```
(* Mathematica Notebook demonstrating usage of DPG packages. *)
(* Created in Mathematica 12.0 *)
(* :Author: Shubha Raj Kharel *)
```

In[•]:=
```
SetDirectory[NotebookDirectory[]];
```

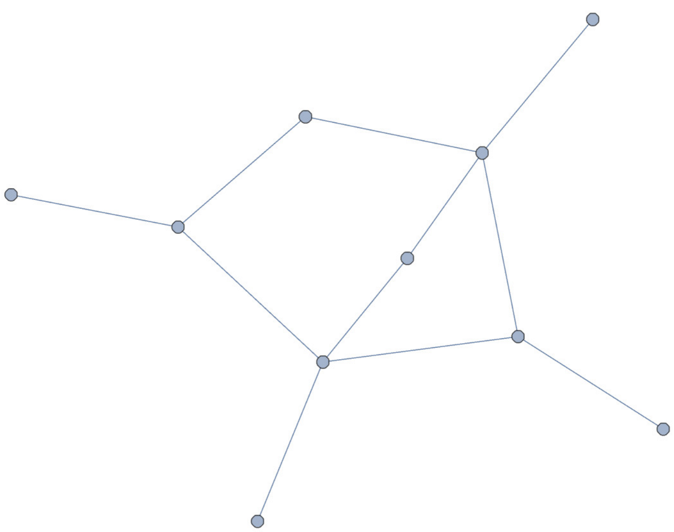
Degree Preserving Network Growth (DPG)

Grow a network with DPG process

In[•]:=
```
Needs["DPG`"]
seedGraph = 
```


```
;
degreeSequence = {1, 2, 2, 3 , 3, 4, 4};
{finalG, phantomV} = DPGrow[seedGraph, degreeSequence];
Graph[finalG, GraphLayout → "SpringElectricalEmbedding"]
```

Out[•]=



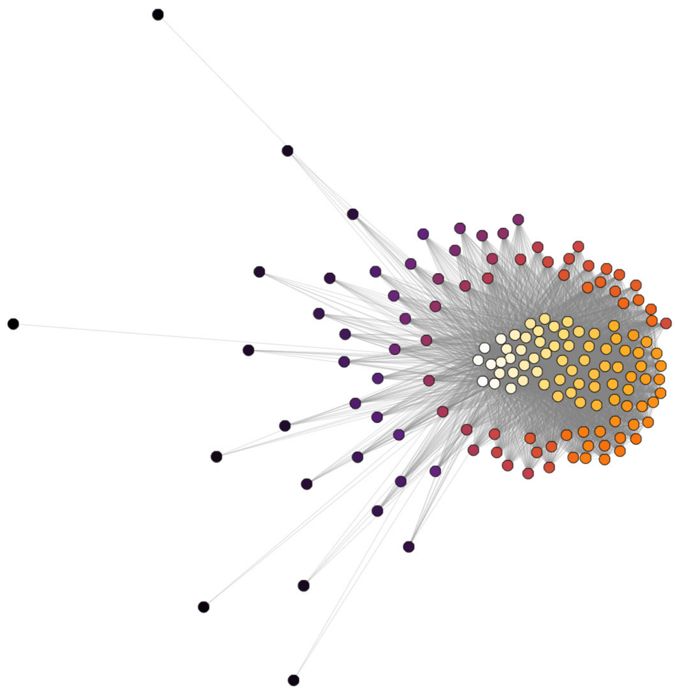
DPG models

In[•]:=
```
Needs["DPGModels`"];
```

MaxDPG

In[•]:=
```
(*Grow an sigle edge by adding 150 nodes through maxDPG process.*)
{g, phantomV} = maxDPG[CompleteGraph[2], 150];

Graph[g, GraphLayout -> "SpringElectricalEmbedding"
    , VertexStyle -> Table[i -> ColorData["SunsetColors"][i / VertexCount@g], {i, VertexList@g}]
    , EdgeStyle -> Opacity[0.2, Gray]]
```

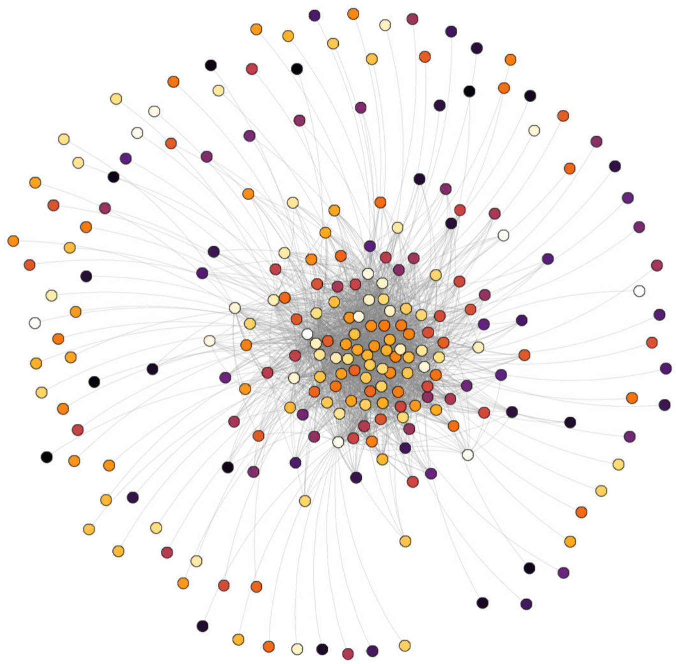
Out[•]=



RndDPG

In[∘]:=
```
{g, newPhantomV} = rndDPG[CompleteGraph[2], 150];

Graph[g, GraphLayout → "GravityEmbedding"
    , VertexStyle -> Table[i → ColorData["SunsetColors"][i / VertexCount@g], {i, VertexList@g}]
    , EdgeStyle → Opacity[0.2, Gray]]
```

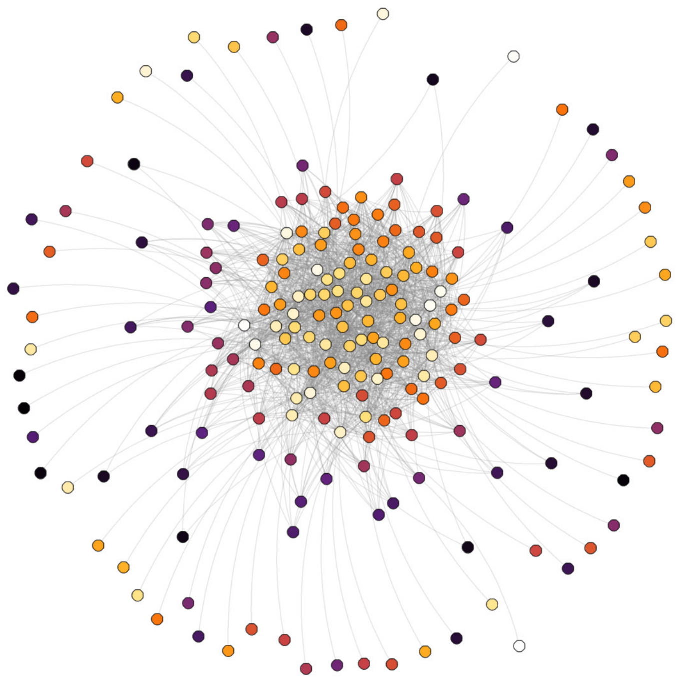
Out[∘]=



LinearDPG

In[•]:=
```
{g, newPhantomV} = linearDPG[CompleteGraph[2], 150, 0.3];

Graph[g, GraphLayout → "GravityEmbedding"
    , VertexStyle -> Table[i → ColorData["SunsetColors"][i / VertexCount@g], {i, VertexList@g}]
    , EdgeStyle → Opacity[0.2, Gray]]
```

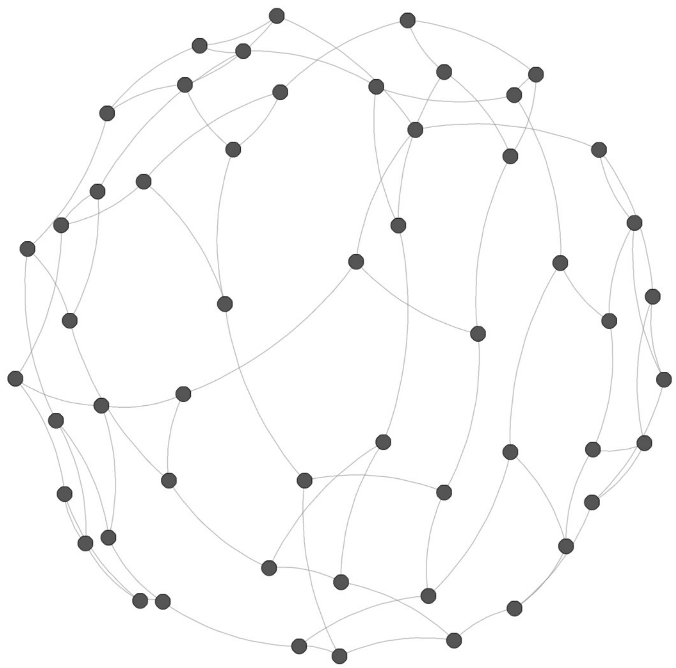
Out[•]=



Regular DPG

In[•]:=
```
{g, newPhantomV} = regularDPG[CompleteGraph[4], 50, 3];

Graph[g, GraphLayout → "GravityEmbedding", VertexStyle → Darker@Gray, EdgeStyle → Opacity[0.5, Gray]]
```

Out[•]=

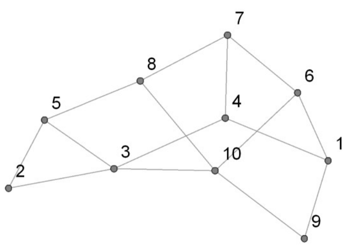


Inverse DPG (Degree preserving reduction)

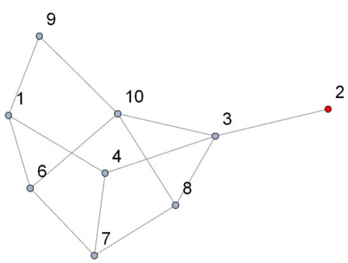
Removes vertices for graph using inverse DPG process

In[•]:=
```
Get["InvDPG`"];

g = RandomGraph[{10, 15}];

(*Reap stores intermediate state of graph during inverser DPG process*)
{g0, {gList}} = Reap@inverseDPG[g, Infinity];

(*Print all inverse DPG step. Red nodes have phantom neighbour.*)
TableForm@gList
```

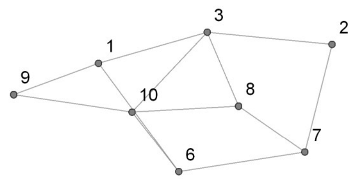
Out[•]//TableForm=



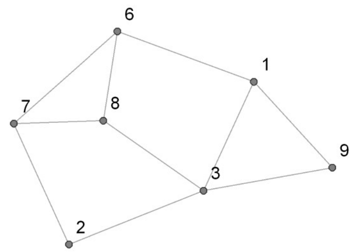

```
Removing 5...
```



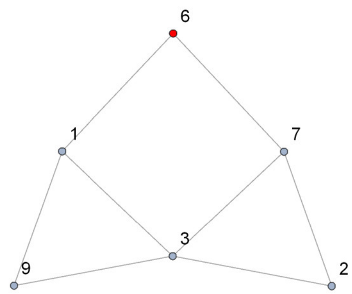

```
Removing 4...
```



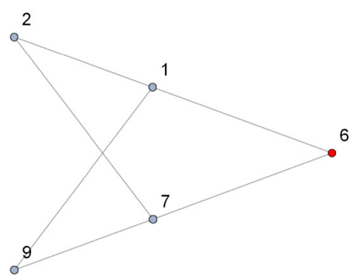
Removing 10...



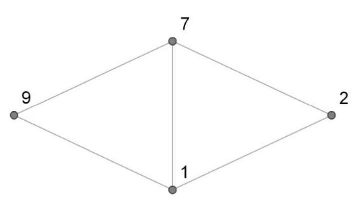
Removing 8...



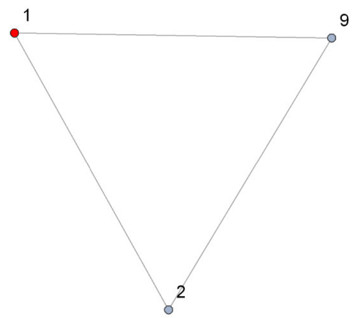
Removing 3...



Removing 6...



Removing 7...

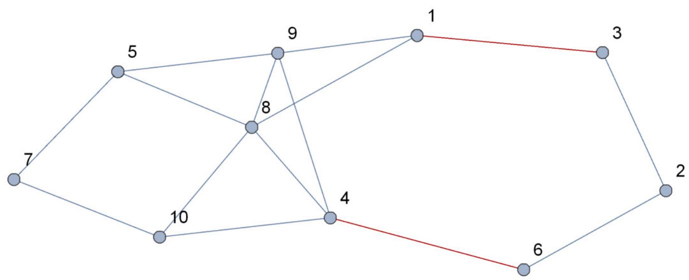


Network optimization

Find weighted independent edges

In[•]:=
```
Get["WeightedMatching`"];

(*Function that will assign weight to the edges*)
WBetCentrality[g_, d_] := EdgeBetweennessCentrality[g];

(*Generate raondom graph*)
g = RandomGraph[{10, 15}, VertexLabels → Automatic];

(*Find matching that tries to maximize the the total weight*)
M = findWeightedIndpendentEdges[g, WBetCentrality, 2];
HighlightGraph[g, M]

(*Print table of centrality of all edges for comparision.*)
TableForm@Transpose@{EdgeList[g], EdgeBetweennessCentrality[g]}
```

Out[∘]=



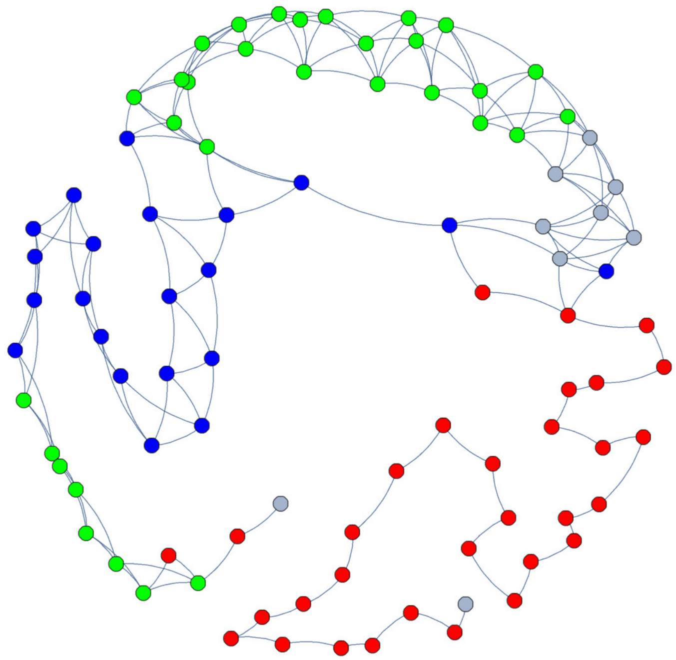
Out[∘]//TableForm=

1 ⟷ 3	19.
1 ⟷ 8	16.5
1 ⟷ 9	11.1667
2 ⟷ 3	10.3333
2 ⟷ 6	14.3333
4 ⟷ 6	23.
4 ⟷ 8	9.83333
4 ⟷ 9	10.8333
4 ⟷ 10	13.
5 ⟷ 7	8.66667
5 ⟷ 8	10.3333
5 ⟷ 9	10.3333
7 ⟷ 10	11.3333
8 ⟷ 9	3.
8 ⟷ 10	10.3333

Grow graph using DPG to optimize assortativity

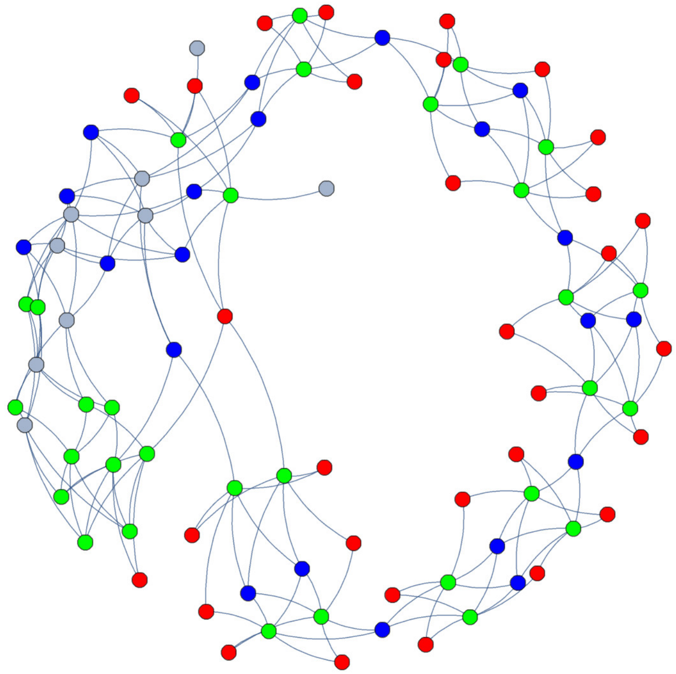
```
Get["DPGAssortativity`"];

(*degree sequence of from which two graphs with different assortativity will be grown*)
degreeSequence = ConstantArray[2, 30]~Join~ConstantArray[4, 30]~Join~ConstantArray[6, 30];

(*DPG grow graph while increasing  degree assortativity*)
{finalG, PhantomV} = DPGrowAssortativity[CompleteGraph[2], degreeSequence];

(*Print high assortativity graph*)
Graph[finalG, GraphLayout → "GravityEmbedding",
 VertexStyle → Join[Join[Table[i → Red, {i, 3, 33}], Table[i → Blue, {i, 34, 54}]], Table[i → Green, {i, 55, 85}]]]
Print["Assortativty =" <> ToString@N@GraphAssortativity@finalG];

(*DPG grow graph while decreasing assortativity*)
{finalG, PhantomV} = DPGrowAssortativity[CompleteGraph[2], degreeSequence, False];

(*Print low assortativity graph*)
Graph[finalG, GraphLayout → "GravityEmbedding",
 VertexStyle → Table[i → Red, {i, 3, 33}]~Join~Table[i → Blue, {i, 34, 54}]~Join~Table[i → Green, {i, 55, 85}]]
Print["Assortativty =" <> ToString@N@GraphAssortativity@finalG];
```

Out[ ]=



Assortativty =0.910492

Out[ ]=

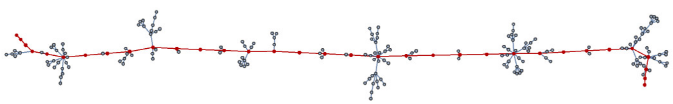


```
Assortativty =-0.792582
```

Network optimization through degree preserving rewiring

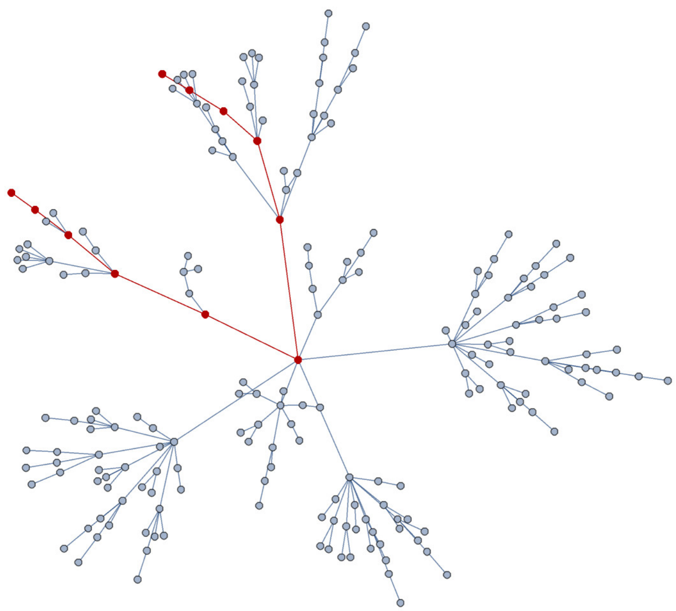
In[•]:=
```
Needs["DPR`"];

(*Generate random tree*)
g0 = RandomGraph[{200, 500}];
g0 = Subgraph[FindSpanningTree@g0, First@ConnectedComponents@FindSpanningTree@g0];

(*function used to find diameter path in undirected graph*)
findDiameterPath[g_?UndirectedGraphQ] := Module[{d = GraphDistanceMatrix[g], u, v, pos}, pos = First@Position[d, Max[d]];
  {u, v} = Part[VertexList[g], pos];
  PathGraph@FindShortestPath[g, u, v]]

(*Do degree preserving rewiring to increase the diamter*)
g = DPROptimize[g0, GraphDiameter, 1, 1000, True];
HighlightGraph[g, findDiameterPath[g]]
Print["Graph Diameter = " <> ToString@GraphDiameter[g]]

(*Do degree preserving rewiring to decrease the diameter*)
g = DPROptimize[g0, GraphDiameter, -1, 1000, True];
HighlightGraph[g, findDiameterPath[g]]
Print["Graph Diameter = " <> ToString@GraphDiameter[g]]
```

Out[•]=



```
Graph Diameter = 32
```

Out[ ]=



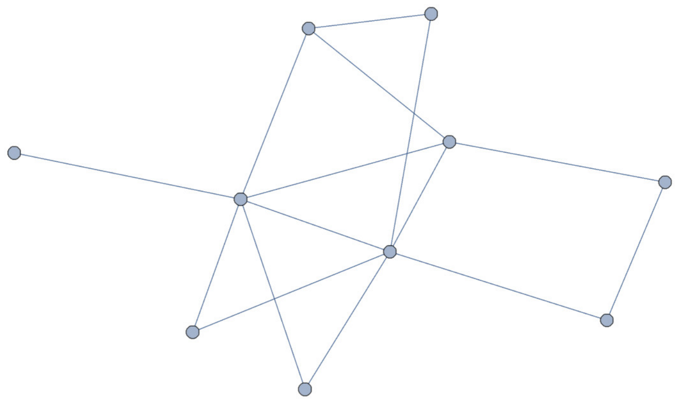
Graph Diameter = 10

Miscellaneous

Calculate splittance of graph

In[•]:=
```
Needs["Splittance`"];
g = RandomGraph[{10, 15}]
Print["Splittance = " <> ToString@findSplittance@g]
```

Out[•]=



```
Splittance = 2
```

Find independent edges using blossom algorithm

In[•]:=
```
Needs["Blossom`"];
g = RandomGraph[{10, 15}];
M = findIndependentEdges[g, {}, Infinity];
HighlightGraph[g, M]
```

Out[•]=