

Data Import

```
In[1]:= SetDirectory[
  "C:/Users/serha/OneDrive/Masaüstü/MyRepo/master_thesis_MMT003/210224_impacts_in_time
  _windows"];

In[2]:= datafull = Import["../data/ccm1_data_modified.csv", HeaderLines → 1];
datafullwithheading = Import["../data/ccm1_data_modified.csv"];

In[3]:= Get["../algorithm_packages/SingleNetworks-algorithm-package.wl"]
(* ?SingleNetworks` * *)

In[4]:= Print["Dataset Length: ", Dimensions@datafull[[All, 9]]];
Dataset Length: {459 203}

In[5]:= Magnify[TableView[datafullwithheading], 0.6];

In[6]:= Print["Width Feature Data Summary: ", Counts@(Head /@ datafull[[All, 9]])]
Print["Width Zero Values: ", Count[datafull[[All, 9]], 0]]
Print["Thickness Feature Data Summary: ", Counts@(Head /@ datafull[[All, 10]])]
Print["Thickness Zero Values: ", Count[datafull[[All, 10]], 0]]
Width Feature Data Summary: <| Real → 397 873, Integer → 61 183, String → 147 |>
Width Zero Values: 61 183
Thickness Feature Data Summary: <| Real → 397 860, Integer → 61 199, String → 144 |>
Thickness Zero Values: 61 199
```

Modifications in the Dataset

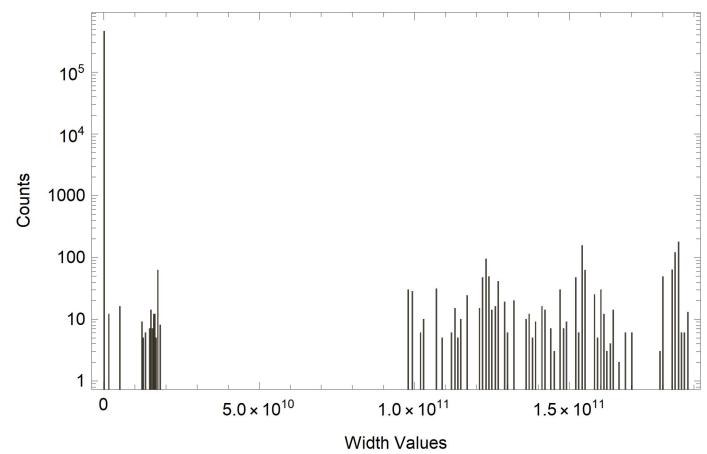
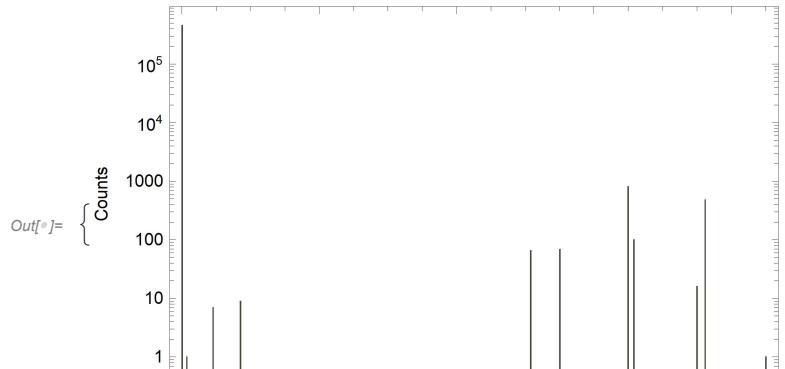
Data consists of 459203 rows.

Preconditions

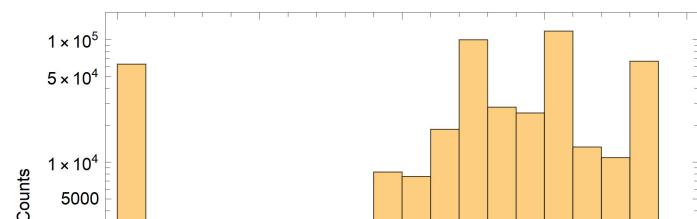
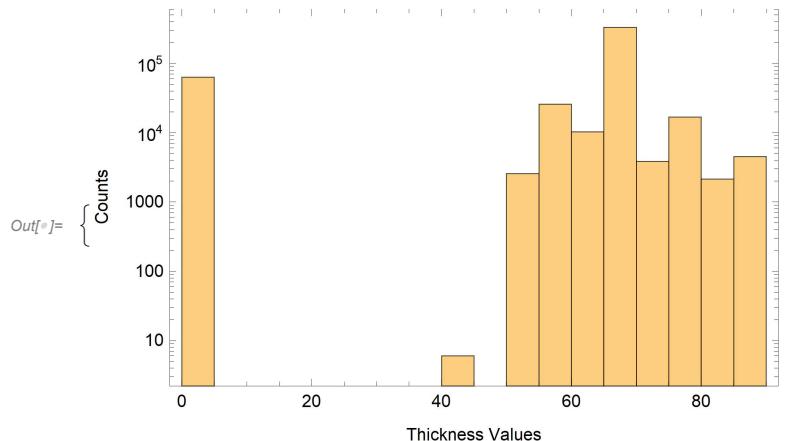
Steel density is considered between 7.00×10^{-6} kg/mm³ and 8.50×10^{-6} kg/mm³.
Width varies between 800 - 2000 mm.
Thickness varies between 40 - 90 mm.
Weight varies between 2669 - 26690 kg.
Length unit is mm.

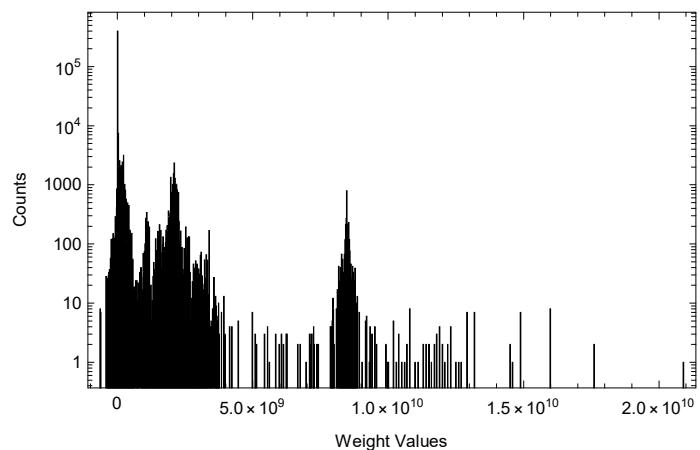
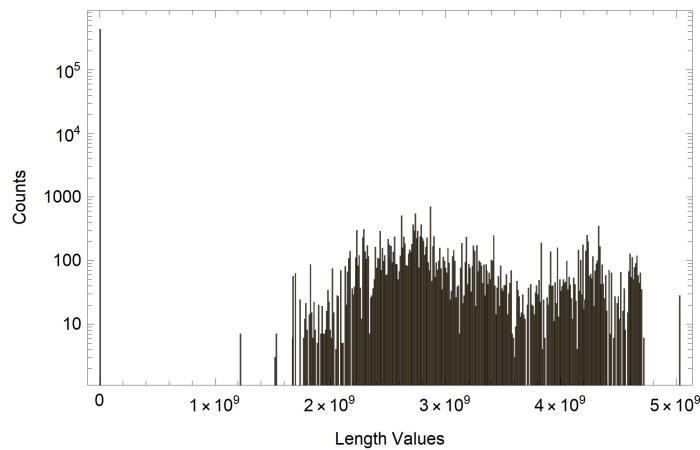
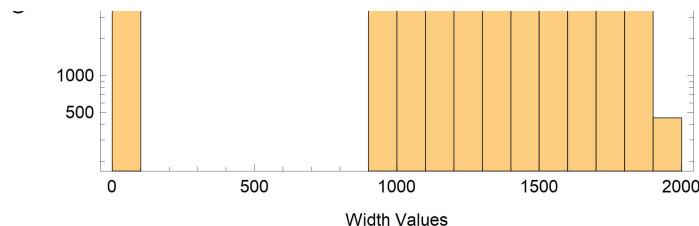
Modification in Density, Thickness and Width Limits

Starting to modify width, thickness, and weight values corresponding to thickness values with 2 digits.

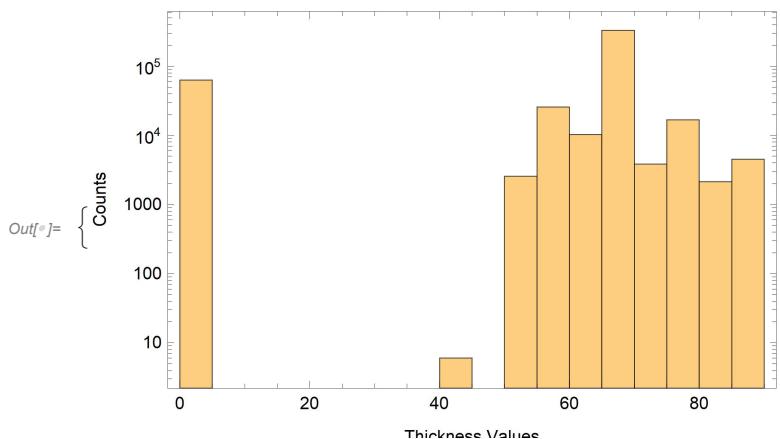


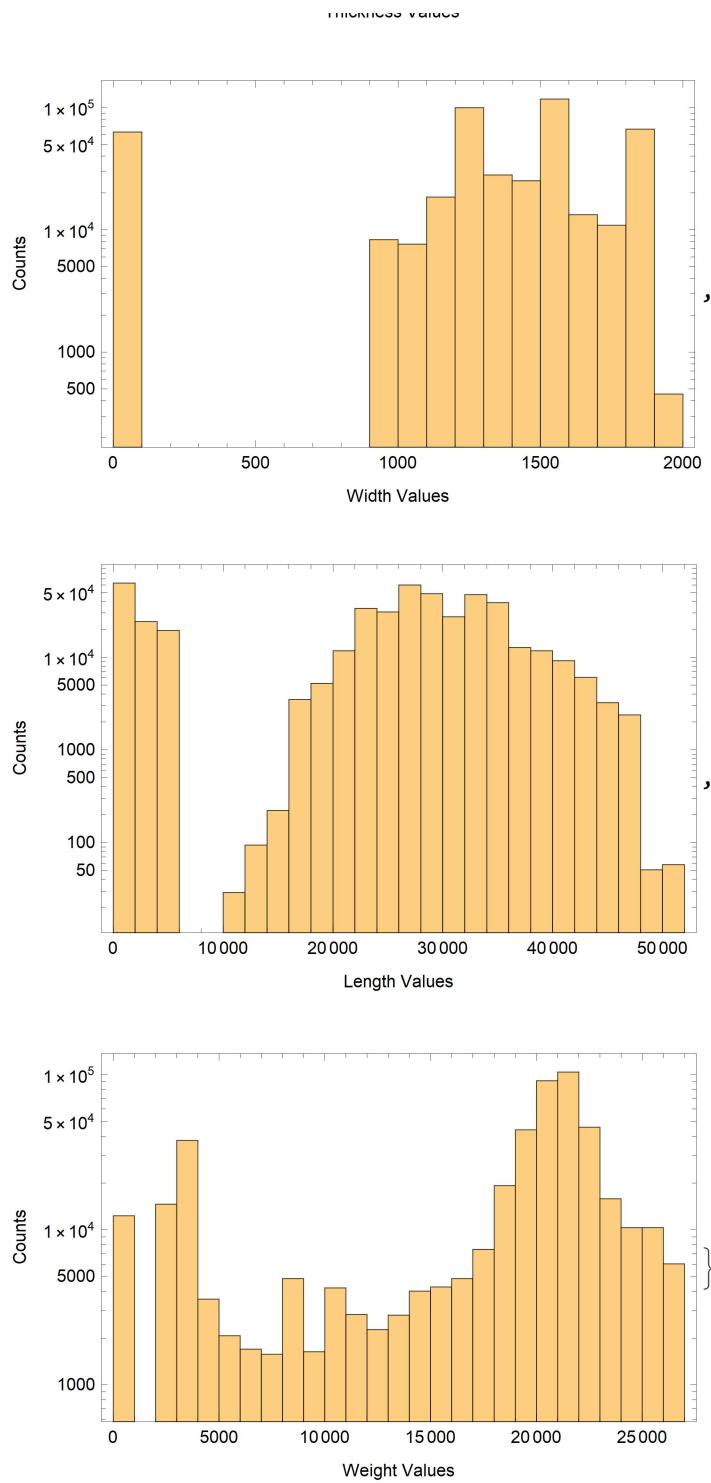
Modification on Length and Weight Values in Density Limit

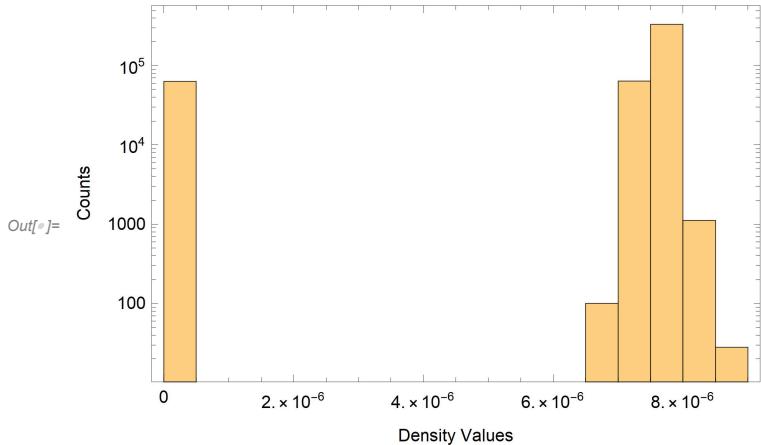




Final Counts for Weight and Length Features and Density







```

In[1]:= datafullmodified = Import["../data/ccm_manipulated.csv", HeaderLines → 1];

In[2]:= Print["Weight Zero Rows: ", Length@Position[datafullmodified[[All, 11]], 0]]
Print["Thickness + Width + Length Zero Rows: ",
Length@Position[datafullmodified[[All, 9]], 0]]
Print["Usable Rows: ", Length@datafullmodified -
Length@Position[datafullmodified[[All, 9]], 0]]

Weight Zero Rows: 10484
Thickness + Width + Length Zero Rows: 61320
Usable Rows: 397883

In[3]:= datafullmodified396096 = Import["../data/ccm_manipulated_396096.csv", HeaderLines → 1];

In[4]:= Print["Weight Zero Rows: ", Length@Position[datafullmodified396096[[All, 11]], 0]]
Print["Thickness + Width + Length Zero Rows: ",
Length@Position[datafullmodified396096[[All, 9]], 0]]
Print["Usable Rows: ", Length@datafullmodified396096 -
Length@Position[datafullmodified396096[[All, 9]], 0]]

Weight Zero Rows: 0
Thickness + Width + Length Zero Rows: 0
Usable Rows: 396096

Time Windows Generation by Data Partitioning

In[5]:= data = Table[Take[datafullmodified, UpTo@i],
{i, {46497, 91690, 138440, 183584, 230005, 275844, 320350, 367179, 413106, 459203}}];
(* Export["../data/ccm_manipulated_partitioned_in_time_windows.mx",data] *)

In[6]:= data396096 = Table[Take[datafullmodified396096, UpTo@i],
{i, {39871, 79567, 118358, 158421, 198041, 237352, 277147, 316411, 356385, 396096}}];
(* Export[
"../data/ccm_manipulated_396096_partitioned_in_time_windows.mx",data396096] *)

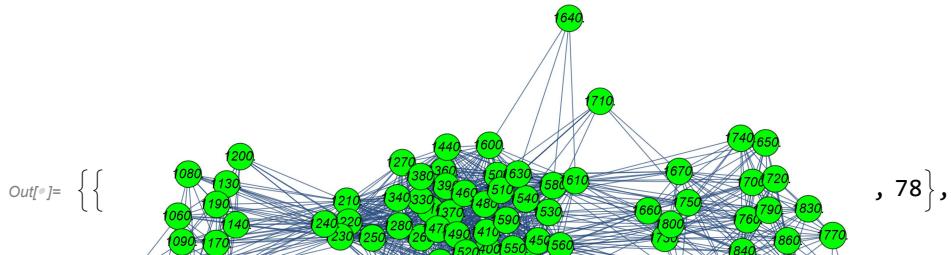
```

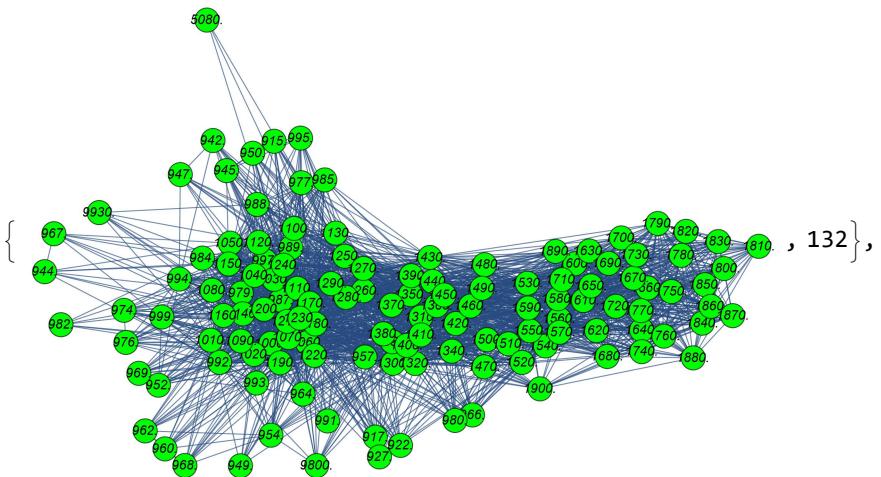
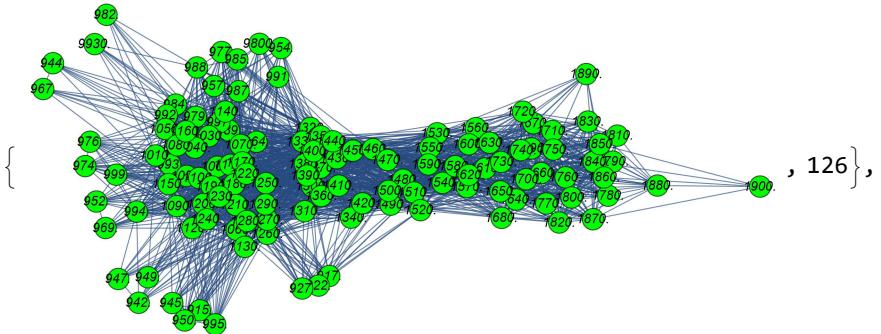
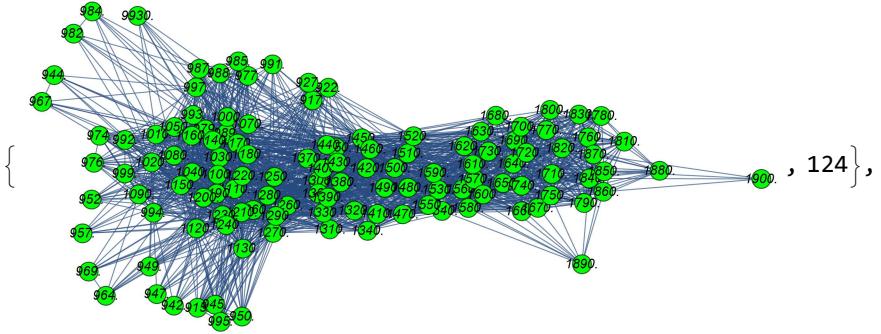
Investigation of Constraints Impact in Time Windows

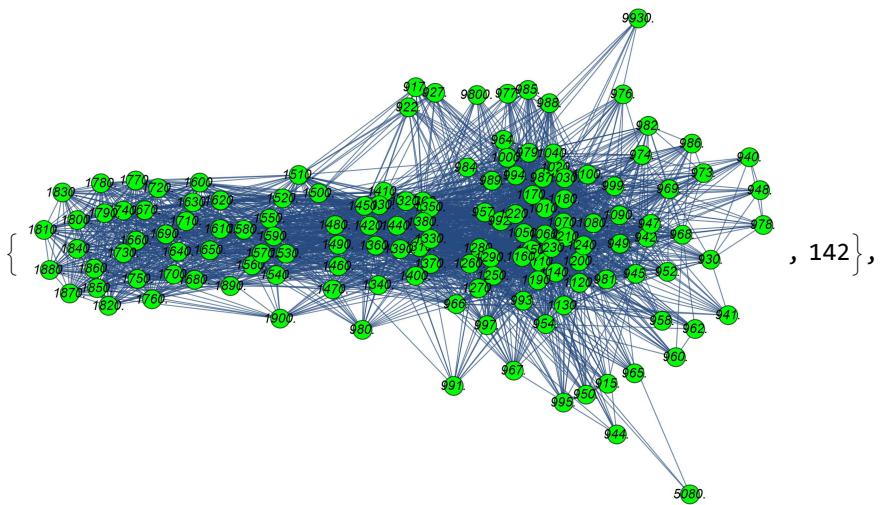
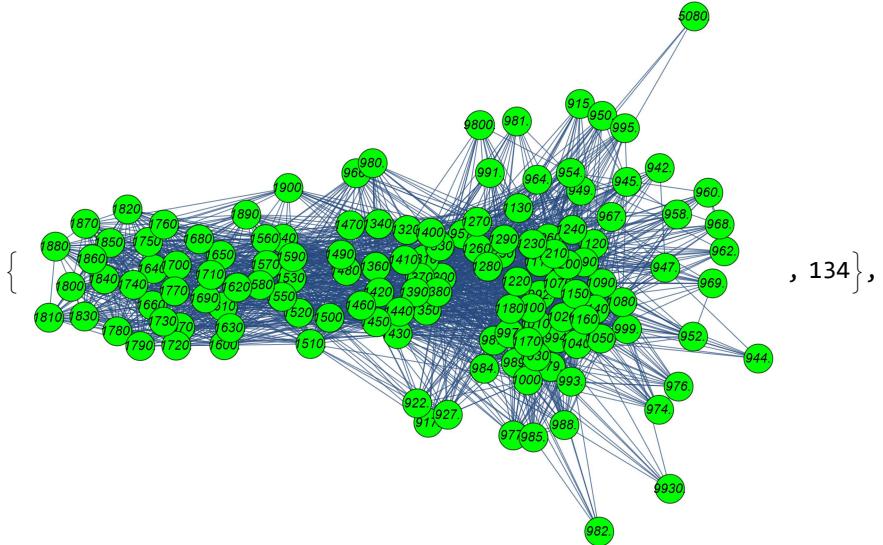
Simple Association Networks

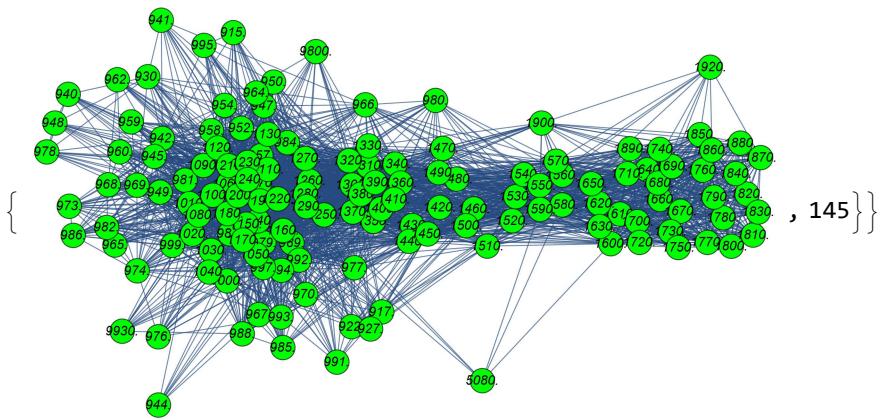
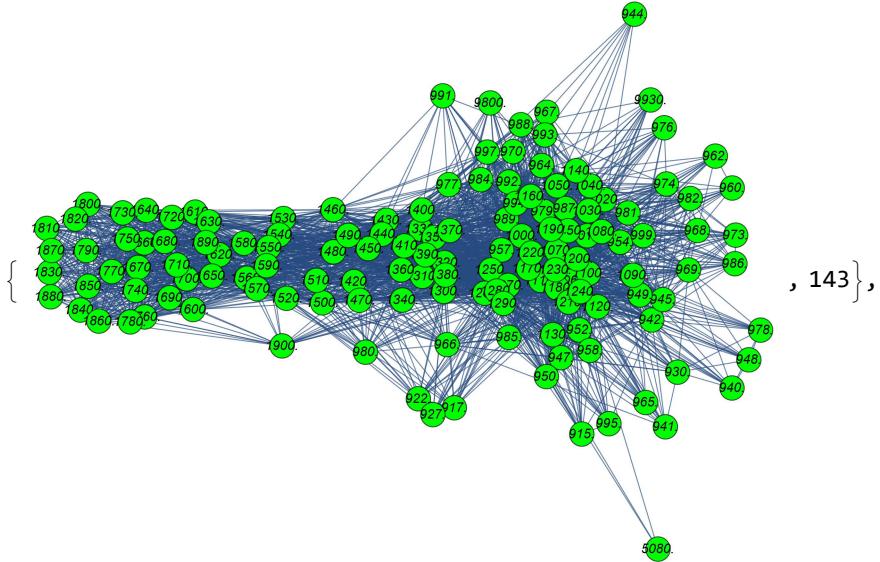
Width Feature

```
In[7]:= AbsoluteTiming [widthdataintimewindows = snetworkdatasingleintimewindows[[9, 10]];]
In[8]:= graphsandnodenumbers = Table[snetworkgraphsinglenodes [widthdataintimewindows[[1]][[i]], widthdataintimewindows[[2]][[i]], 2, 7, 400, Green], {i, Range@10}];
In[9]:= graphsandnodenumbers
```









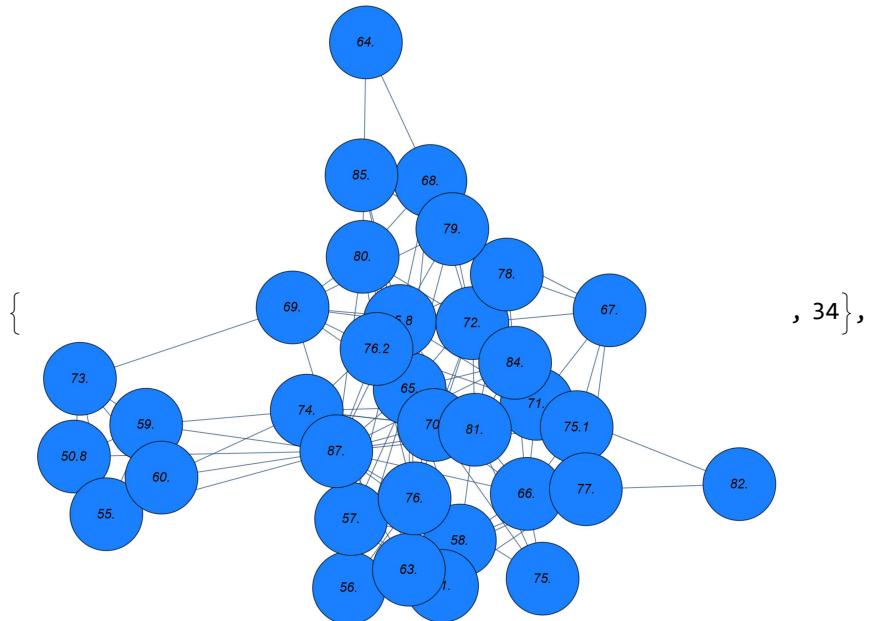
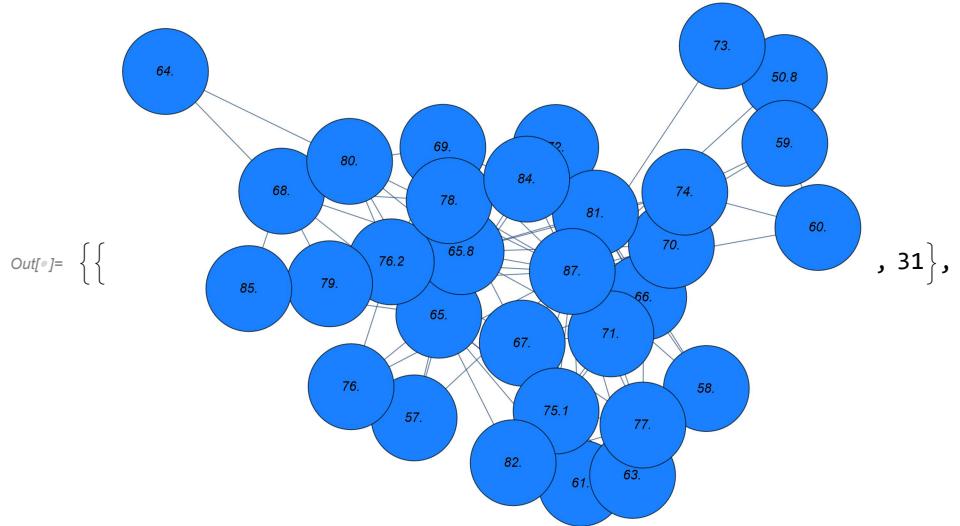
Thickness Feature

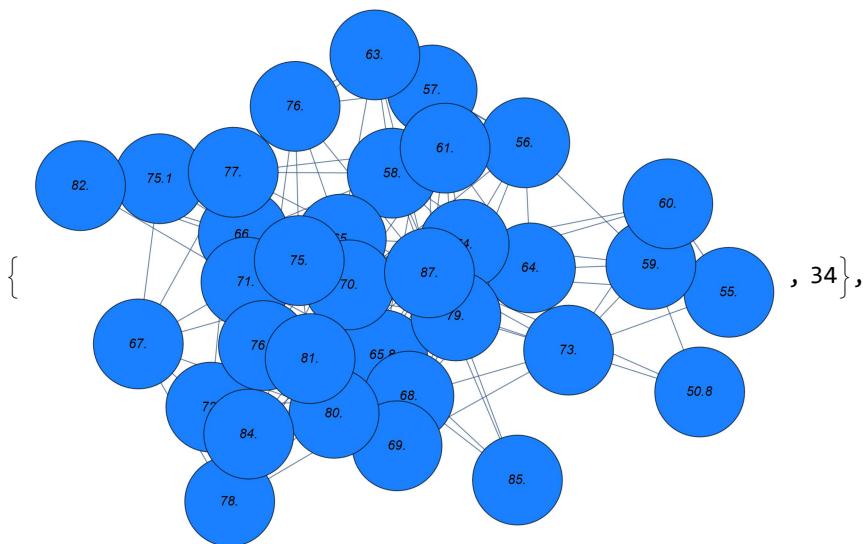
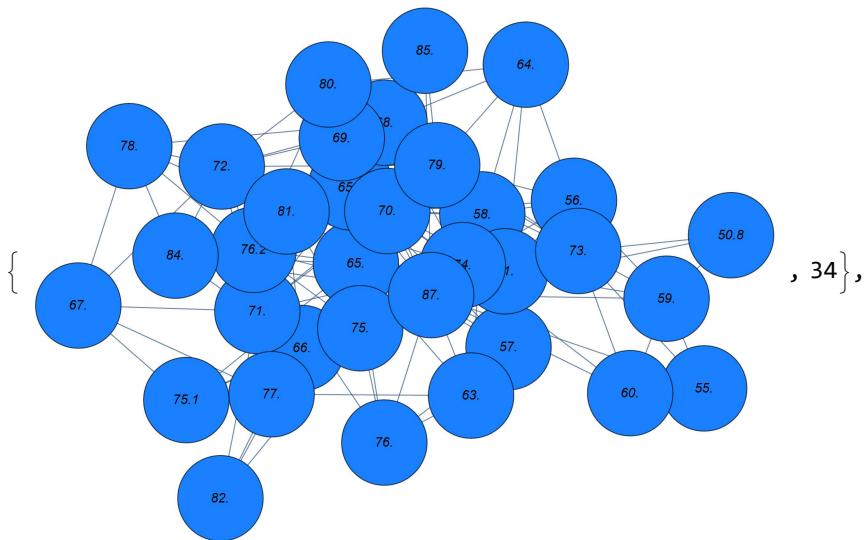
```
In[=]:= AbsoluteTiming[thicknessdataintimewindows = snetworkdatasingleintimewindows [10, 10];]
```

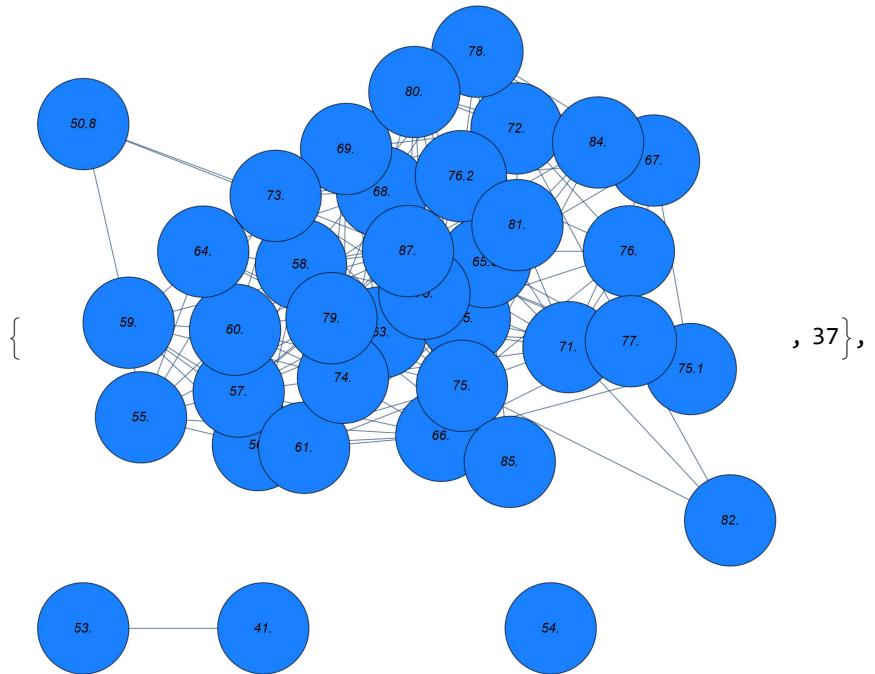
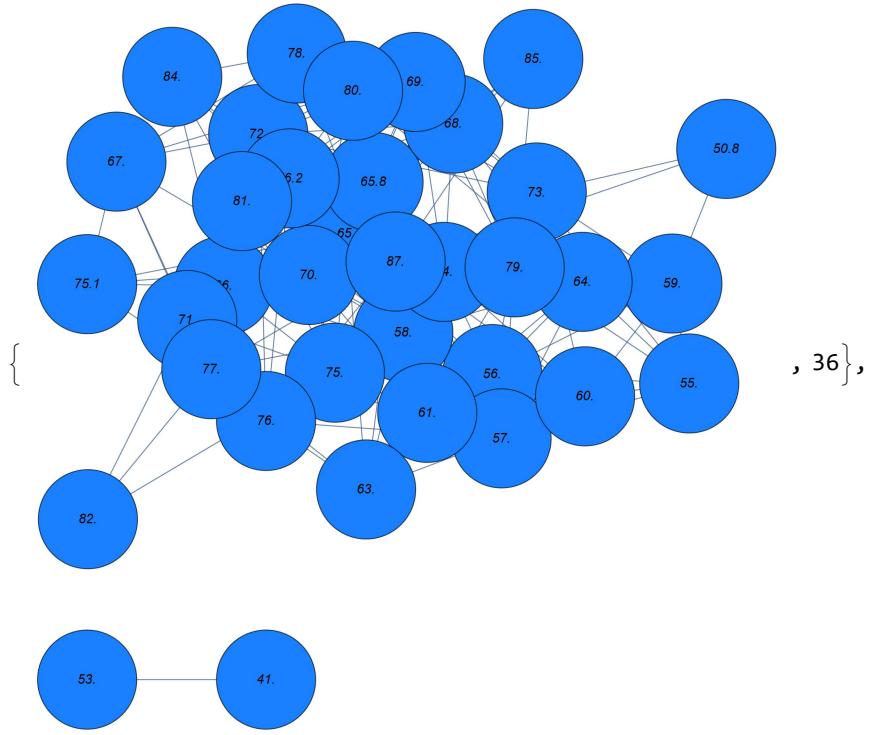
```
Out[=]= {2211.65, Null}
```

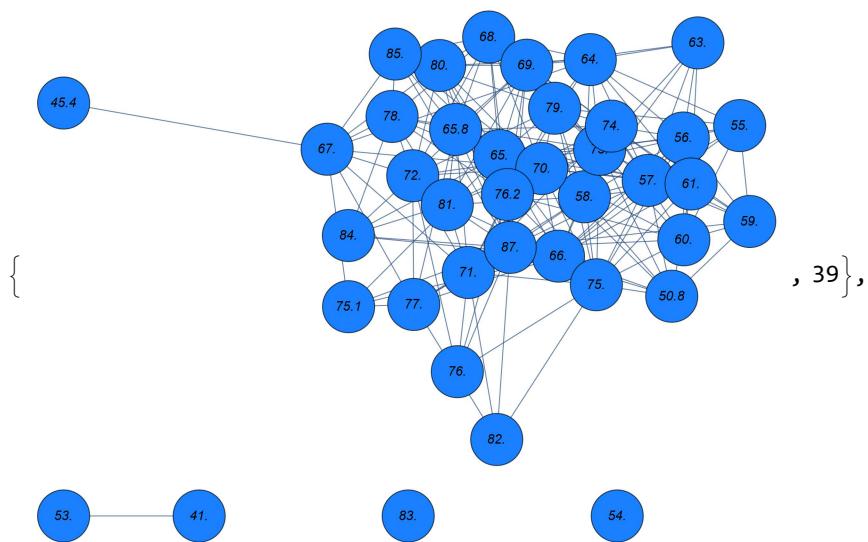
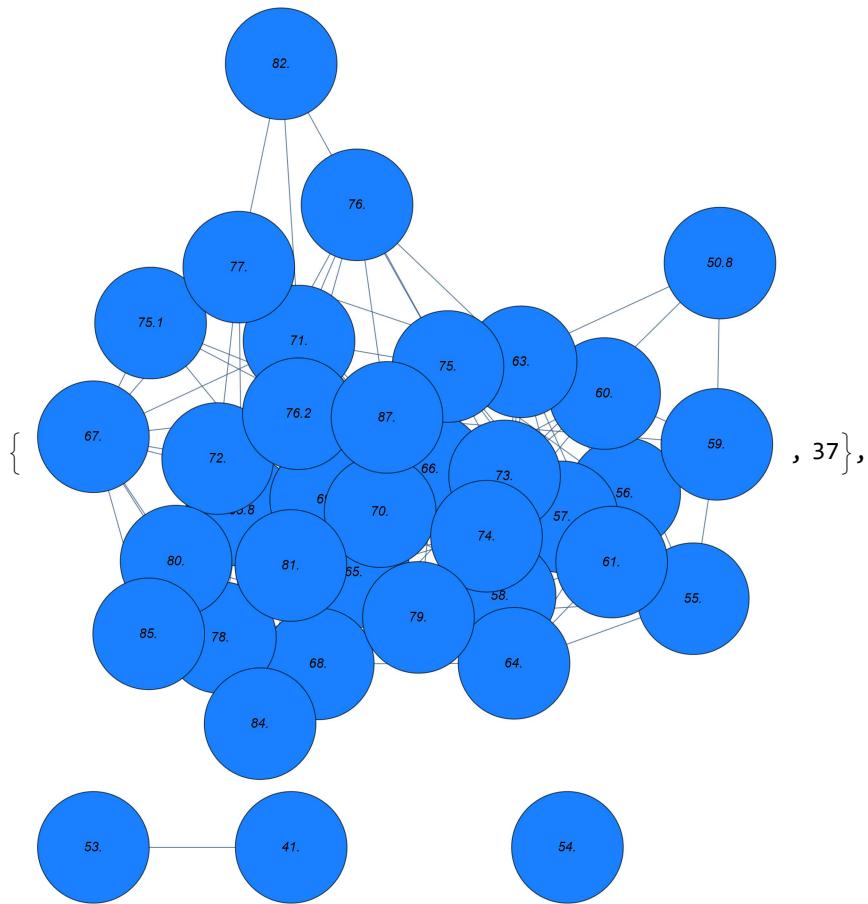
```
In[=]:= graphsandnodenumbers = Table[snetworkgraphsinglenodes [
  thicknessdataintimewindows [[1]][[i]], thicknessdataintimewindows [[2]][[i]],
  2, 7, 400, RGBColor[0.1, 0.5, 1.]], {i, Range@10}];
```

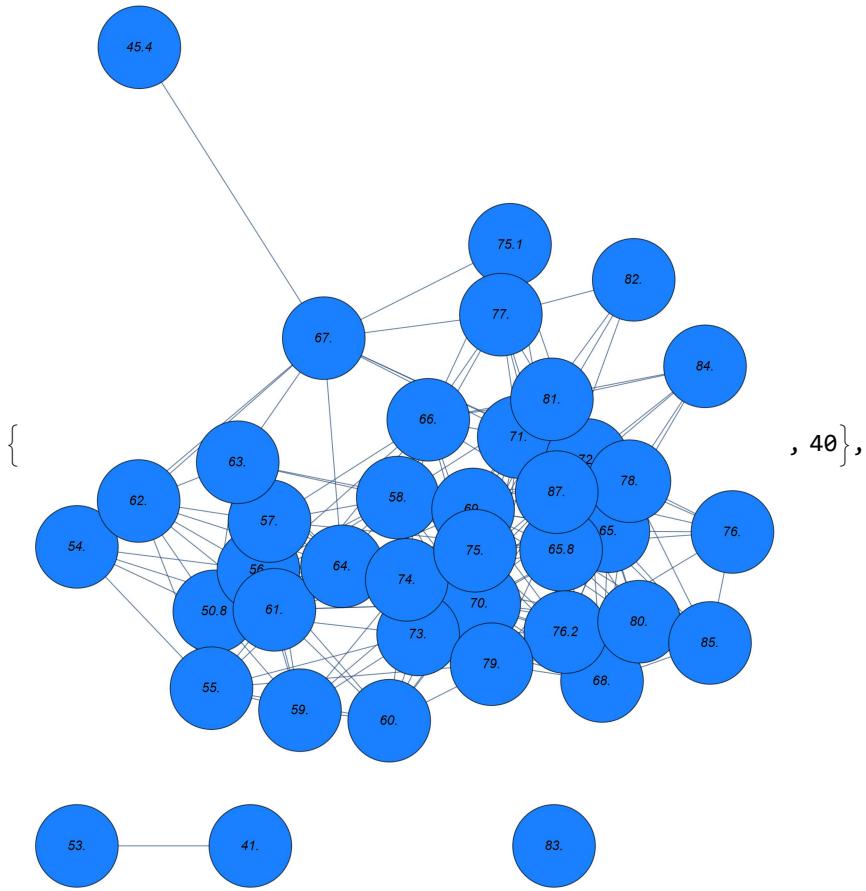
```
In[=]:= graphsandnodenumbers
```

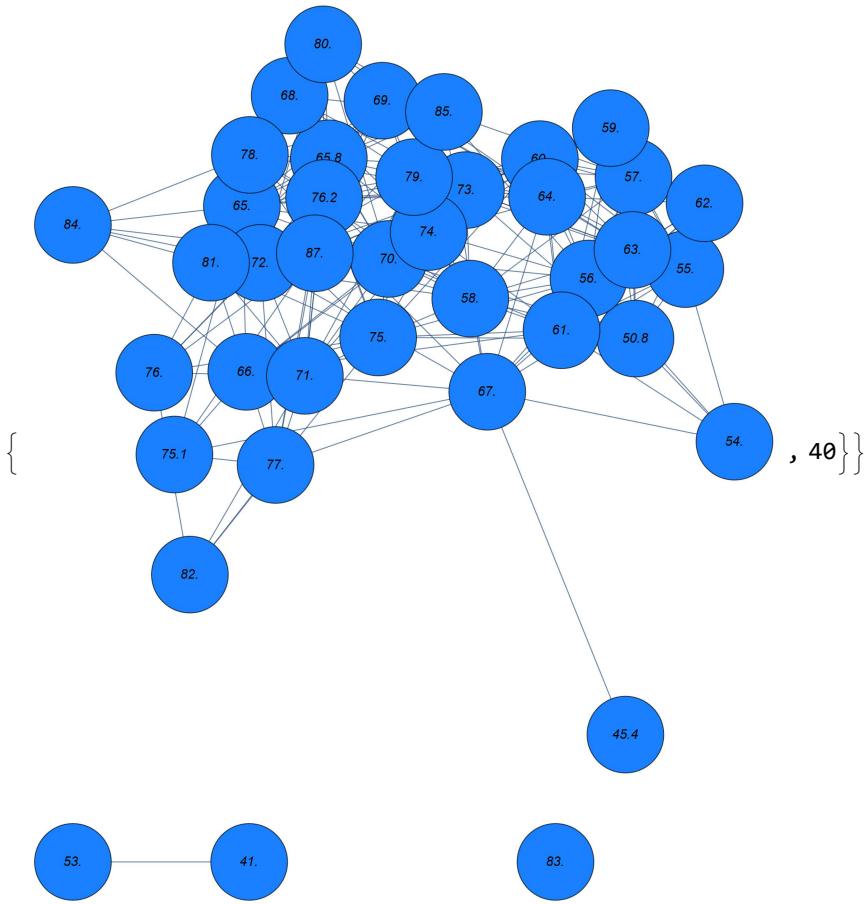












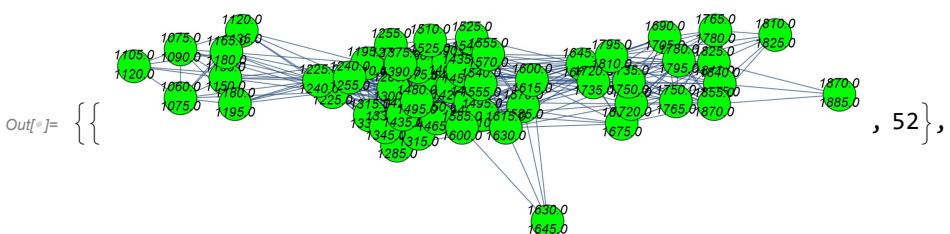
Fixed Step Size Networks

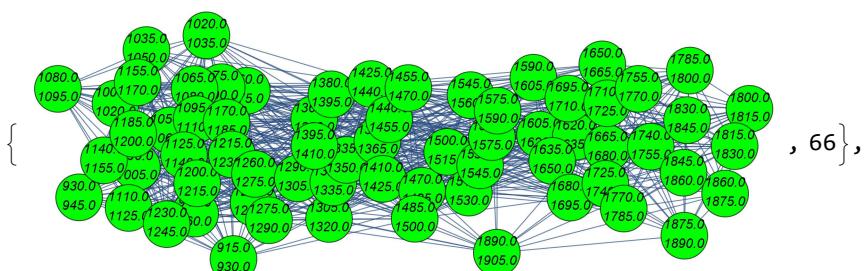
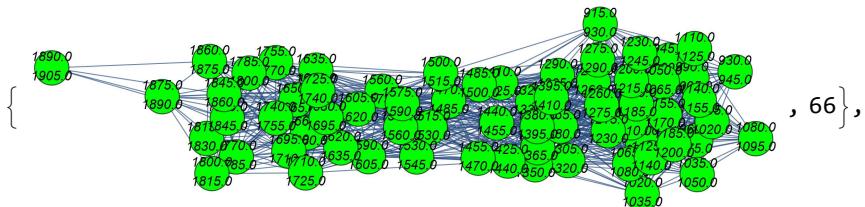
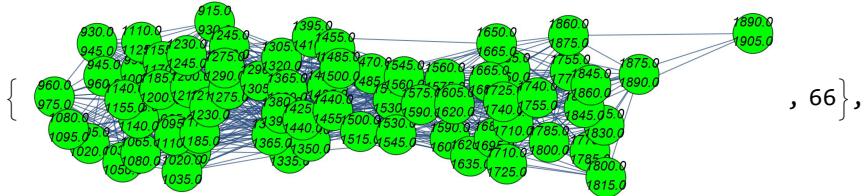
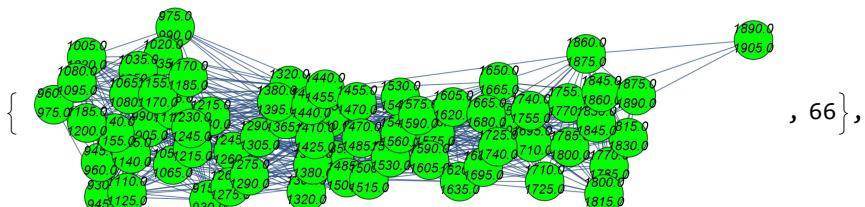
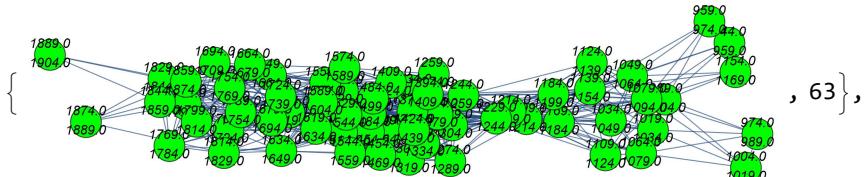
Width Feature

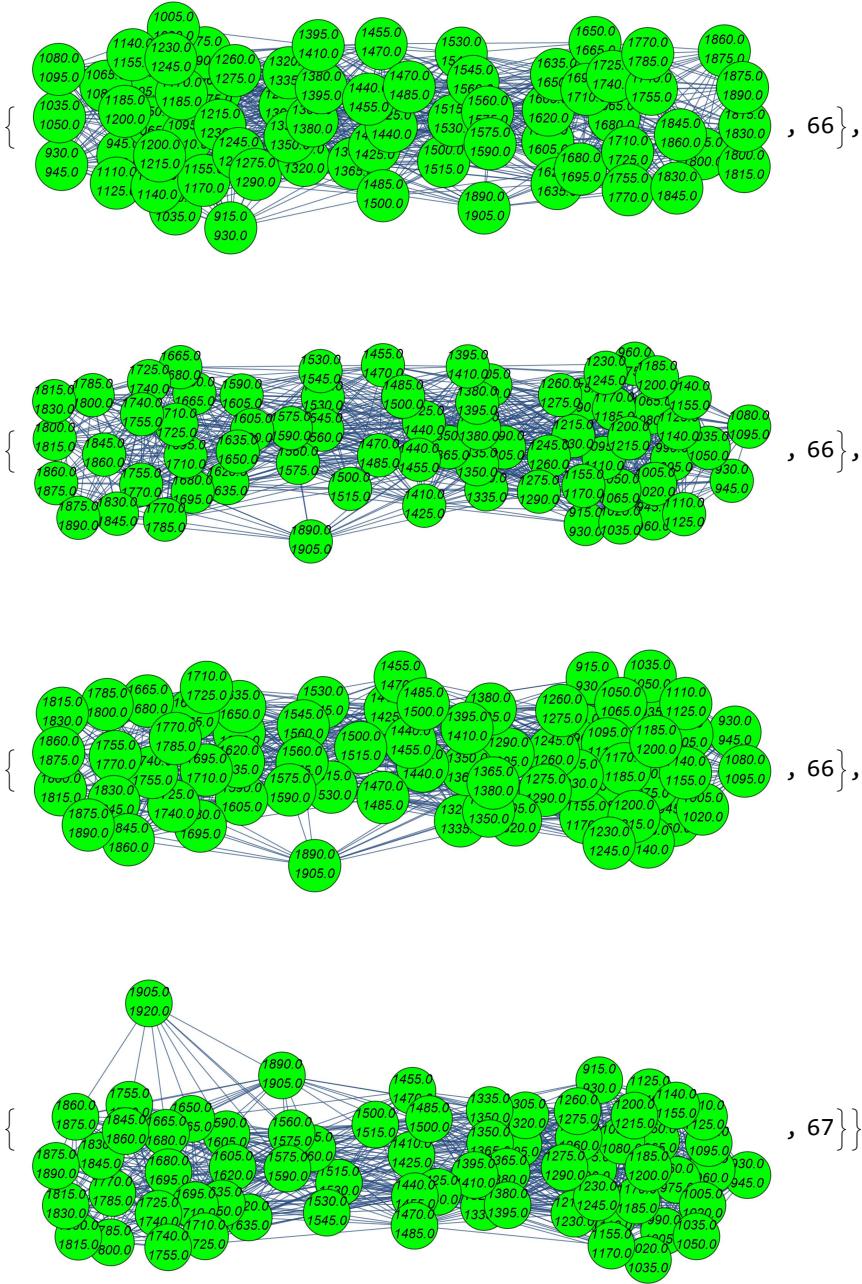
```
In[=]:= AbsoluteTiming[  
  widthdataintimewindowsFixedstep = snetworkdatabinnedintimewindows [9, 15, 10];]  
Out[=]= {1335.75, Null}
```

```
In[=]:= graphsandnodenumbers = Table[snetworkgraph[widthdataintimewindowsFixedstep[[1]][[i]],  
  widthdataintimewindowsFixedstep[[2]][[i]], 2, 7, 400, Green], {i, Range@10}];
```

```
In[=]:= graphsandnodenumbers
```

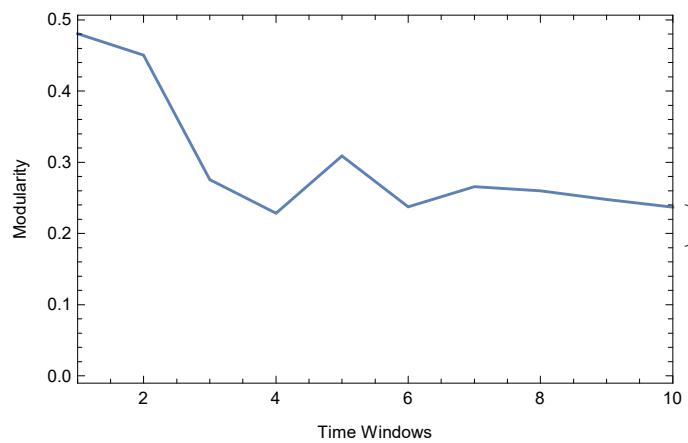
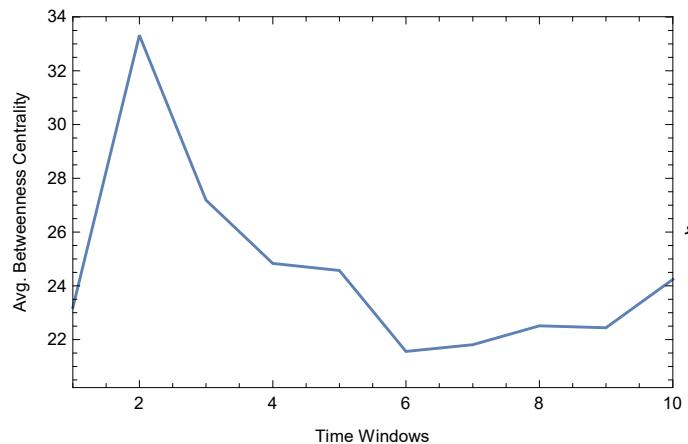
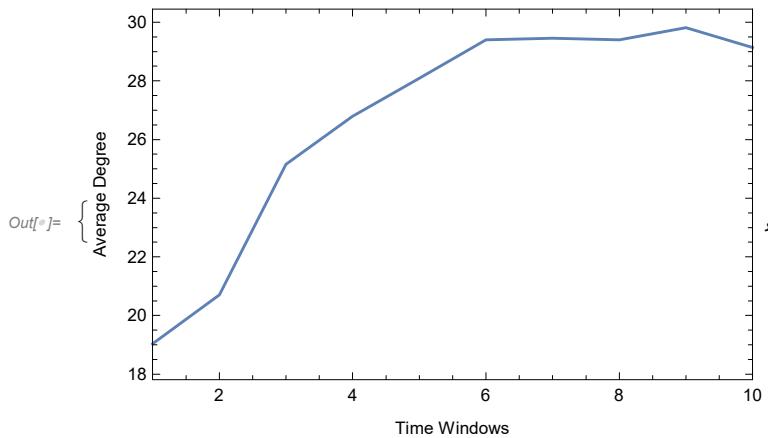






```
In[6]:= ABCvalues = Table[Mean@BetweennessCentrality[graphsandnodenumbers[[i]][[1]]], {i, Length@graphsandnodenumbers}];  
modularityvalues = Table[N@GraphAssortativity[graphsandnodenumbers[[i]][[1]]], {i, Length@graphsandnodenumbers}];  
degreevalues = Table[N@Mean@VertexDegree[graphsandnodenumbers[[i]][[1]]], {i, Length@graphsandnodenumbers}];
```

```
In[6]:= {ListLinePlot[Thread[{Range@10, degreevalues}], Frame → True,
  FrameLabel → {"Time Windows", "Average Degree"}, ImageSize → 350,
  PlotRange → {{1, 10}, All}], ListLinePlot[Thread[{Range@10, ABCvalues}],
  Frame → True, FrameLabel → {"Time Windows", "Avg. Betweenness Centrality"},
  ImageSize → 350, PlotRange → {{1, 10}, All}],
  ListLinePlot[Thread[{Range@10, modularityvalues}], Frame → True,
  FrameLabel → {"Time Windows", "Modularity"}, ImageSize → 350, PlotRange → {{1, 10}, All}]}
```



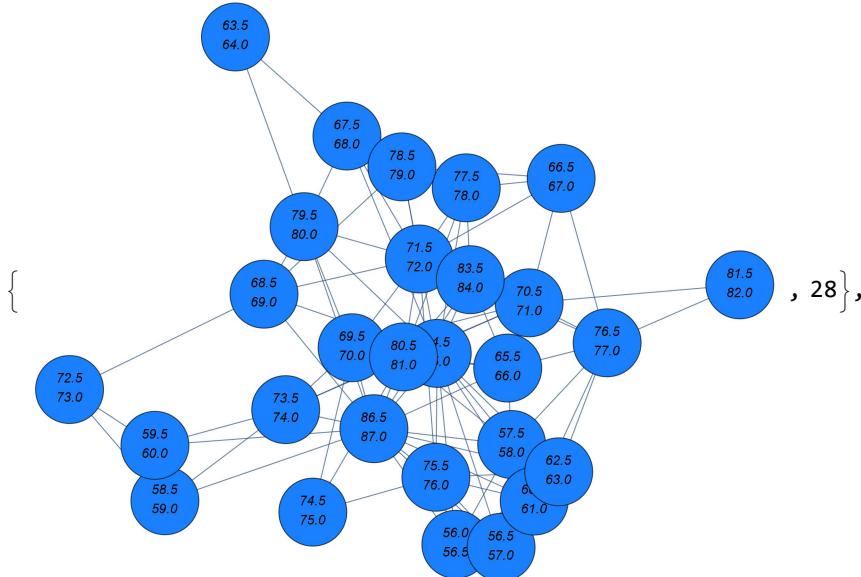
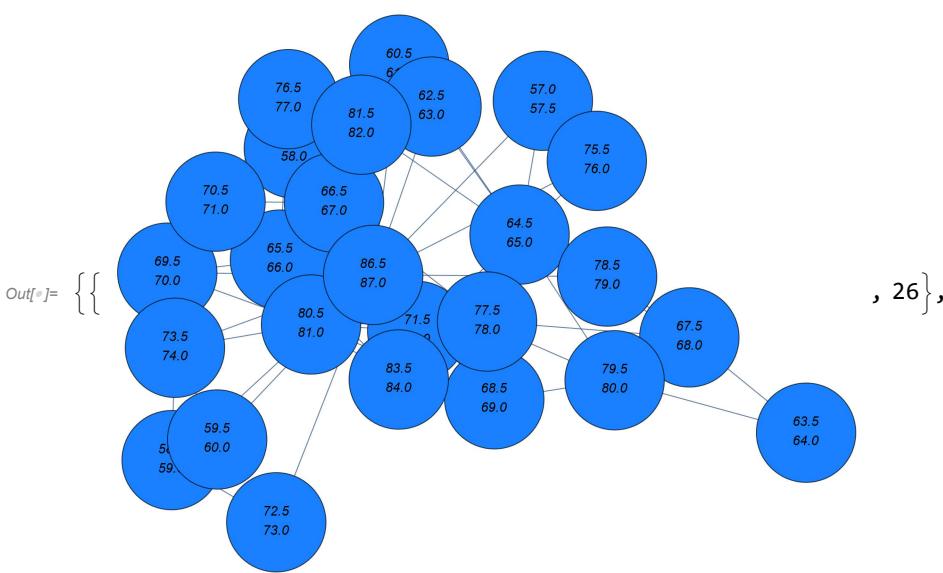
Thickness Feature

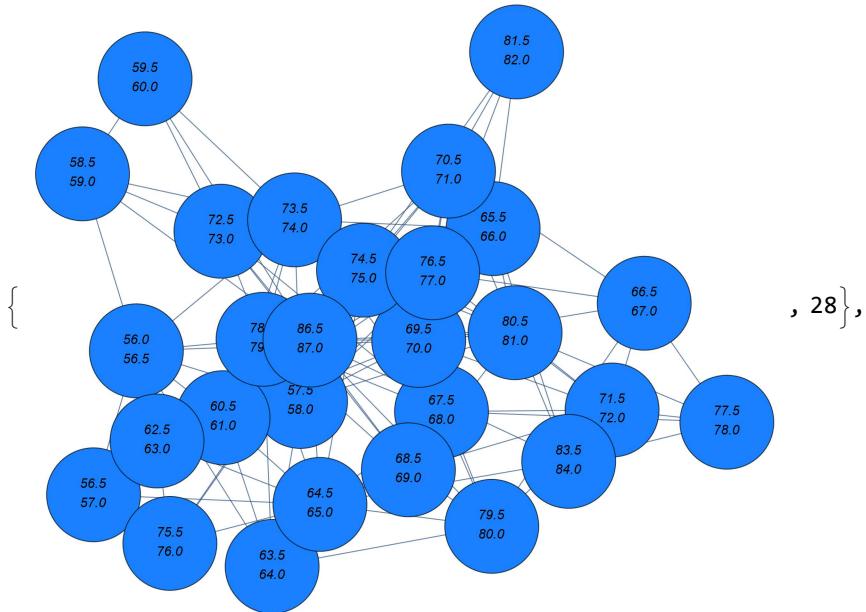
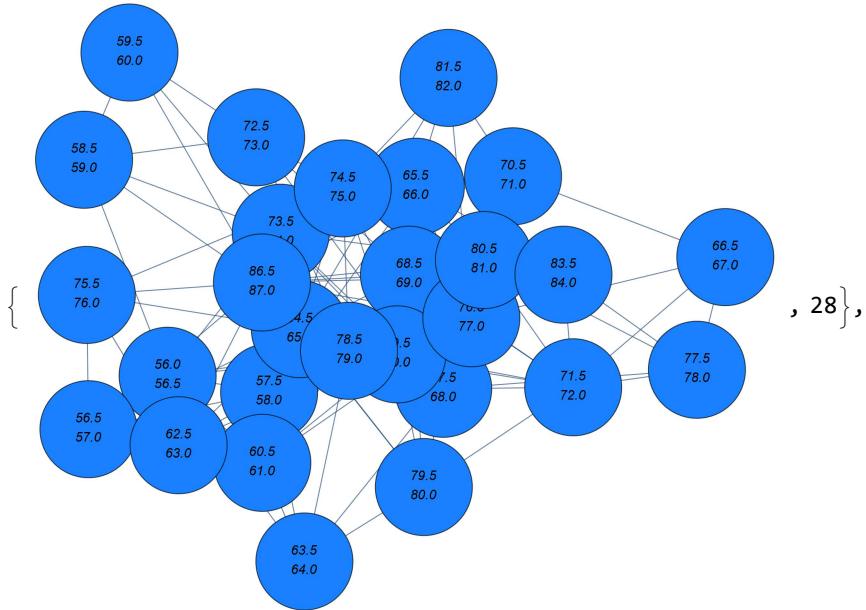
```
In[6]:= AbsoluteTiming[
  thicknessdataintimewindowsFixedstep = snetworkdatabinnedintimewindows[10, 0.5, 10];
]

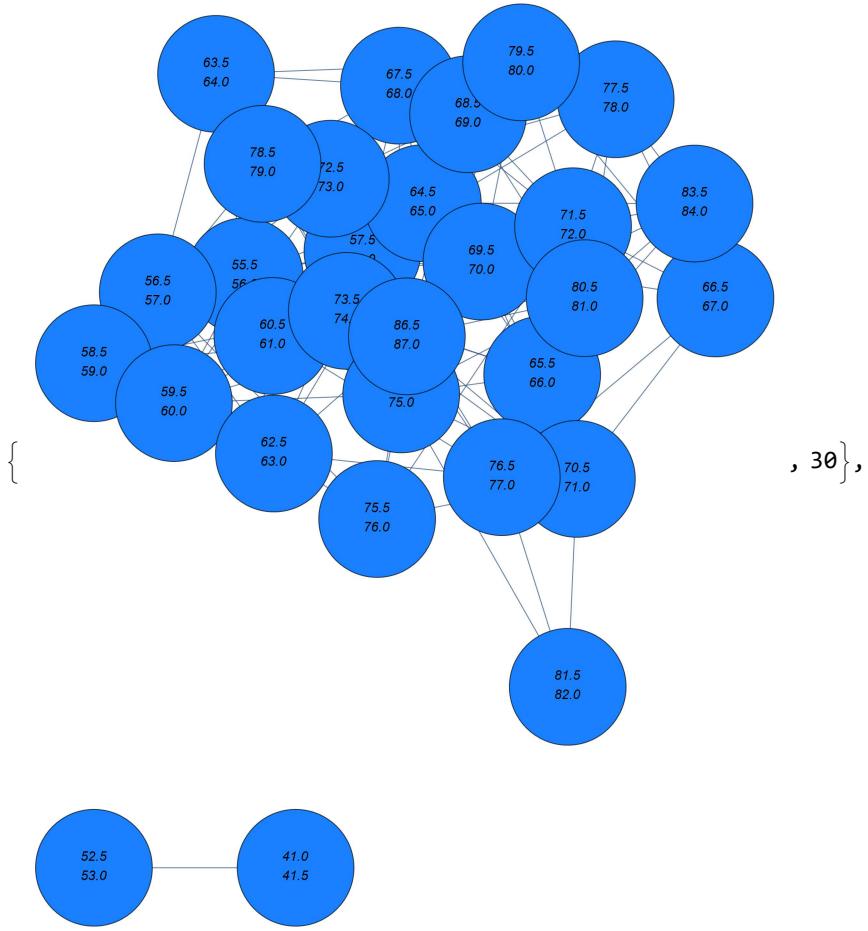
Out[6]= {1335.39, Null}

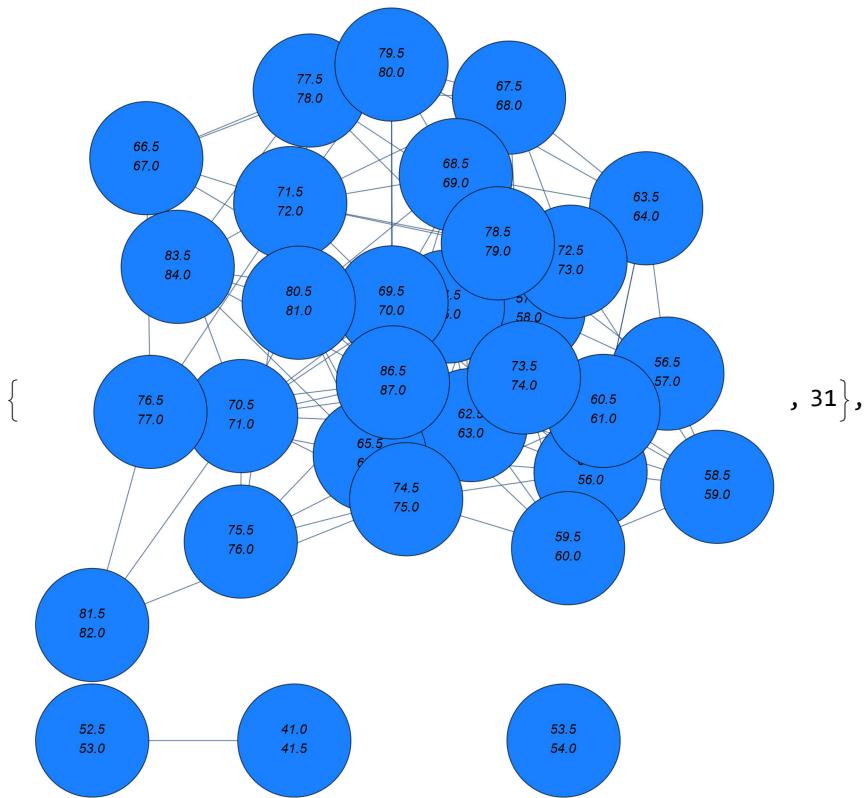
In[7]:= graphsandnodenumbers = Table[snetworkgraph[thicknessdataintimewindowsFixedstep[[1]][[i]],
  thicknessdataintimewindowsFixedstep[[2]][[i]]],
```

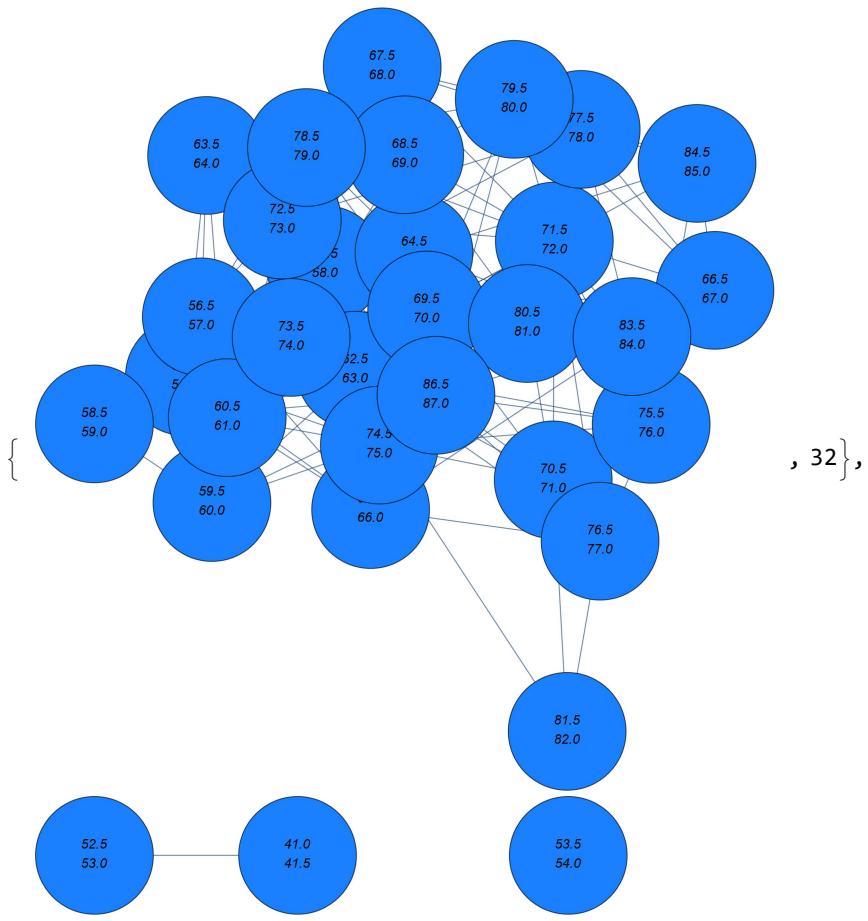
In[1]:= graphsandnodenumbers

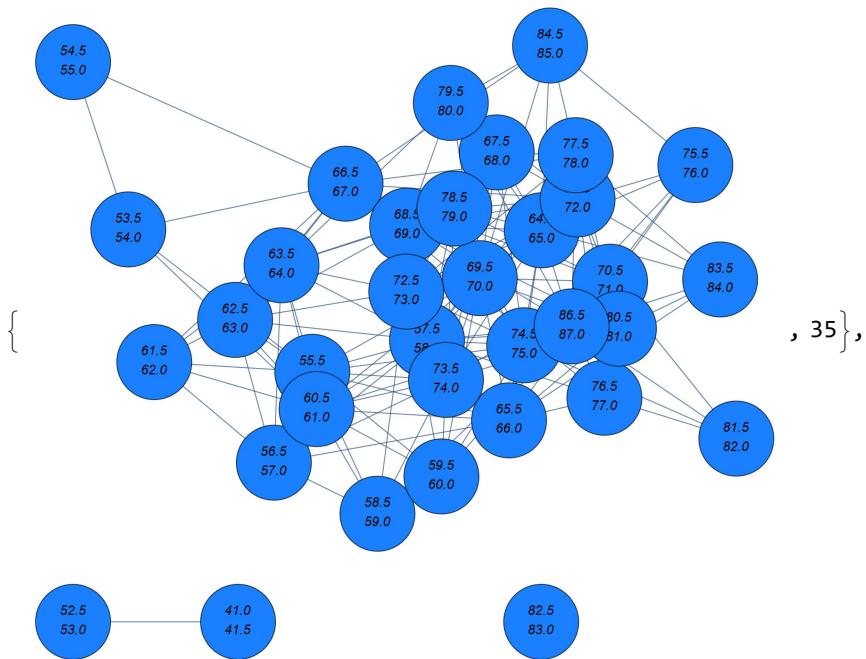
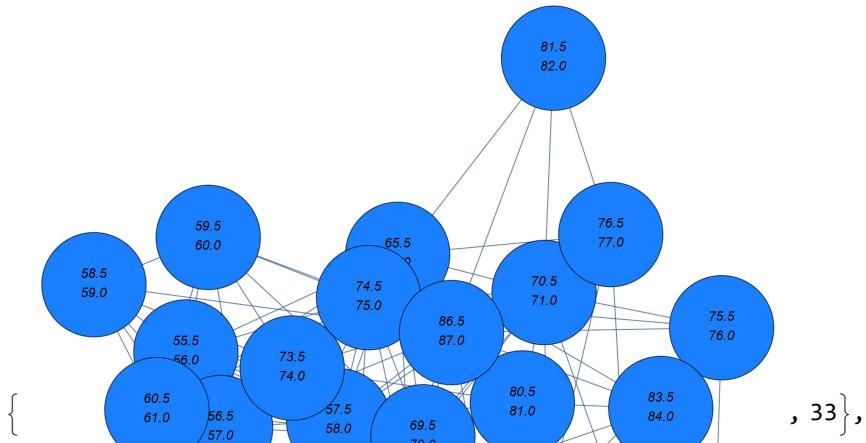


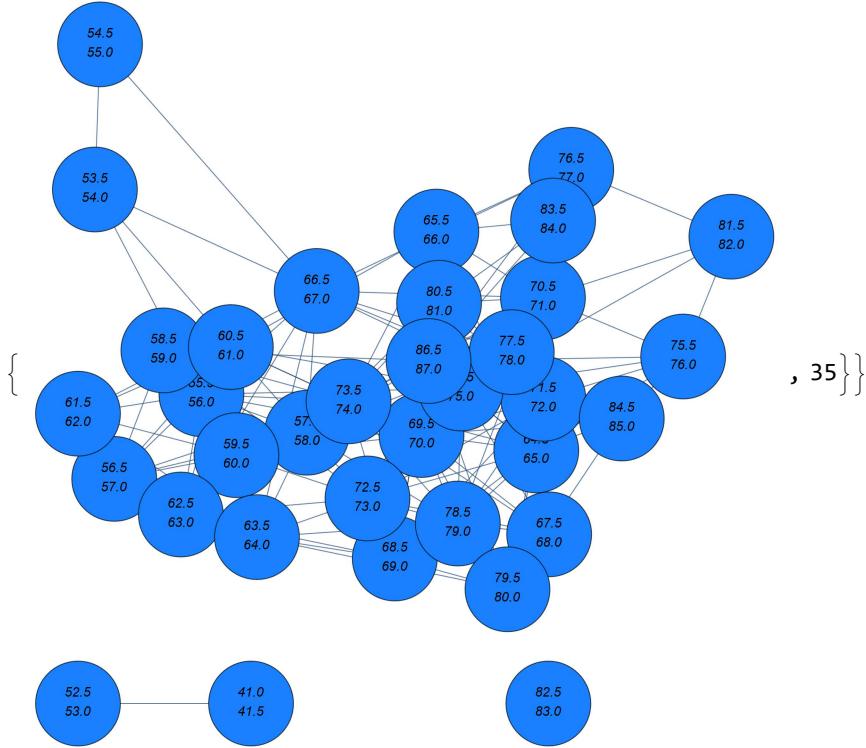










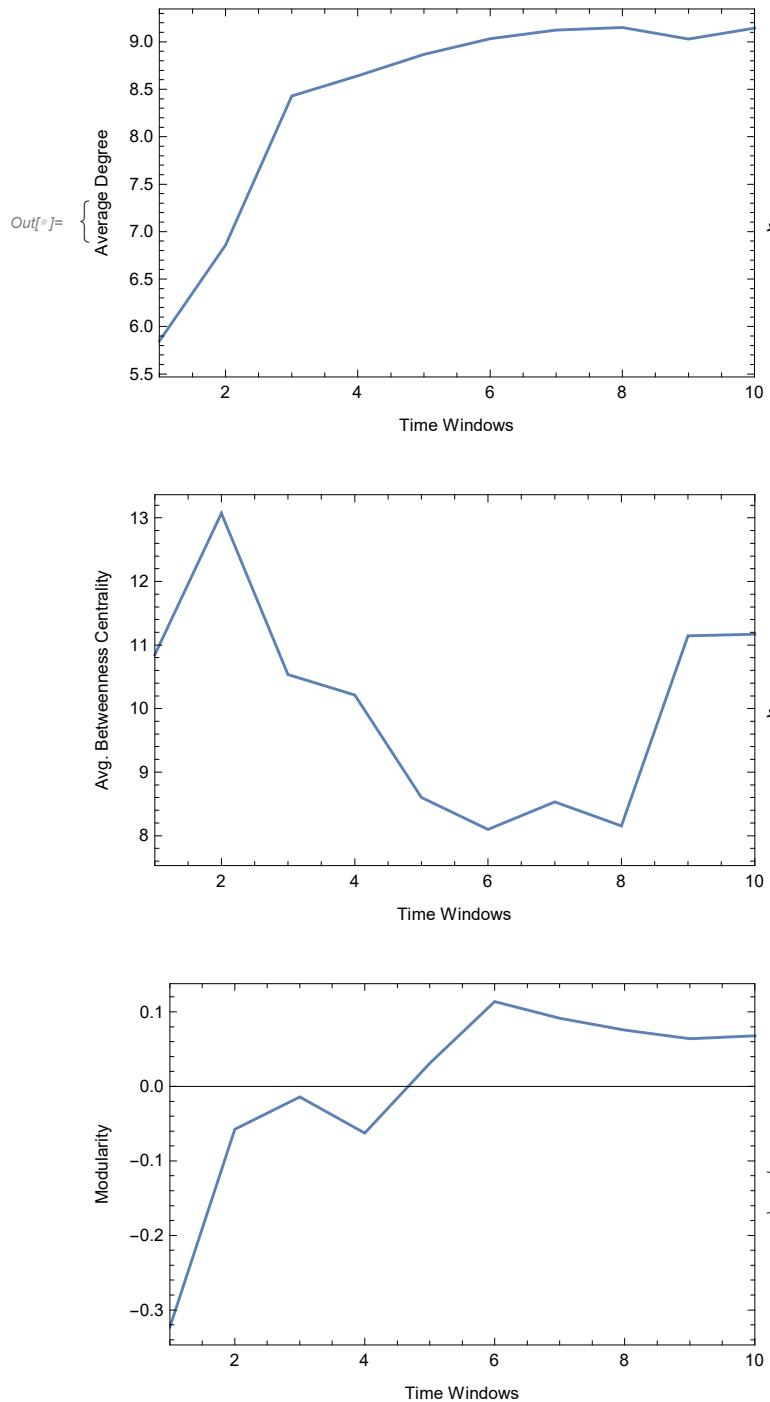


```

In[=]:= ABCvalues = Table[Mean@BetweennessCentrality[graphsandnodenumbers[[i]][[1]]],
 {i, Length@graphsandnodenumbers}];
modularityvalues = Table[N@GraphAssortativity[graphsandnodenumbers[[i]][[1]]],
 {i, Length@graphsandnodenumbers}];
degreevalues = Table[N@Mean@VertexDegree[graphsandnodenumbers[[i]][[1]]],
 {i, Length@graphsandnodenumbers}];

In[=]:= {ListLinePlot[Thread[{Range@10, degreevalues}], Frame -> True,
 FrameLabel -> {"Time Windows", "Average Degree"}, ImageSize -> 350,
 PlotRange -> {{1, 10}, All}], ListLinePlot[Thread[{Range@10, ABCvalues}],
 Frame -> True, FrameLabel -> {"Time Windows", "Avg. Betweenness Centrality"},
 ImageSize -> 350, PlotRange -> {{1, 10}, All}],
 ListLinePlot[Thread[{Range@10, modularityvalues}], Frame -> True,
 FrameLabel -> {"Time Windows", "Modularity"}, ImageSize -> 350, PlotRange -> {{1, 10}, All}]}

```



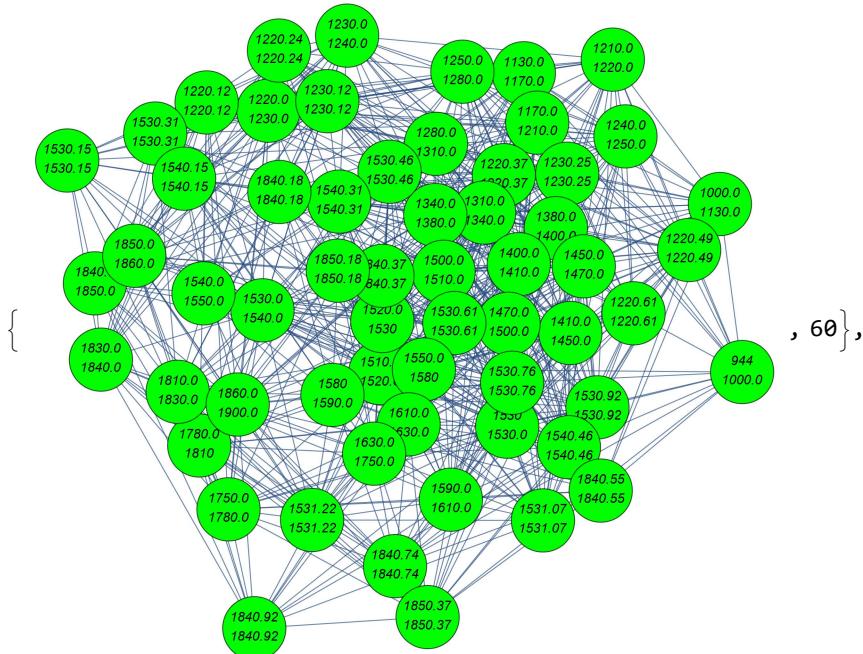
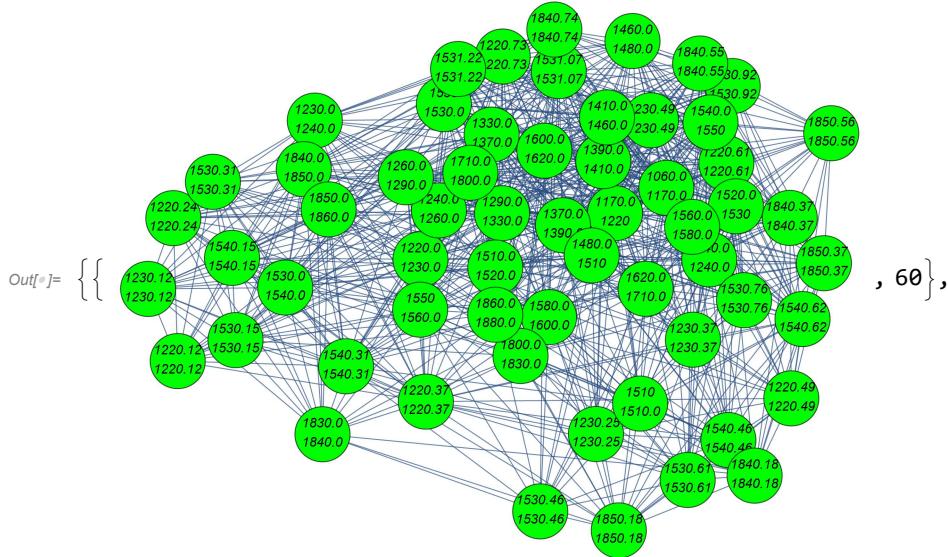
Fixed Bucket Size Networks

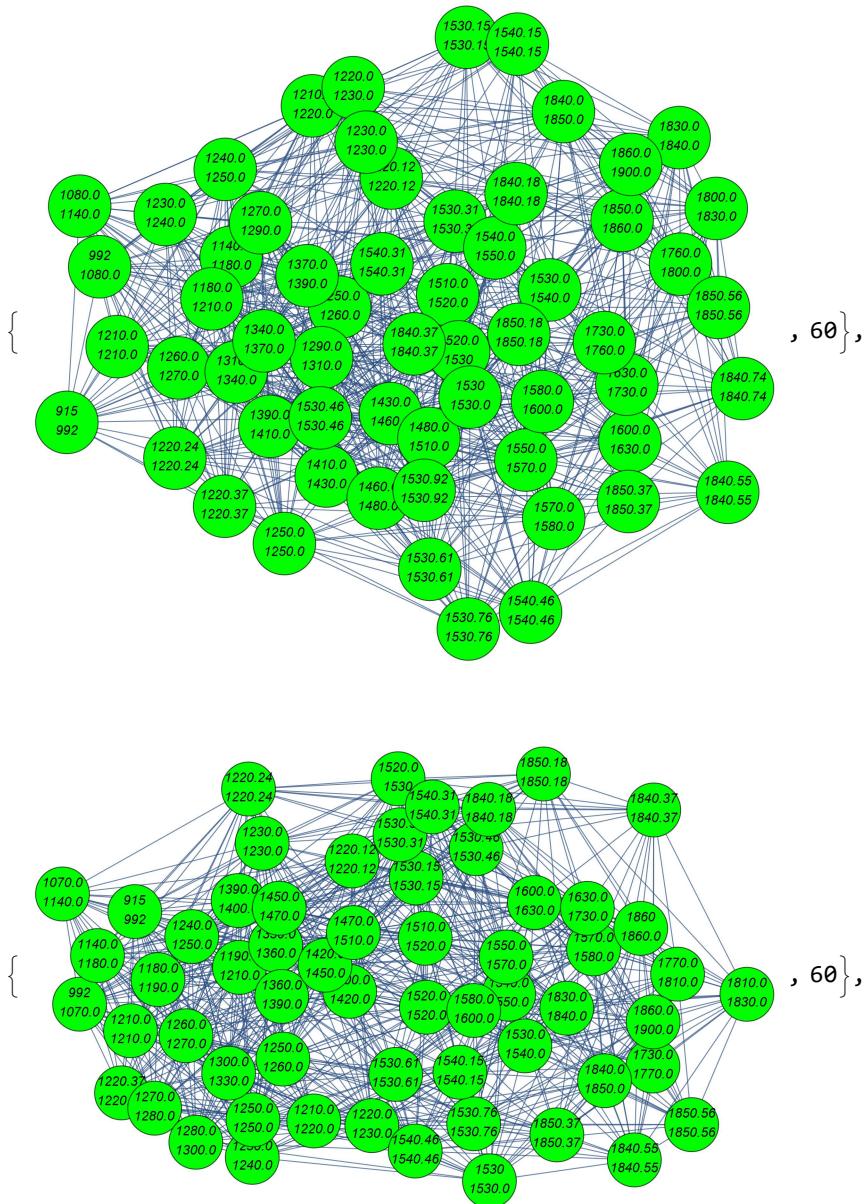
Width Feature

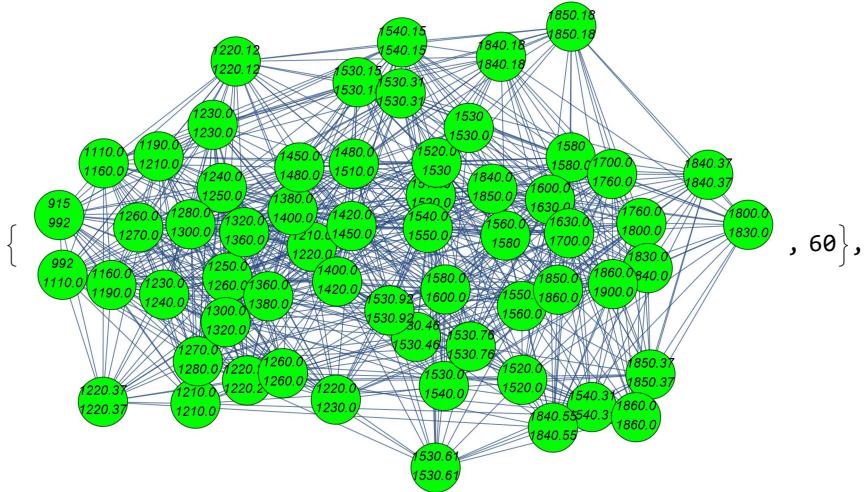
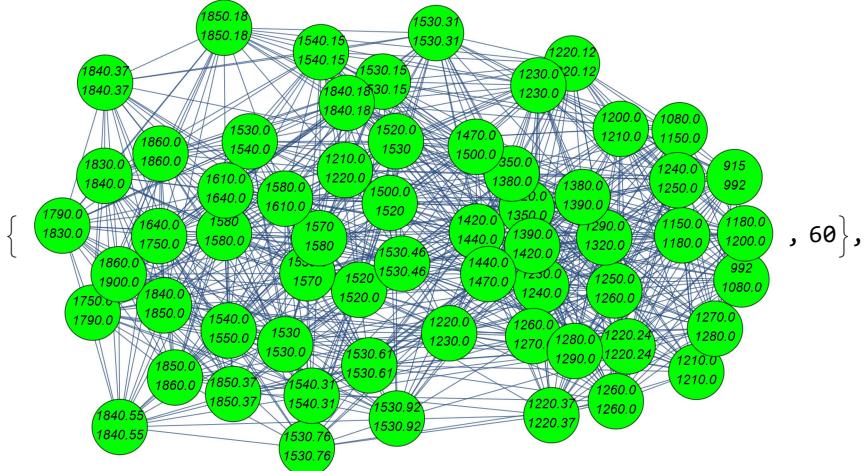
```
In[6]:= AbsoluteTiming[
  widthdataintimewindowsFixedbucket = snetworkdatafdbucketintimewindows [9, 60, 10];]
Out[6]= {2159.36, Null}
```

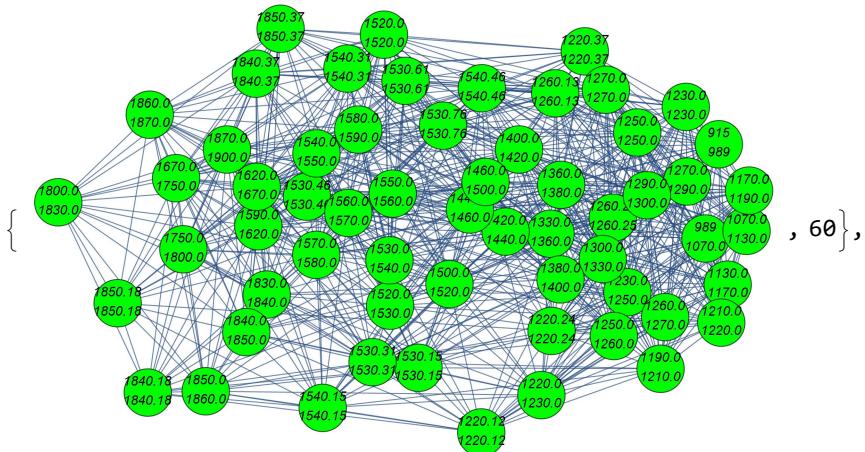
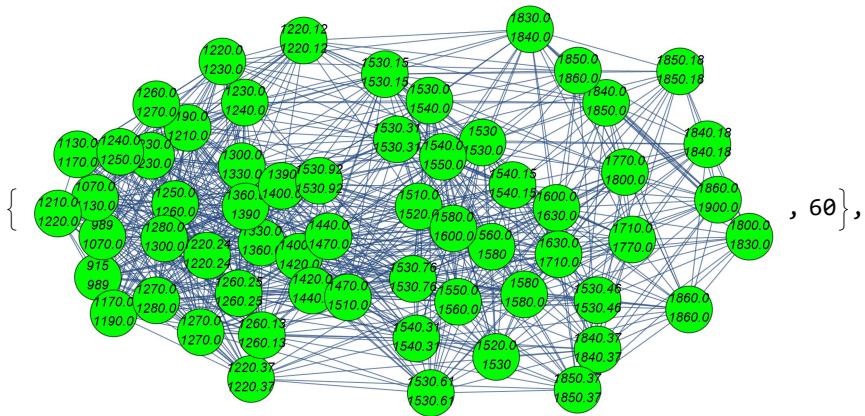
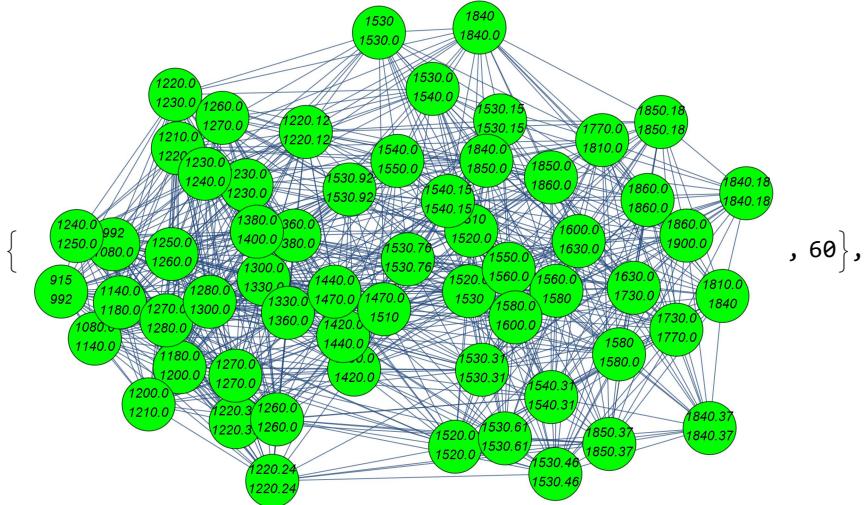
```
In[1]:= graphsandnodenumbers = Table[snetworkgraph[widthdataintimewindowsFixedbucket[[1]][[i]],  
widthdataintimewindowsFixedbucket[[2]][[i]], 1.5, 7, 400, Green], {i, Range@10}];
```

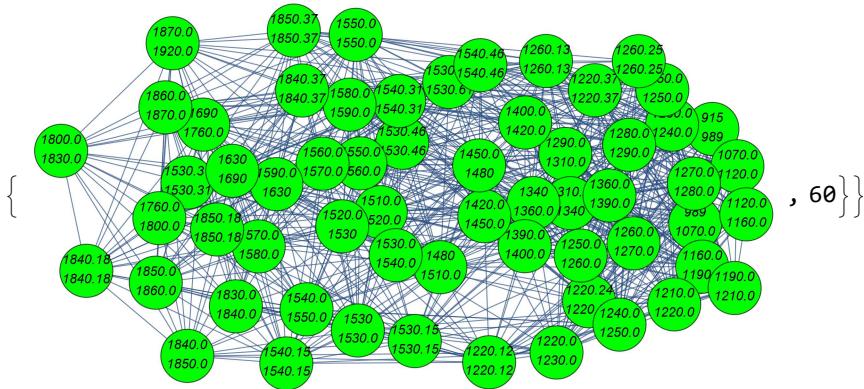
```
In[2]:= graphsandnodenumbers
```



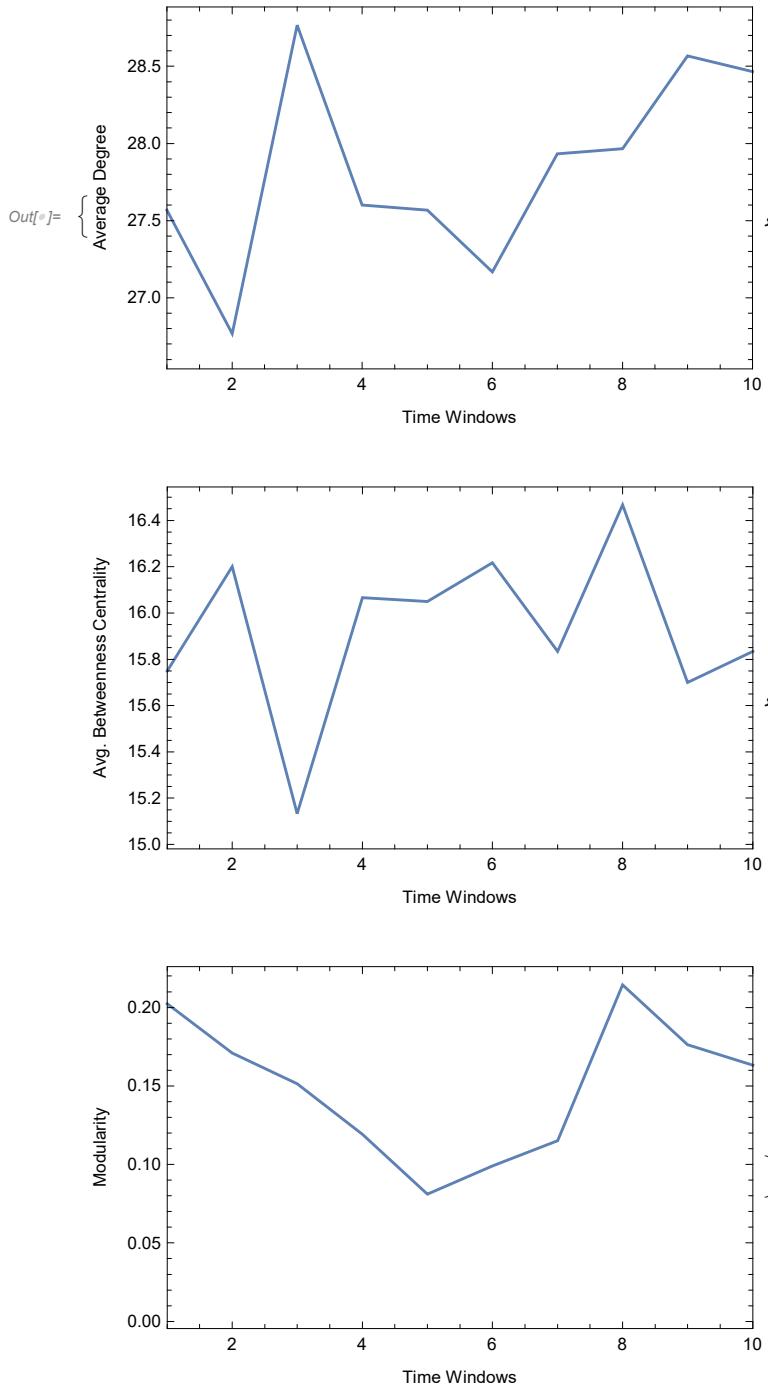








```
In[=]:= ABCvalues = Table[Mean@BetweennessCentrality[graphsandnodenumbers[[i]][[1]]], {i, Length@graphsandnodenumbers}];  
modularityvalues = Table[N@GraphAssortativity[graphsandnodenumbers[[i]][[1]]], {i, Length@graphsandnodenumbers}];  
degreevalues = Table[N@Mean@VertexDegree[graphsandnodenumbers[[i]][[1]]], {i, Length@graphsandnodenumbers}];  
  
In[=]:= {ListLinePlot[Thread[{Range@10, degreevalues}], Frame -> True, FrameLabel -> {"Time Windows", "Average Degree"}, ImageSize -> 350, PlotRange -> {{1, 10}, All}], ListLinePlot[Thread[{Range@10, ABCvalues}], Frame -> True, FrameLabel -> {"Time Windows", "Avg. Betweenness Centrality"}, ImageSize -> 350, PlotRange -> {{1, 10}, All}], ListLinePlot[Thread[{Range@10, modularityvalues}], Frame -> True, FrameLabel -> {"Time Windows", "Modularity"}, ImageSize -> 350, PlotRange -> {{1, 10}, All}]}
```



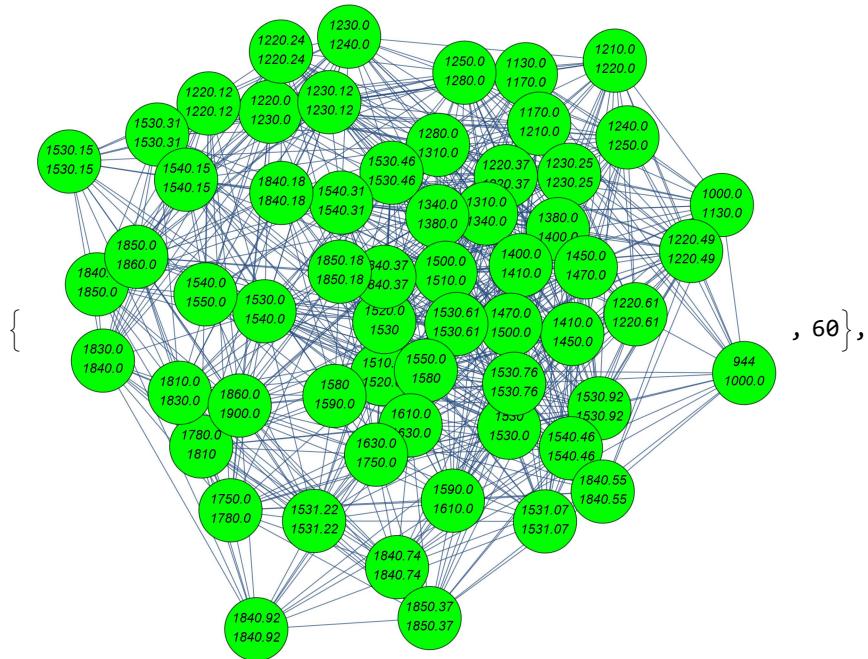
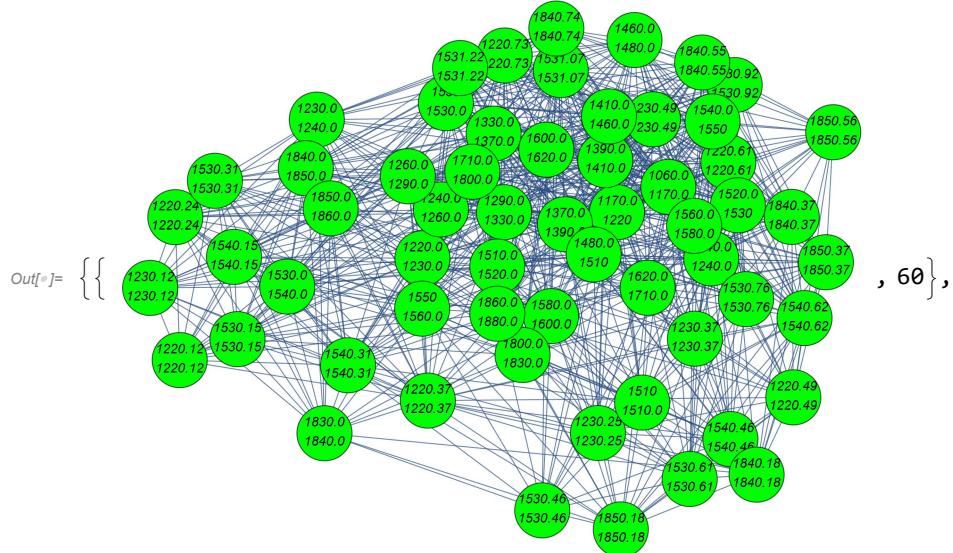
Thickness Feature

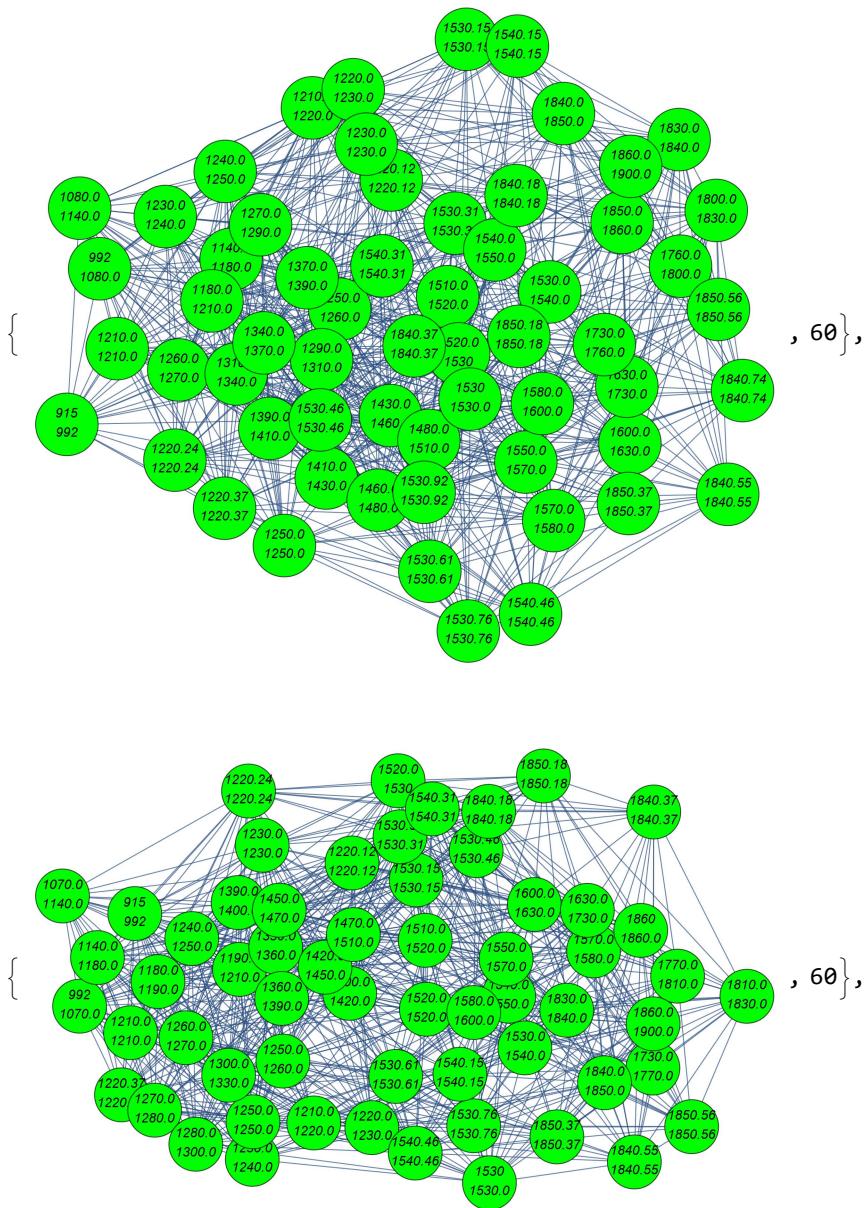
```
In[8]:= AbsoluteTiming[
  widthdataintimewindowsFixedbucket = snetworkdatafdbucketintimewindows[9, 60, 10];
]

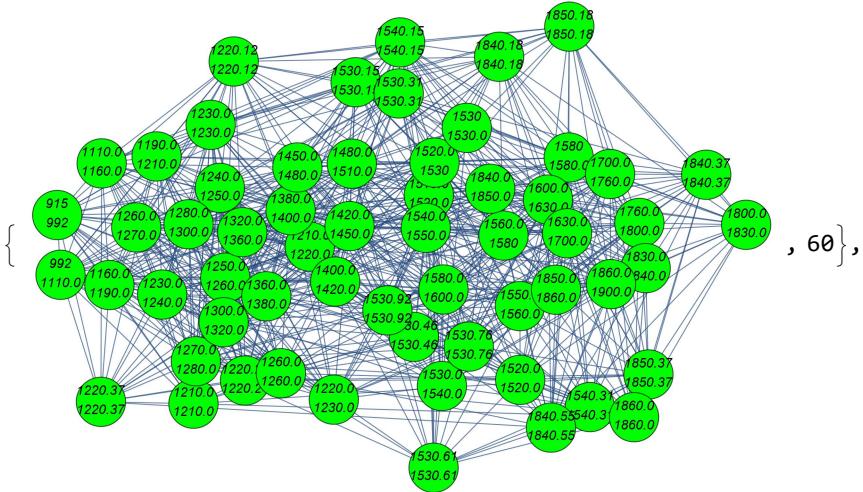
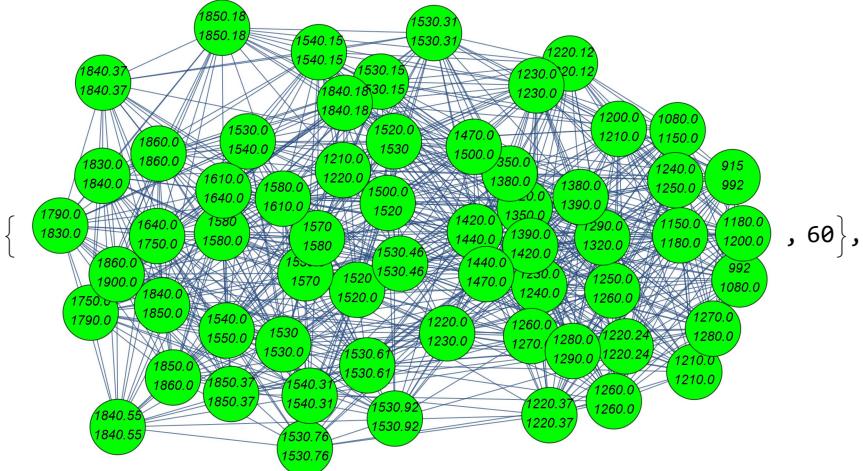
Out[8]= {2159.36, Null}

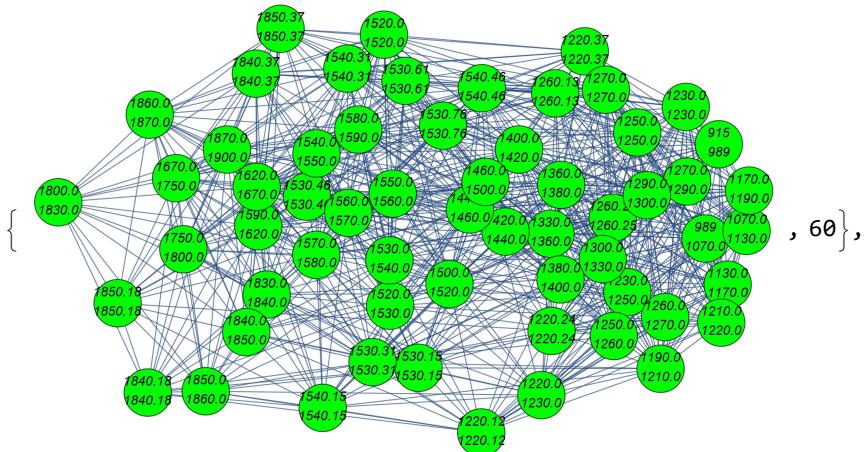
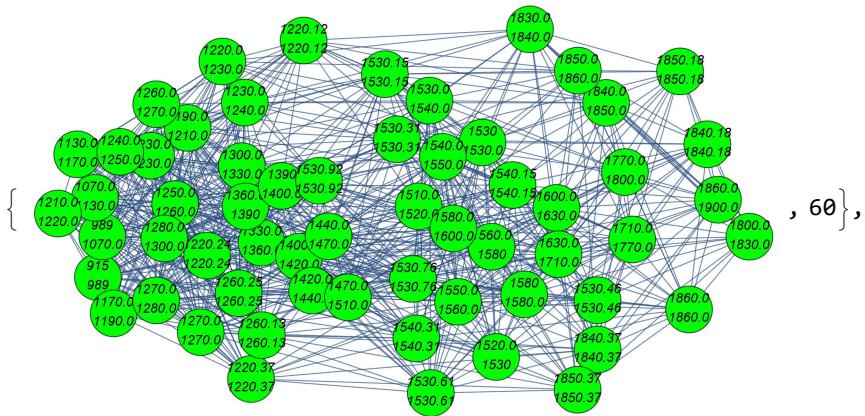
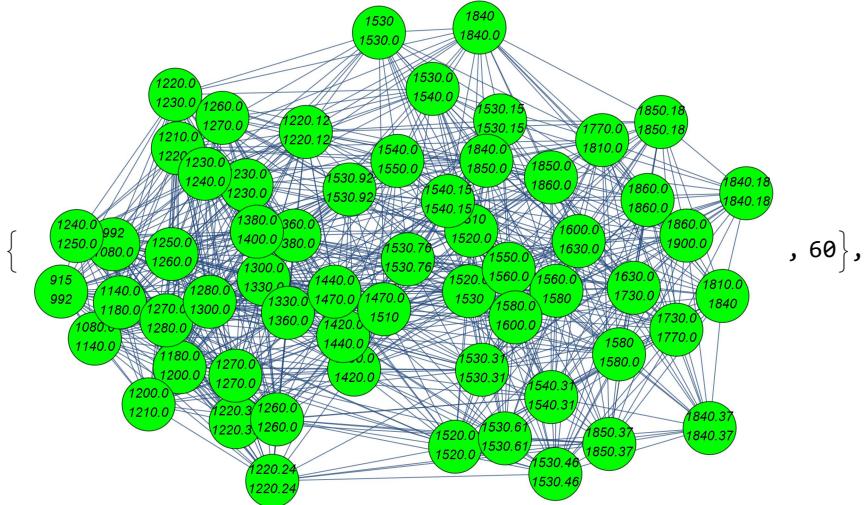
In[9]:= graphsandnodenumbers = Table[snetworkgraph[widthdataintimewindowsFixedbucket[[1]][[i]],
  widthdataintimewindowsFixedbucket[[2]][[i]], 1.5, 7, 400, Green], {i, Range@10}];
```

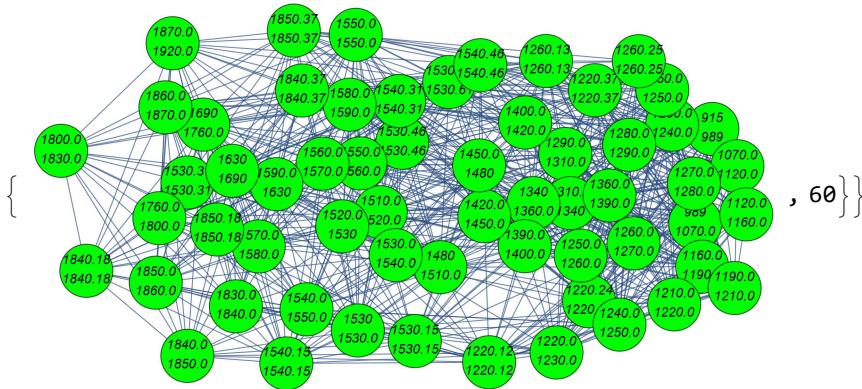
In[1]:= **graphsandnodenumbers**



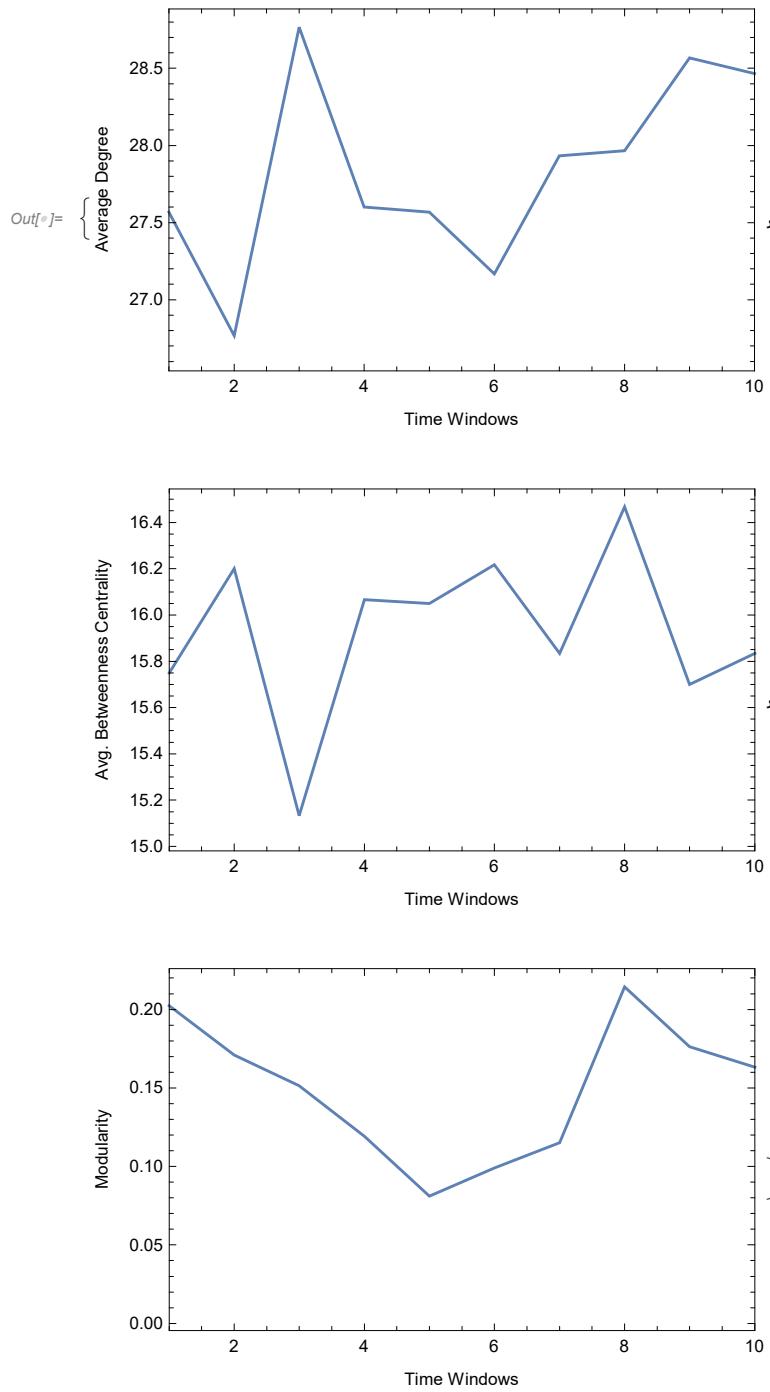








```
In[=]:= ABCvalues = Table[Mean@BetweennessCentrality[graphsandnodenumbers[[i]][[1]]], {i, Length@graphsandnodenumbers}];  
modularityvalues = Table[N@GraphAssortativity[graphsandnodenumbers[[i]][[1]]], {i, Length@graphsandnodenumbers}];  
degreevalues = Table[N@Mean@VertexDegree[graphsandnodenumbers[[i]][[1]]], {i, Length@graphsandnodenumbers}];  
  
In[=]:= {ListLinePlot[Thread[{Range@10, degreevalues}], Frame -> True, FrameLabel -> {"Time Windows", "Average Degree"}, ImageSize -> 350, PlotRange -> {{1, 10}, All}], ListLinePlot[Thread[{Range@10, ABCvalues}], Frame -> True, FrameLabel -> {"Time Windows", "Avg. Betweenness Centrality"}, ImageSize -> 350, PlotRange -> {{1, 10}, All}], ListLinePlot[Thread[{Range@10, modularityvalues}], Frame -> True, FrameLabel -> {"Time Windows", "Modularity"}, ImageSize -> 350, PlotRange -> {{1, 10}, All}]}
```

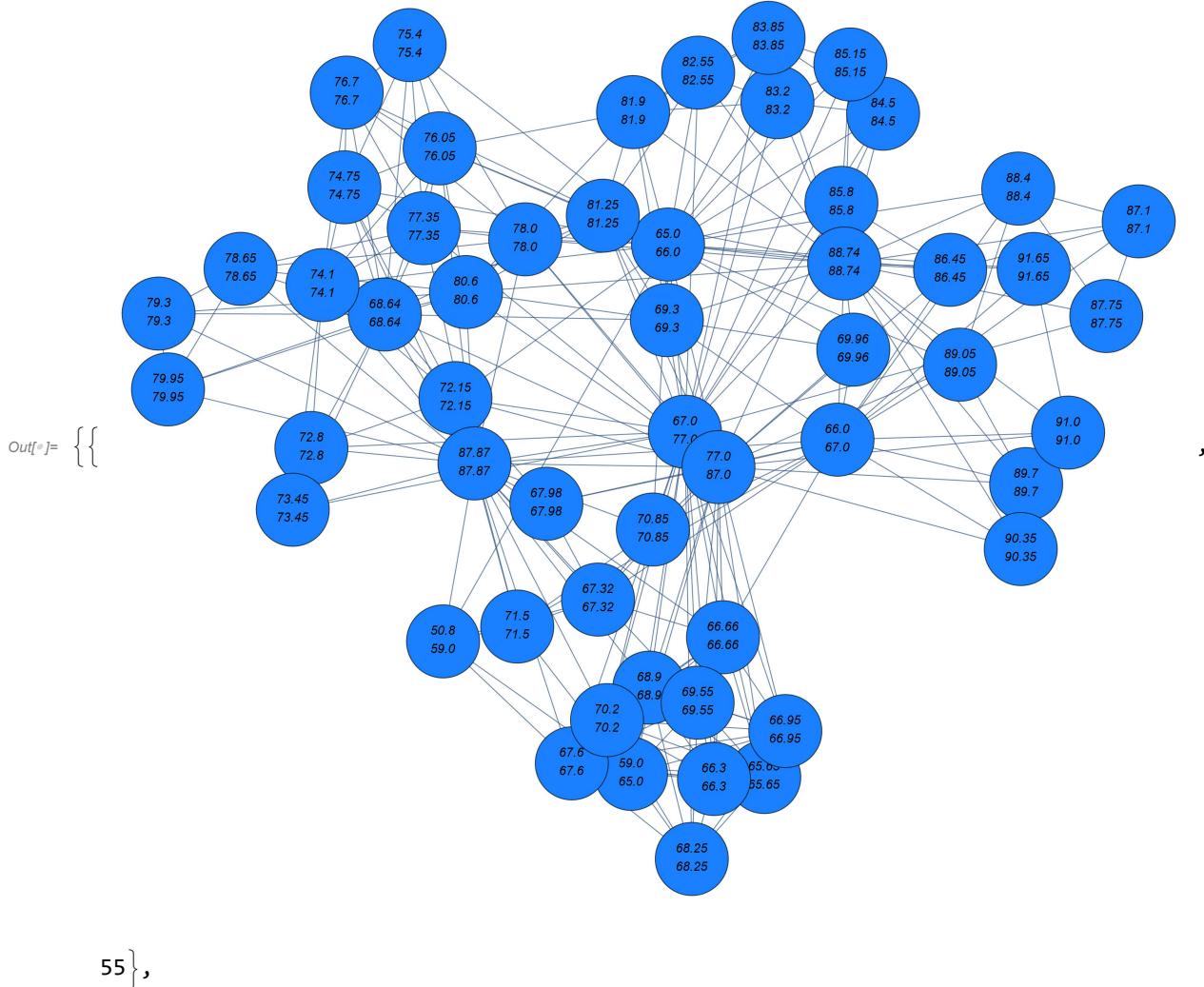


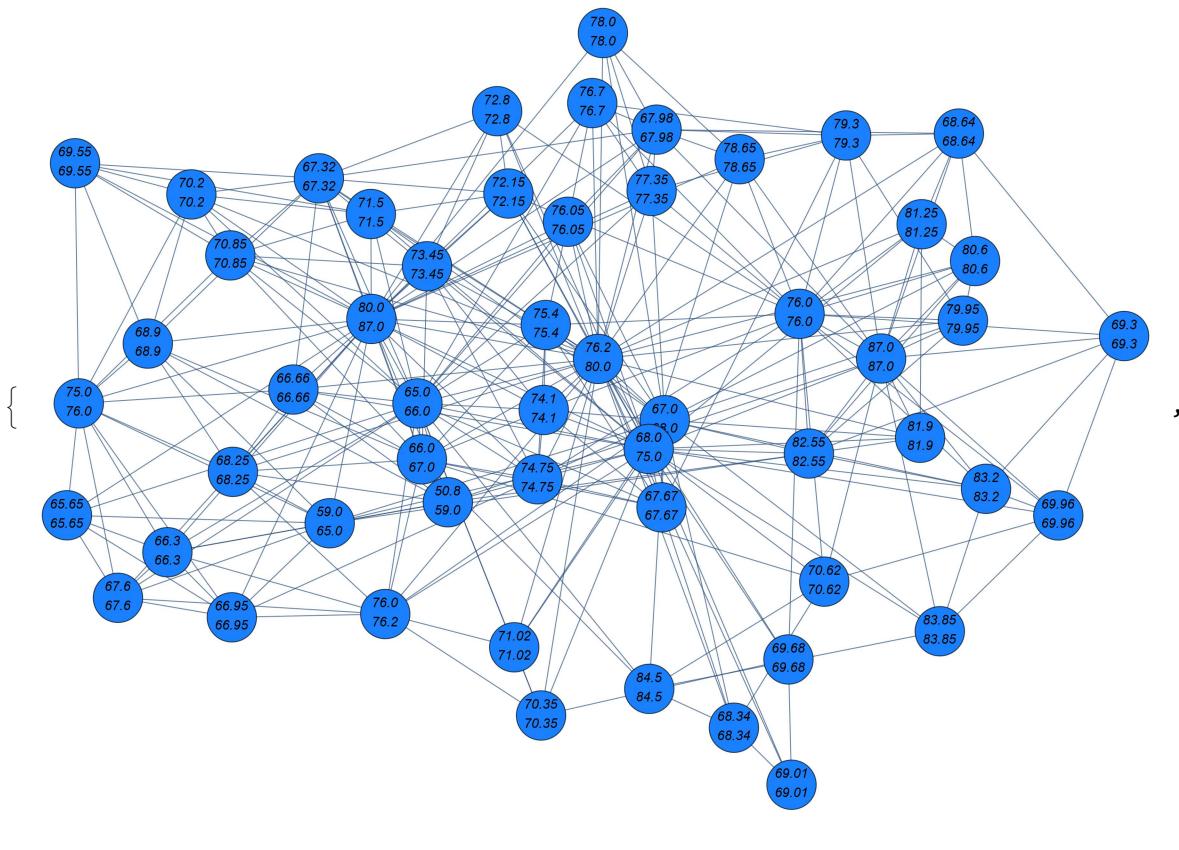
Thickness Feature

```
In[6]:= AbsoluteTiming [thicknessdatawithfdbucketintimewindows =
snetworkdatafdbucketintimewindows [10, 55, 10];]
Out[6]= {3701.96, Null}
```

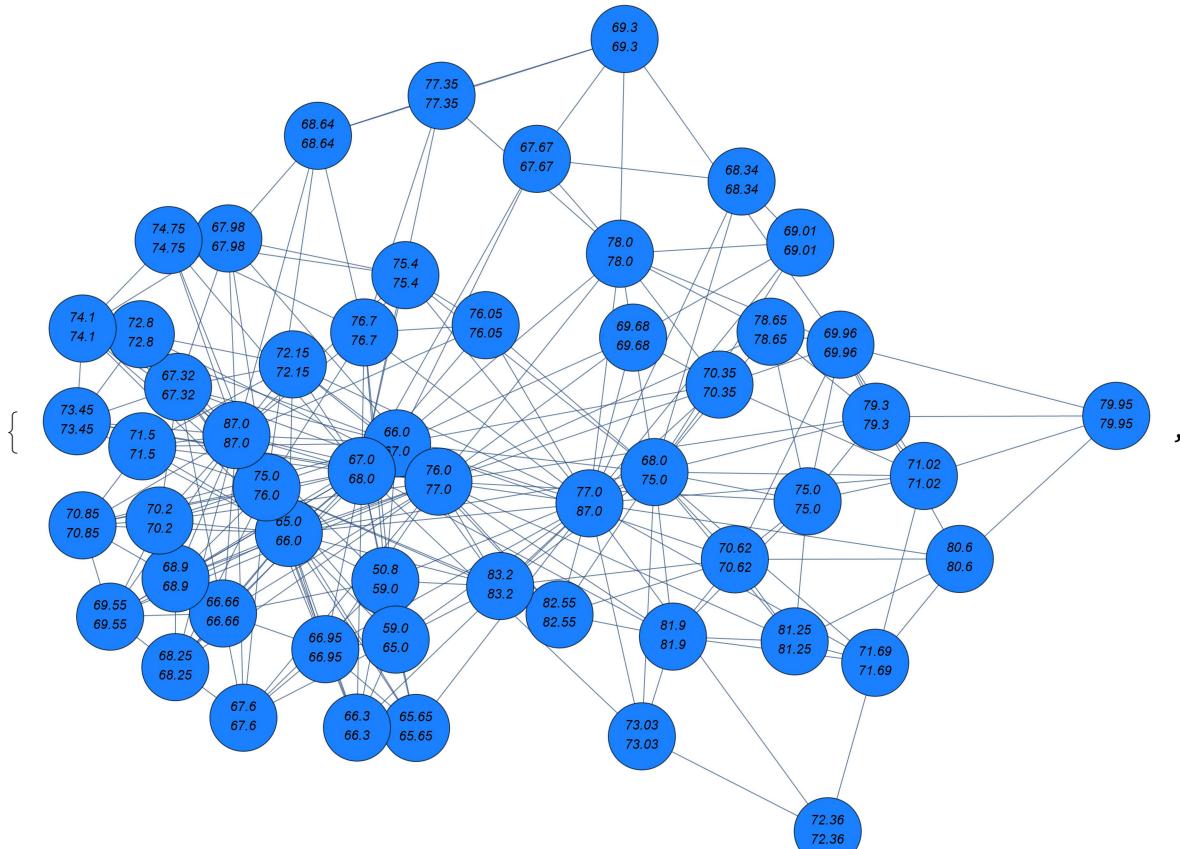
```
In[1]:= graphsandnodenumbers =
Table[snetworkgraph[thicknessdatawithfxdbucketintimewindows[[1]][[i]],
thicknessdatawithfxdbucketintimewindows[[2]][[i]],
1.5, 7, 600, RGBColor[0.1, 0.5, 1.]], {i, Range@10}];
```

```
In[2]:= graphsandnodenumbers
```

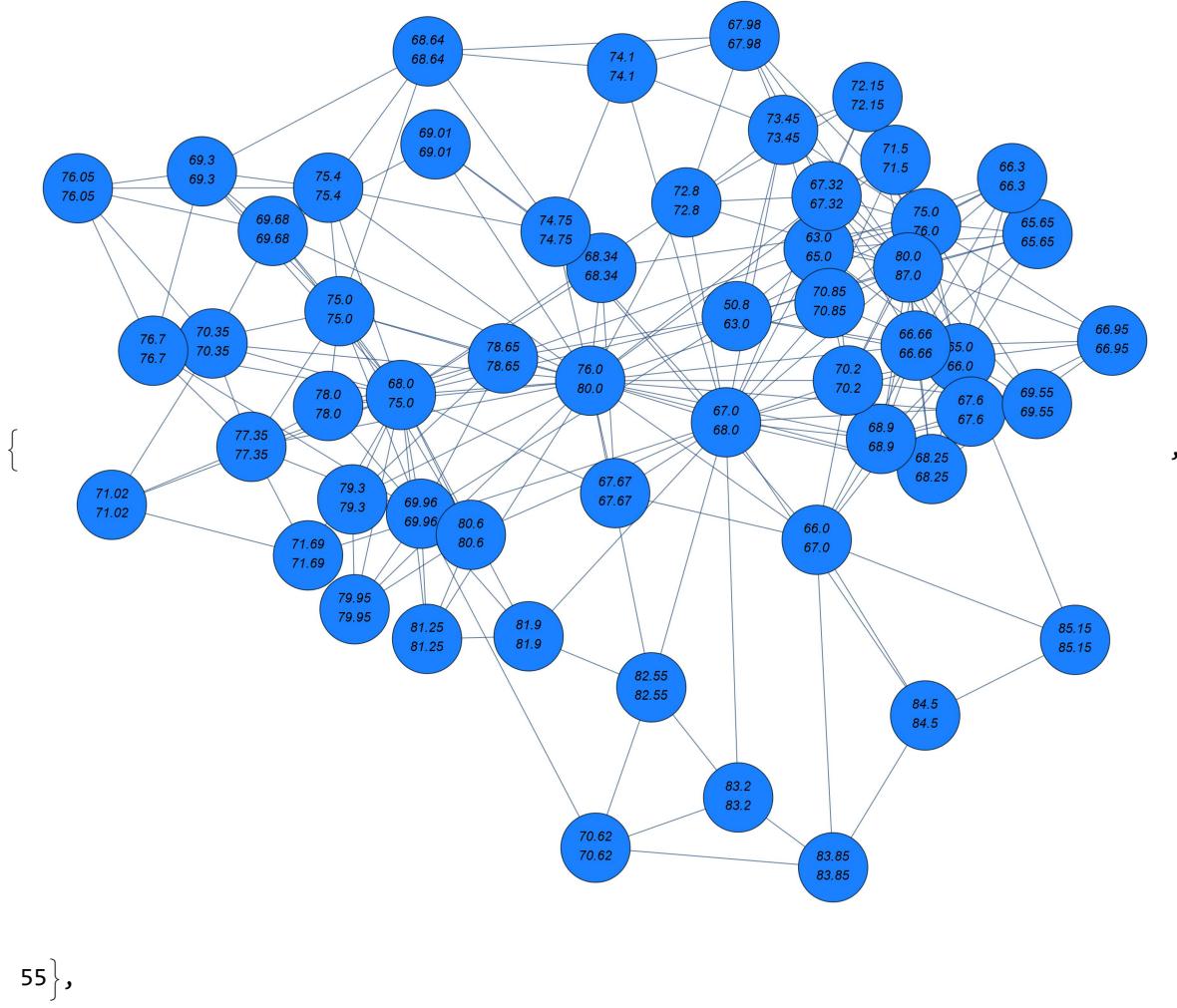


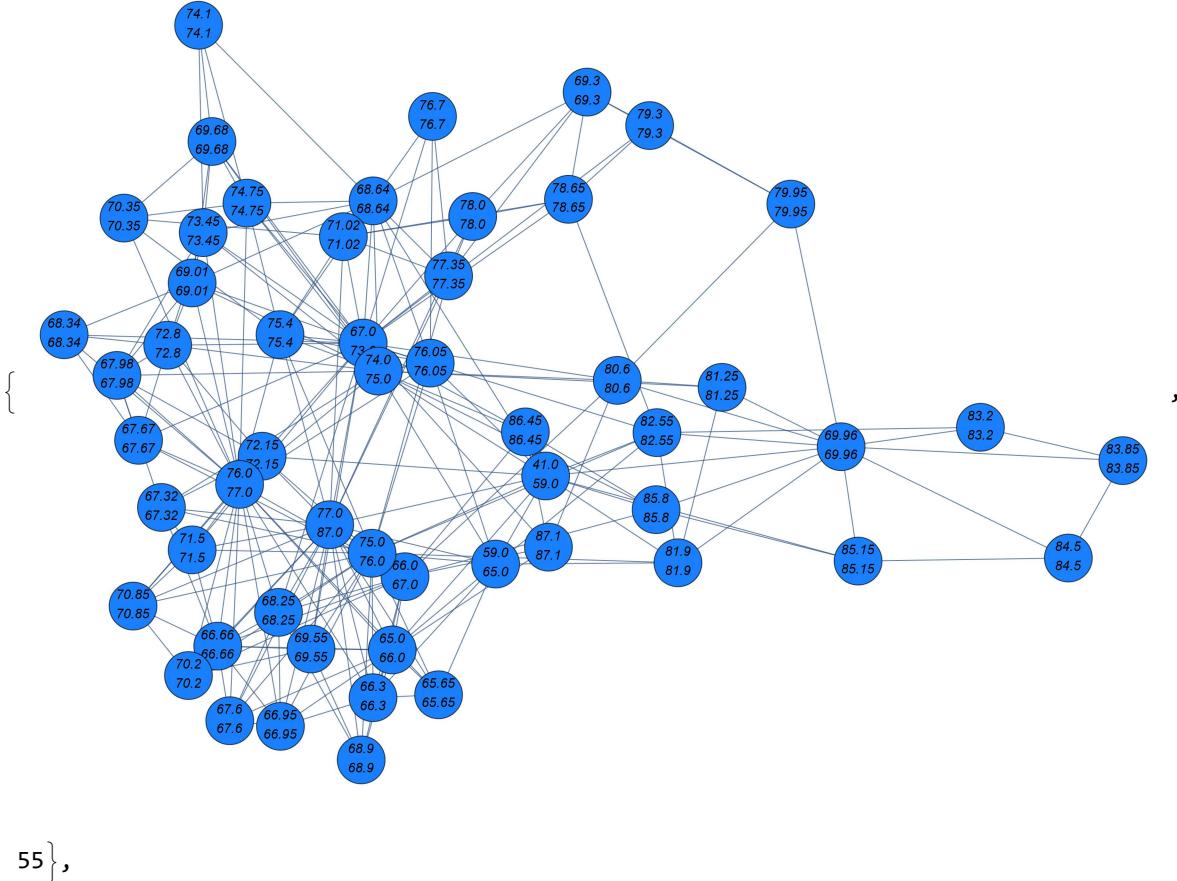


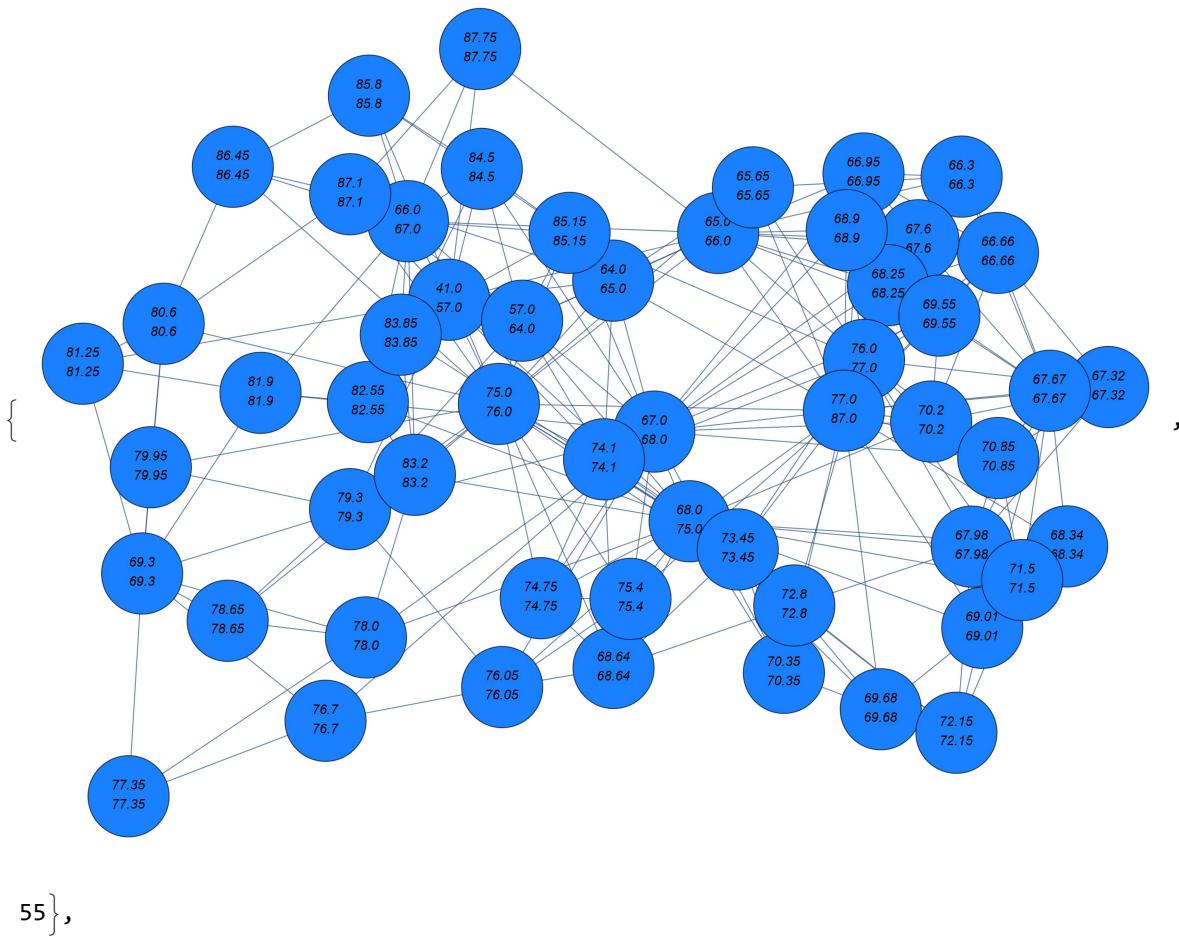
55},

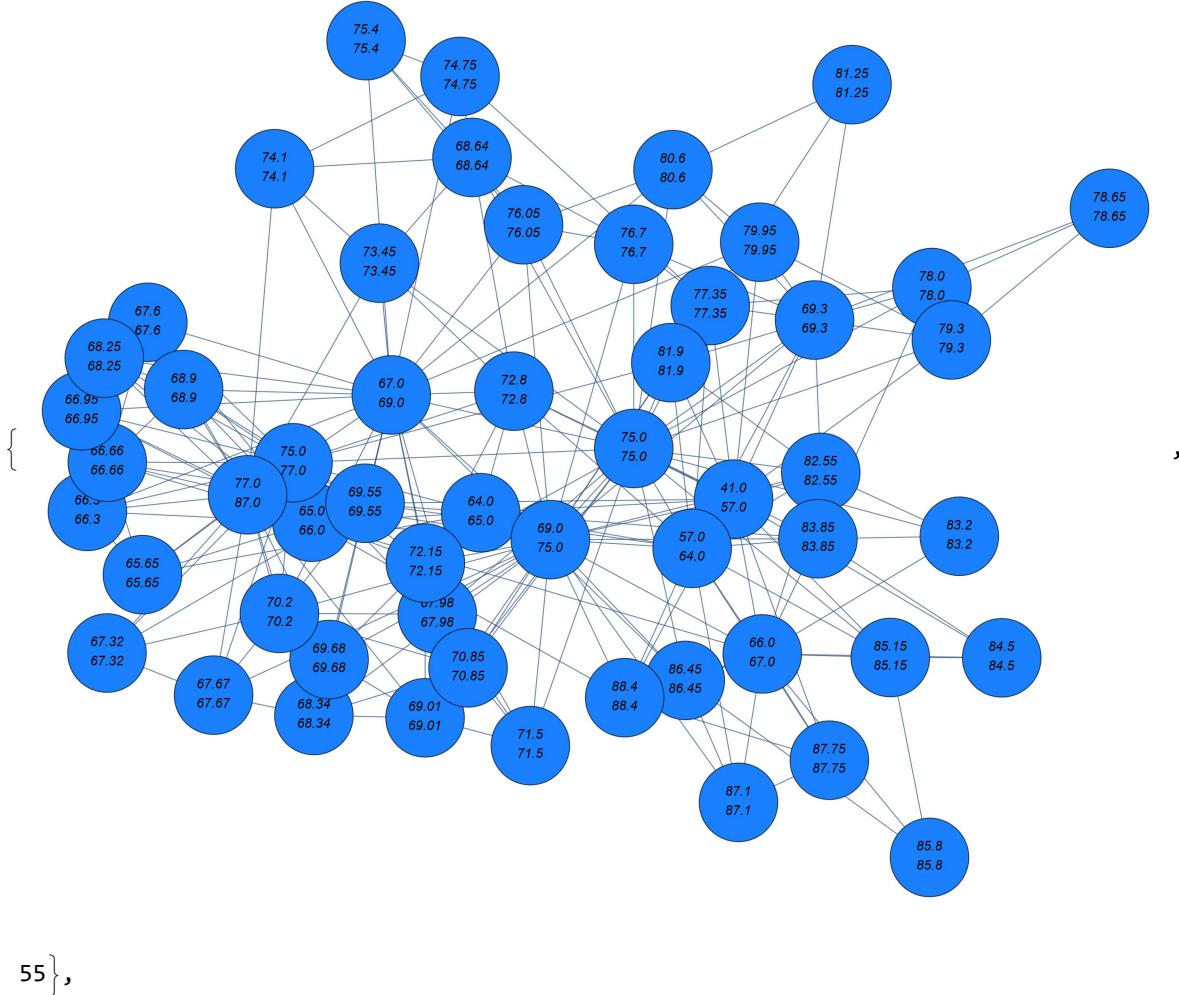


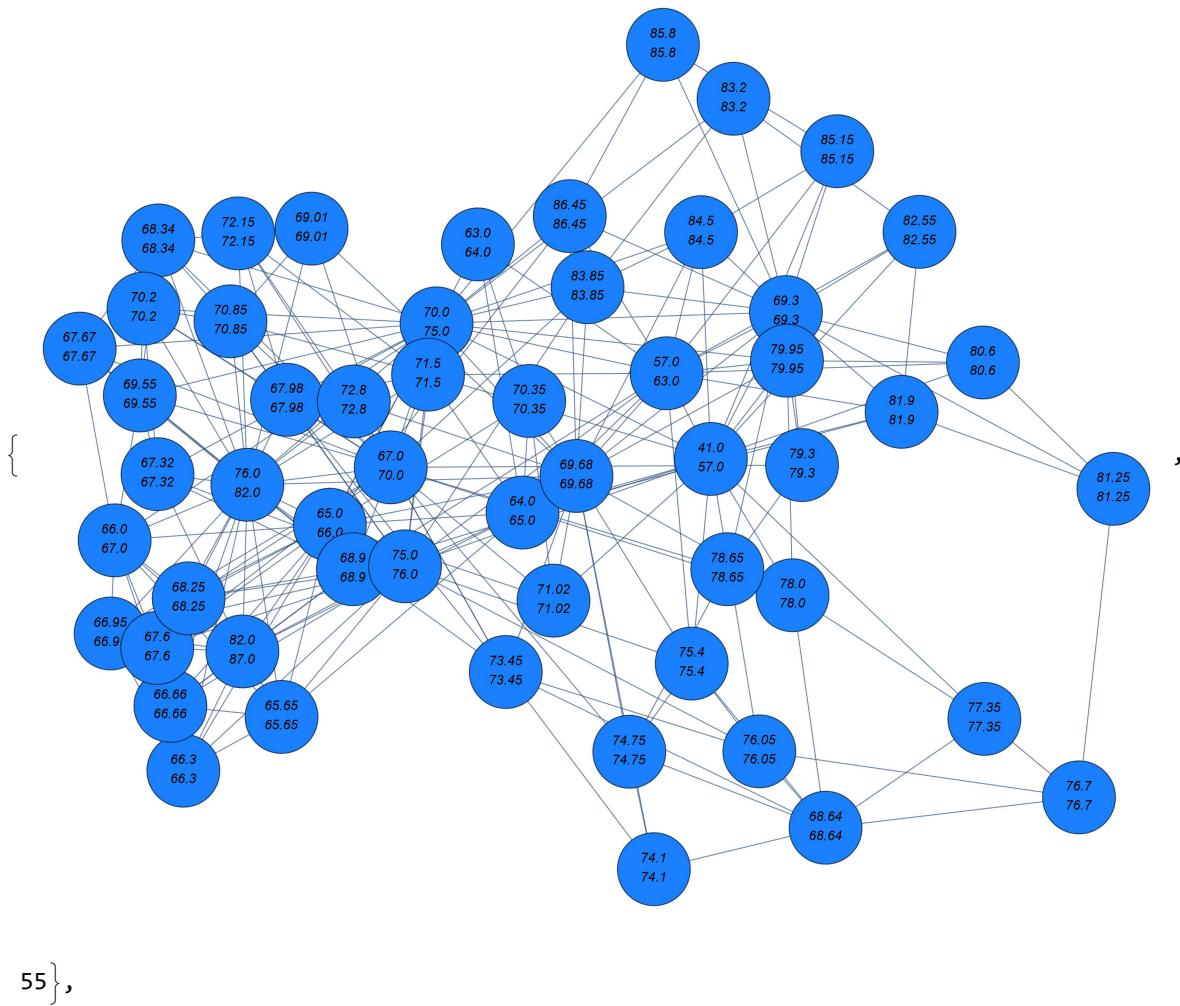
55},

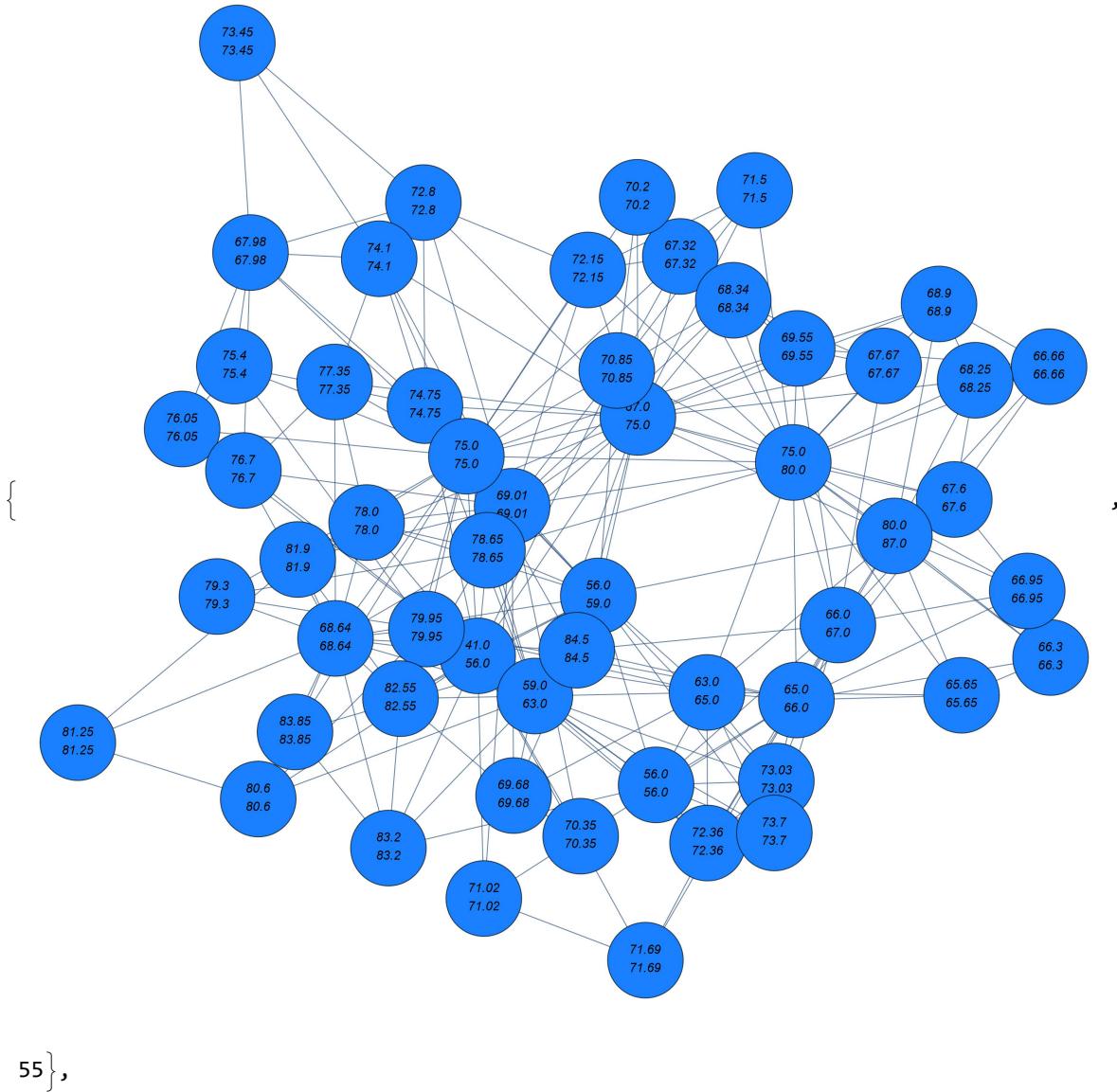


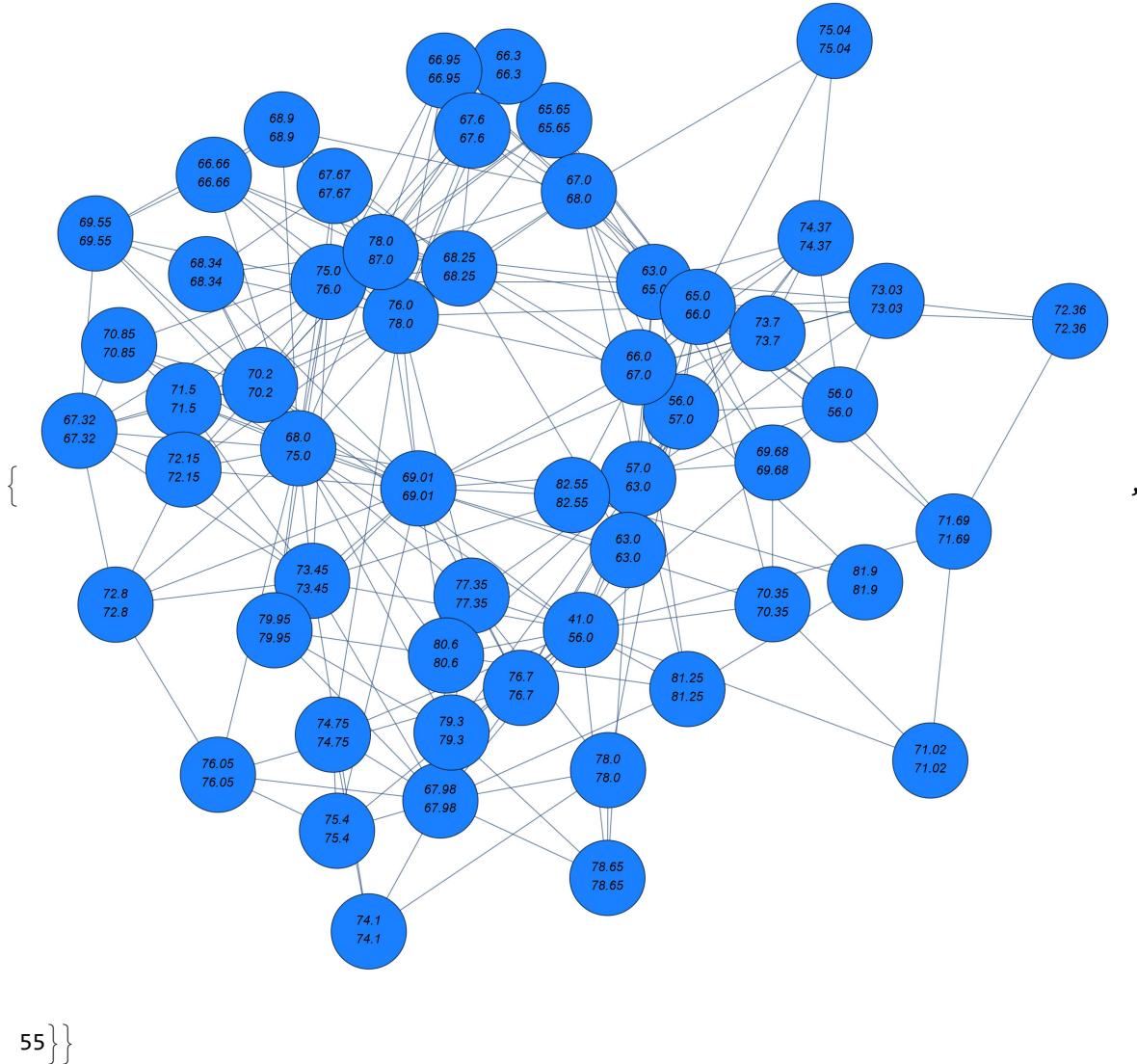












```

In[=]:= correlationvaluesthroughwindowsspearman =
Table[correlationfunction[i, 1], {i, graphsandnodenumbers[[All, 1]]}];

correlationvaluesthroughwindowspearson =
Table[correlationfunction[i, 2], {i, graphsandnodenumbers[[All, 1]]}];

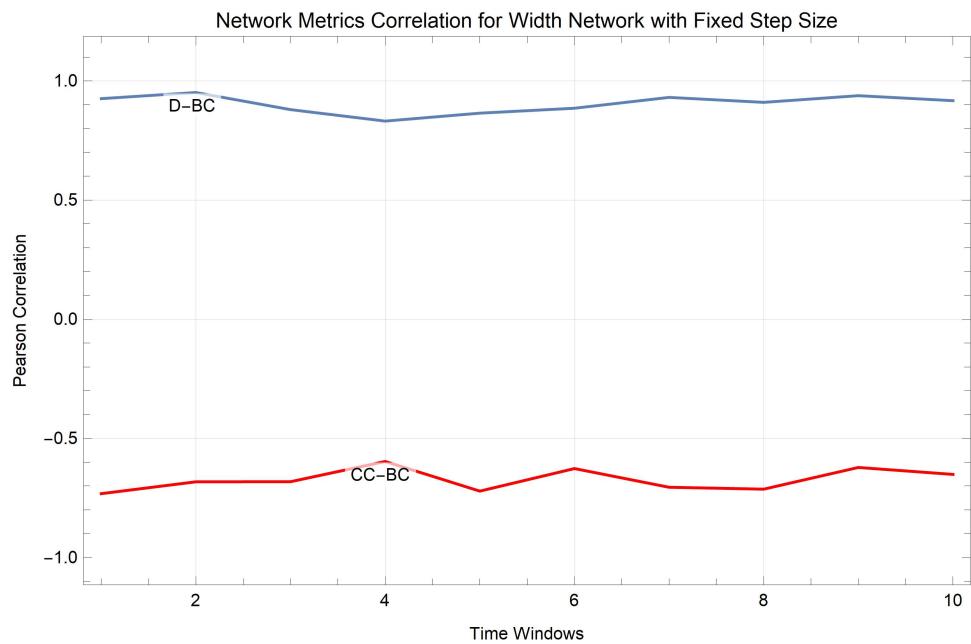
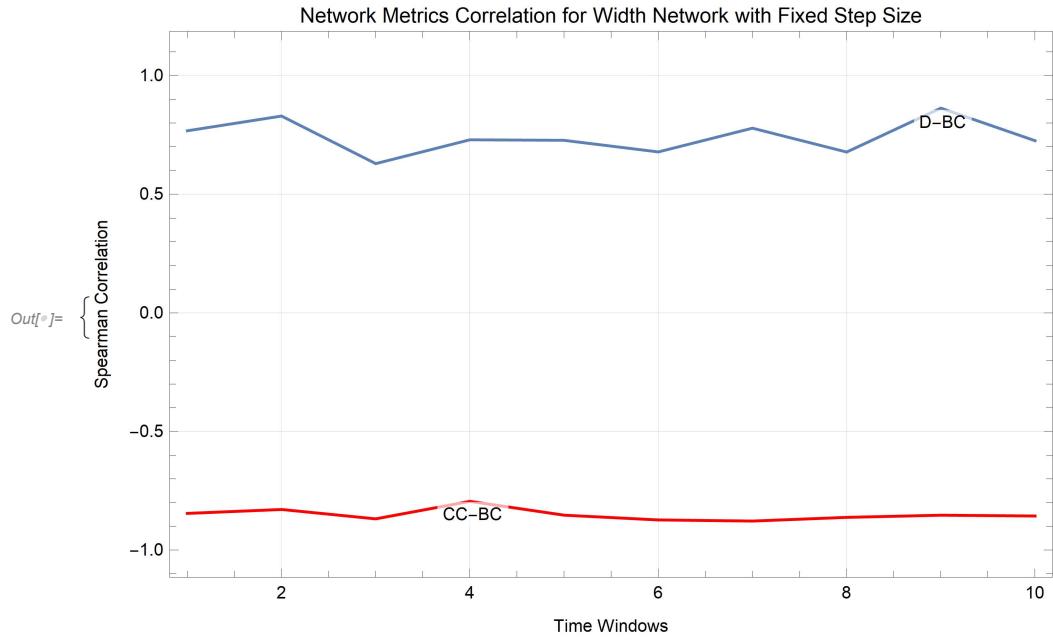
In[=]:= correlationvaluesthroughwindowsspearman
correlationvaluesthroughwindowspearson

Out[=]= {{0.767914, -0.845664}, {0.829948, -0.829075},
{0.629385, -0.868622}, {0.729863, -0.79477}, {0.727612, -0.853122},
{0.678766, -0.873149}, {0.778866, -0.877886},
{0.678203, -0.862349}, {0.863328, -0.853203}, {0.726022, -0.85655} }

```

```
Out[]= {{0.925784, -0.731837}, {0.951473, -0.682085},  
{0.879689, -0.681712}, {0.831552, -0.596759},  
{0.864873, -0.721212}, {0.885541, -0.626575}, {0.931057, -0.705016},  
{0.910229, -0.712981}, {0.938219, -0.621927}, {0.917204, -0.651067}}
```

```
In[]:= Show[ListPlot[Transpose[  
{Range@10, Table[correlationvaluesthroughwindowsspearman[[j, 1]], {j, 1, 10}]}]],  
Joined → True, PlotLabels → Placed[{"D-BC"}, Top], Frame → True,  
FrameLabel → {"Time Windows", "Spearman Correlation"}], ListPlot[Transpose[  
{Range@10, Table[correlationvaluesthroughwindowsspearman[[j, 2]], {j, 1, 10}]}]],  
Joined → True, PlotLabels → Placed[{"CC-BC"}, Top], PlotStyle → Red,  
Frame → True, FrameLabel → {"Time Windows", "Spearman Correlation"}],  
PlotRange → {All, {-1, 1}}, Axes → False, ImageSize → 500, GridLines → Automatic,  
PlotLabel → "Network Metrics Correlation for Width Network with Fixed Step Size"],  
Show[ListPlot[Transpose[  
{Range@10, Table[correlationvaluesthroughwindowspearson[[j, 1]], {j, 1, 10}]}]],  
Joined → True, PlotLabels → Placed[{"D-BC"}, Top], Frame → True,  
FrameLabel → {"Time Windows", "Pearson Correlation"}], ListPlot[Transpose[  
{Range@10, Table[correlationvaluesthroughwindowspearson[[j, 2]], {j, 1, 10}]}]],  
Joined → True, PlotLabels → Placed[{"CC-BC"}, Top], PlotStyle → Red,  
Frame → True, FrameLabel → {"Time Windows", "Pearson Correlation"}],  
PlotRange → {All, {-1, 1}}, Axes → False, ImageSize → 500, GridLines → Automatic,  
PlotLabel → "Network Metrics Correlation for Width Network with Fixed Step Size"]]
```



```
In[6]:= ZscoreDeBCspearman = Transpose[{Range[1, 10],  
Table[randomnessfunction[i, 1], {i, graphsandnodenumbers[[All, 1]]}][[All, 1]]}]
```

```
Out[6]= {{1, -7.61033}, {2, -4.95744}, {3, -14.6055}, {4, -8.65119}, {5, -8.74502},  
{6, -10.2952}, {7, -6.73297}, {8, -10.547}, {9, -3.03971}, {10, -9.2238}}
```

```
In[7]:= ZscoreCCBCspearman = Transpose[{Range[1, 10],  
Table[randomnessfunction[i, 1], {i, graphsandnodenumbers[[All, 1]]}][[All, 2]]}]
```

```
Out[7]= {{1, -4.65096}, {2, -4.52137}, {3, -4.92712}, {4, -4.61019}, {5, -5.03007},  
{6, -4.87373}, {7, -4.99681}, {8, -5.07192}, {9, -4.9179}, {10, -4.90242}}
```

```

In[=]:= ZscoreDeBCpearson = Transpose[{Range[1, 10],
Table[randomnessfunction[i, 2], {i, graphsandnodenumbers[[All, 1]]}][[All, 1]]}]

Out[=]= {{1, -0.0593356}, {2, 1.15447}, {3, -2.19479}, {4, -3.58037}, {5, -2.2706},
{6, -1.51536}, {7, 0.267788}, {8, -0.603555}, {9, 0.515586}, {10, -0.296038} }

In[=]:= ZscoreCCBCpearson = Transpose[{Range[1, 10],
Table[randomnessfunction[i, 2], {i, graphsandnodenumbers[[All, 1]]}][[All, 2]]}]

Out[=]= {{1, -4.21661}, {2, -3.70766}, {3, -3.88207}, {4, -3.5312}, {5, -4.53877},
{6, -3.59823}, {7, -4.27859}, {8, -4.46446}, {9, -3.61586}, {10, -3.82381} }

In[=]:= {Show[ListPlot[ZscoreDeBCspearman, Joined → True, PlotLabels → Placed[{"D-BC"}, Top],
Frame → True, FrameLabel → {"Time Windows", "Z-Score (Spearman)"}],
ListPlot[ZscoreCCBCspearman, Joined → True, PlotLabels → Placed[{"CC-BC"}, Top],
PlotStyle → Red, Frame → True, FrameLabel → {"Time Windows", "Z-Score (Spearman)"}],
PlotRange → {All, {-40, 0}}, Axes → False, ImageSize → 500,
GridLines → Automatic, PlotLabel →
"Z-Score Deviation on Different Time Windows for Width Network with Fixed Step Size"],
Show[ListPlot[ZscoreDeBCpearson, Joined → True, PlotLabels → Placed[{"D-BC"}, Top],
Frame → True, FrameLabel → {"Time Windows", "Z-Score (Pearson)"}],
ListPlot[ZscoreCCBCpearson, Joined → True, PlotLabels → Placed[{"CC-BC"}, Top],
PlotStyle → Red, Frame → True, FrameLabel → {"Time Windows", "Z-Score (Pearson)"}],
PlotRange → {All, {-40, 0}}, Axes → False, ImageSize → 500,
GridLines → Automatic, PlotLabel →
"Z-Score Deviation on Different Time Windows for Width Network with Fixed Step Size"]}

```

