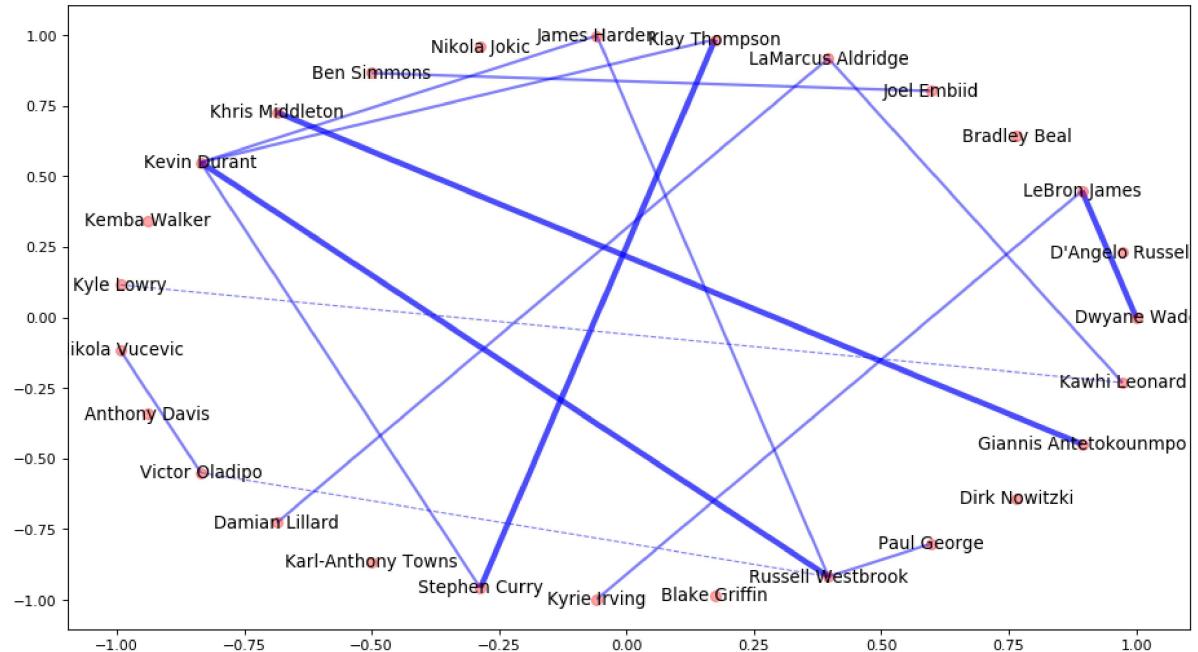
figure(num=None, figsize=(14, 8), dpi=80)
pos = net.circular_layout(AllStar_network) # positions for all nodes

# nodes
net.draw_networkx_nodes(AllStar_network, pos, node_size=50, node_color='r', alpha=0.35)
#net.draw_networkx_nodes(Kawhi_network, pos, nodelist=["Kawhi Leonard"], node_size=200, node_color='r')

# edges
net.draw_networkx_edges(AllStar_network, pos, edgelist=four_plus_seasons,
                       width=4, edge_color='b', alpha=0.7)
net.draw_networkx_edges(AllStar_network, pos, edgelist=two_three_seasons,
                       width=2, edge_color='b', alpha=0.5)
net.draw_networkx_edges(AllStar_network, pos, edgelist=one_season,
                       width=1, alpha=0.5, edge_color='b', style='dashed')

# Labels
net.draw_networkx_labels(AllStar_network, pos, font_size=12, font_weight = 'normal', font_family='sans-serif')
```

```
Out[230]: {'Anthony Davis': Text(-0.939693,-0.34202,u'Anthony Davis'),
 'Ben Simmons': Text(-0.5,0.866025,u'Ben Simmons'),
 'Blake Griffin': Text(0.173648,-0.984808,u'Blake Griffin'),
 'Bradley Beal': Text(0.766044,0.642788,u'Bradley Beal'),
 "D'Angelo Russell": Text(0.973045,0.230616,u"D'Angelo Russell"),
 'Damian Lillard': Text(-0.686242,-0.727374,u'Damian Lillard'),
 'Dirk Nowitzki': Text(0.766044,-0.642788,u'Dirk Nowitzki'),
 'Dwyane Wade': Text(1,9.65816e-09,u'Dwyane Wade'),
 'Giannis Antetokounmpo': Text(0.893633,-0.448799,u'Giannis Antetokounmpo'),
 'James Harden': Text(-0.0581448,0.998308,u'James Harden'),
 'Joel Embiid': Text(0.597159,0.802123,u'Joel Embiid'),
 'Karl-Anthony Towns': Text(-0.5,-0.866025,u'Karl-Anthony Towns'),
 'Kawhi Leonard': Text(0.973045,-0.230616,u'Kawhi Leonard'),
 'Kemba Walker': Text(-0.939693,0.34202,u'Kemba Walker'),
 'Kevin Durant': Text(-0.835488,0.549509,u'Kevin Durant'),
 'Khrys Middleton': Text(-0.686242,0.727374,u'Khrys Middleton'),
 'Klay Thompson': Text(0.173648,0.984808,u'Klay Thompson'),
 'Kyle Lowry': Text(-0.993238,0.116093,u'Kyle Lowry'),
 'Kyrie Irving': Text(-0.0581447,-0.998308,u'Kyrie Irving'),
 'LaMarcus Aldridge': Text(0.39608,0.918216,u'LaMarcus Aldridge'),
 'LeBron James': Text(0.893633,0.448799,u'LeBron James'),
 'Nikola Jokic': Text(-0.286803,0.95799,u'Nikola Jokic'),
 'Nikola Vucevic': Text(-0.993238,-0.116093,u'Nikola Vucevic'),
 'Paul George': Text(0.597159,-0.802123,u'Paul George'),
 'Russell Westbrook': Text(0.39608,-0.918216,u'Russell Westbrook'),
 'Stephen Curry': Text(-0.286803,-0.95799,u'Stephen Curry'),
 'Victor Oladipo': Text(-0.835488,-0.549509,u'Victor Oladipo')}
```



Kevin Durant and Russell Westbrook have played with four current All-Stars at some point in their careers. But, the list below shows 8 current All-Stars have never played with another current All-Star.

```
In [239]: AS_list = []

for i in All_Star_players:
    AS_list.append([i, len([n for n in AllStar_network.neighbors(i)])])

AS_df = pd.DataFrame(AS_list, columns = ['Player', 'All-Star Teammates'])

AS_df = AS_df.sort_values(by=['All-Star Teammates'], ascending=False)
AS_df

#for i in All_Star_players:
#    print i, "total All-Star teammates:", len([n for n in ALLStar_network.nei
ghbors(i)])
```

Out[239]:

	Player	All-Star Teammates
26	Russell Westbrook	4
1	Kevin Durant	4
11	Klay Thompson	2
25	Victor Oladipo	2
14	Stephen Curry	2
12	LaMarcus Aldridge	2
0	James Harden	2
4	LeBron James	2
3	Kawhi Leonard	2
13	Giannis Antetokounmpo	1
21	Khris Middleton	1
9	Dwyane Wade	1
2	Kyrie Irving	1
6	Ben Simmons	1
24	Nikola Vucevic	1
15	Joel Embiid	1
16	Paul George	1
8	Damian Lillard	1
22	Kyle Lowry	1
23	Nikola Jokic	0
7	Bradley Beal	0
20	Dirk Nowitzki	0
19	D'Angelo Russell	0
18	Blake Griffin	0
5	Anthony Davis	0
10	Karl-Anthony Towns	0
17	Kemba Walker	0

Players that have played for most teams:

```
In [259]: nba_players = pd.DataFrame(nba_data_df.groupby("Player").Team.unique())
nba_players = nba_players.sort_values(by=["Team"], ascending=False)
nba_players.head(20)
```

Out[259]:

	Team
Player	
Gerald Green	8
Jerryd Bayless	8
Shaun Livingston	8
Anthony Tolliver	8
Jamal Crawford	7
Trevor Ariza	7
Jodie Meeks	7
Vince Carter	7
Jeremy Lin	7
Michael Beasley	7
Jeff Green	7
Ish Smith	7
Marco Belinelli	7
Courtney Lee	6
Jason Smith	6
Dwight Howard	6
DeMarre Carroll	6
Jose Calderon	6
Tyson Chandler	6
Quincy Acy	6

Teams that have had the most active players:

```
In [262]: nba_teams = pd.DataFrame(nba_data_df.groupby("Team").Player.nunique())
nba_teams = nba_teams.sort_values(by=["Player"], ascending=False)
nba_teams.head(10)
```

Out[262]:

	Player
Team	
Suns	50
Grizzlies	47
Hawks	47
Rockets	46
Sixers	45
Bulls	43
Knicks	41
Magic	41
Hornets	40
Lakers	40

From above: Nearly 10% of the current players have played on the Suns during their career.