

**Social Networks**  
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**Lecture – 58**  
**Homophily (Continued) & Positive and Negative Relationships**  
**Schelling Model Implementation – Base Code**

Before we start the implementation in the editor I want to show you certain commands in the ipython console, so that it becomes easier for you to understand these commands when I write there in the editor. I basically want to show you some intermediate results. So, I will be easier for you to understand. So, let me ask you what is our aim our aim is to how a grid then we have to put people on the cells of the script then we have to identity the nodes which are the people which are unsatisfied and then we have to move these are unsatisfied people to different locations that is what is the cracks. Now what is the first step? The first step is you want to grid, right.

So, how do we get the grid is your any network expansion that can help us to get the grid. So, apparently, we have this function grid to be graph which we can make use of although not to suit our complete purpose, but we can make changes into that and then basically we can manipulate that.

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```
anamika@anamika-Inspiron-5423:~$ ipython
Python 2.7.6 (default, Oct 26 2016, 20:30:19)
Type "copyright", "credits" or "license" for more information.

IPython 1.2.1 -- An enhanced Interactive Python.
?                -> Introduction and overview of IPython's features.
%quickref        -> Quick reference.
help             -> Python's own help system.
object?         -> Details about 'object', use 'object??' for extra details.

In [1]: import networkx as nx

In [2]: N = 10

In [3]: G = nx.grid_2d_graph(N,N)

In [4]: import matplotlib.pyplot as plt

In [5]: nx.draw(G)

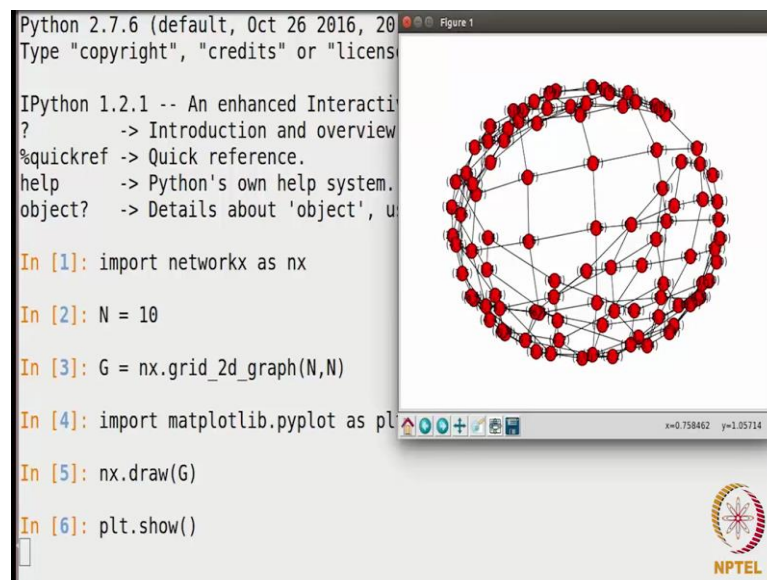
In [6]: plt.show()
```



So, let us get started I will start my ipython console and lets import. So, let us create a 10 cross 10 grid. So, I will take N to be 10 and then I will use the function. So, I will write `nx.grid_2d_graph` and we want to N to be N cross and that is a 10 cross 10 in this case.

So, this is the function that we will use let me show how it looks like. So, I need to show I need to show that. So, I need to import `matplotlib.pyplot` as `plt`. So, I will write `nx.draw(G)` and `plt.show`.

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So, this is how it looks like; obviously, it is not looking. So, good it is not even looking like a grid of, but it is a grid although it is not looking like the way we want to show it. So, we might need to make some changes into it let us see what kind of changes we can make here I am going to close it the graph is not looking. So, nice because the nodes are not displayed in the form of a grid apparently, we do not have an in grid layout a `networkx`.

So, we might need to manually assign the positions to the grid to the nodes now how can we do that before I tell you that let me show you the nodes of this graph.

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```
In [2]: N = 10
In [3]: G = nx.grid_2d_graph(N,N)
In [4]: import matplotlib.pyplot as plt
In [5]: nx.draw(G)
In [6]: plt.show()
In [7]: G.nodes()
Out[7]:
[(7, 3),
 (6, 9),
 (0, 7),
 (1, 6),
 (3, 7),
 (2, 5),
 (8, 5),
 (5, 8),
 (4, 0),
```




So, I will write G.nodes now this something different here in the other kinds of graphs we get either some number or some use a define string as the label of the nodes, but here see I wrote G.nodes and what I am getting is and getting a tuple for every node and the tuple consist in 2 values which is basically the row number and the column number of that node. So, basically it is like a grid, but it just that is not looking like a grid.

So, we might need to display it accordingly we might need to assign appropriate positioning to every node. So, I will show you how we can do that please note that we are getting both x and y positions which are relative positions of these nodes with respect to each other.


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```
(5, 6),  
(7, 7),  
(0, 3),  
(1, 2),  
(4, 9),  
(3, 3),  
(2, 9),  
(8, 1),  
(4, 4),  
(6, 3),  
(0, 0),  
(7, 9),  
(3, 8),  
(2, 0),  
(1, 8),  
(8, 8),  
(4, 3),  
(9, 5),  
(5, 2)]  
  
In [8]:
```



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```
(4, 9),  
(3, 3),  
(2, 9),  
(8, 1),  
(4, 4),  
(6, 3),  
(0, 0),  
(7, 9),  
(3, 8),  
(2, 0),  
(1, 8),  
(8, 8),  
(4, 3),  
(9, 5),  
(5, 2)]  
  
In [8]: pos = dict((n,0) for n in G.nodes())  
In [9]: nx.draw(G, pos)  
In [10]: plt.show()
```



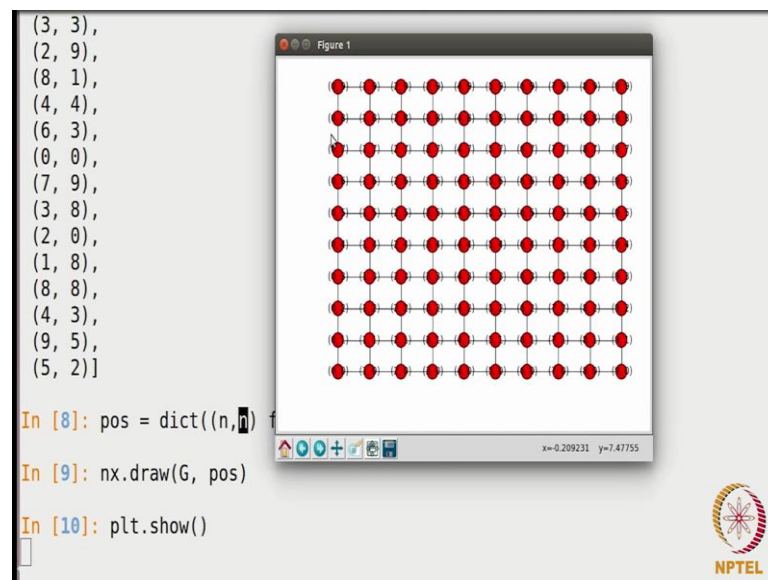
So, what we can do is I will write  $((N, N))$  for  $N$  in  $G.nodes$  or since we have used  $N$  capital  $N$  already maybe I should use small  $n$ . So, what I will write is I will convert this into a dictionary, and I will assign that dictionary to a variable say  $pos$ .

Let me explain you what I have done. So, these are  $G.nodes$  as you can see please note the pattern of the nodes are we getting here. So, these  $(8, 8)$  for example, will be  $N$  will be 1  $N$ . So, what I am doing here for  $N$  in  $G.nodes$  that is for all these tuples I am writing  $(N, N)$ . So, I am creating tuple where there are 2  $N$ s  $(N, N)$ . So, it will be like 8 8 comma

8 8 what I am doing is for node I am fixing its position which is the same as its label, right so, and after that I am converting that into dictionary because that is how we pass the parameter that we pass should be in the form of dictionary. So, this dict function this is the function in python what it does is it converts a tuple into a dictionary where the first value of the tuple will be the key and the second value of the tuple will be the value of the dictionary.

So, this pos this is the positioning that we have fixed and we can assign these positions to nodes and how we can do that is we call this function and it is not draw G we can pass this positioning here and then we can write plt.show.

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Alright, this looks beautiful now listen it right. So, as you can see, we are getting the grid and now other thing that we have to node here is that the labels are not in. So, nice one thing that you should note here is that 0 0 is here and the bottom left corner and it goes like this 0 0 0 1 0 2 0 3 and then comes back from 1 0 1 1 and so on. So, this is the default sequencing of the nodes that this function provides that we used what grid 2 d graph if you want you can change this label in such a way that 0 0 pairs here, but I do not think we need that. So, we will let it be like this, but one thing that you would want to do is that we would want to change the label of basically we have 10 cross 10 that is hundred nodes here and it will be nice if we assign the no labels like 0 2 0 1 2 3 up to 99.

So, that is one thing that we would like to do here now let me show you how we can do that again we will assign different label to every node now the name of the node itself carries the row and column number that is what we will be using in order to assign the label. So, the 0 0 should be having the label 0 0 1 should be having label 1 and so on 0 1 2 3 4 up to 10; now 0 up to 9 and then 10 should be here than 11 and so on. So, this is how we have to assign the labels how can we do that if you know a little math you should be able to understand what I am doing.

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```
(0, 0),
(7, 9),
(3, 8),
(2, 0),
(1, 8),
(8, 8),
(4, 3),
(9, 5),
(5, 2)]

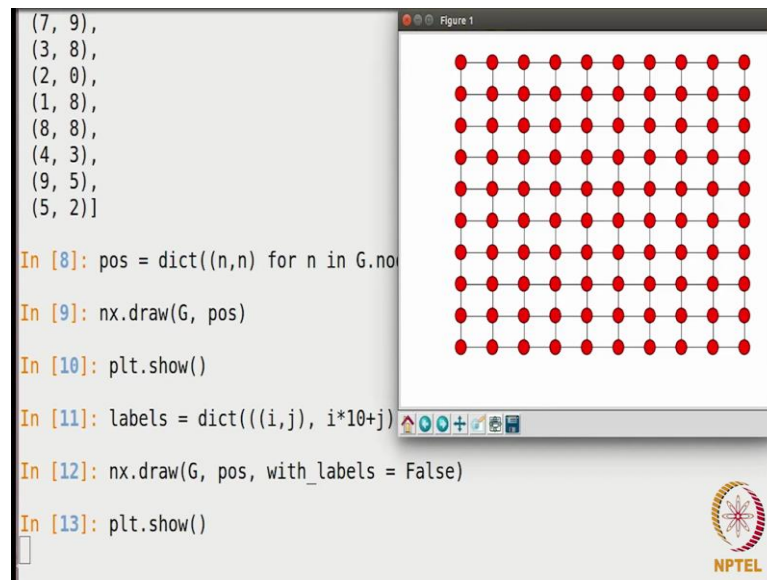
In [8]: pos = dict((n,n) for n in G.nodes())
In [9]: nx.draw(G, pos)
In [10]: plt.show()
In [11]: labels = dict(((i,j), i*10+j) for i,j in G.nodes())
In [12]: nx.draw(G, pos, with_labels = False)
In [13]: plt.show()
```



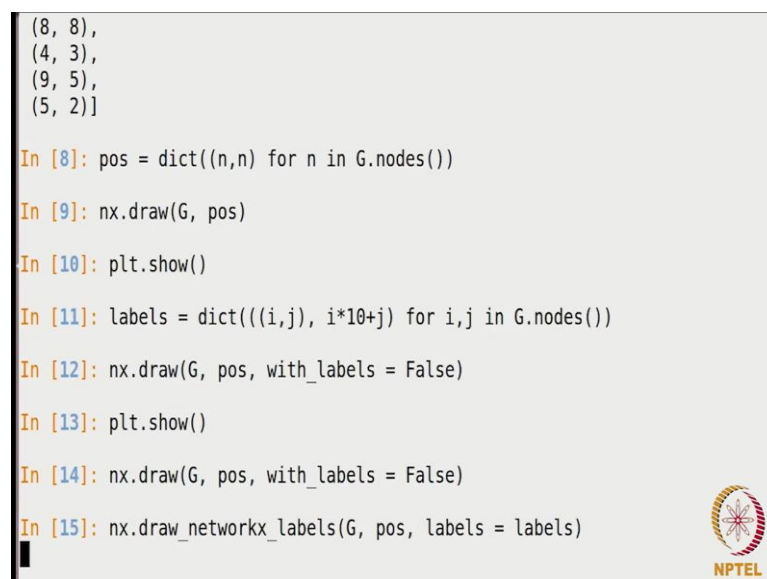
So, what I will do is (i, j) to (i, j) what I am assigning is  $i * 10 + j$  this is what I am assigning to first node and to the (i, j)th node this I will do for every node. So, I will write for (i, j) in G.nodes and again I will convert this into dictionary. So, I will use the same function and let me call this dictionary labels or when they should go.

So, what I am doing here is that to every node which is (i, j) like here like 4 3. I am assigning label which is  $i * 10 + j$  in the case (4, 3) it will be 43. So, that label I am assigning to every node and that information I am keeping in the form of a dictionary in this dictionary called labels which I am going to use. So, let me show you how we can do that. So, we used nx.draw a previously which displace some labels by default which is the labels that I showed you just now we do not want those labels to be displayed. So, what I will write is with labels = false right. So, the labels that it will showing it will not be visible you can check that is well if you I can pretty show you.

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So, there are no label displayed here; here now we want to display our own labels for that we have a function `nx.draw_networkx_labels`. Now again we have to pos the graph we have to pos the positioning and then we have to pos the labels dictionary labels dictionary.

So, this is how we write labels is it would labels this should work now the labels have the new labels have been assigned that is display them oh, yeah, this looks nice.



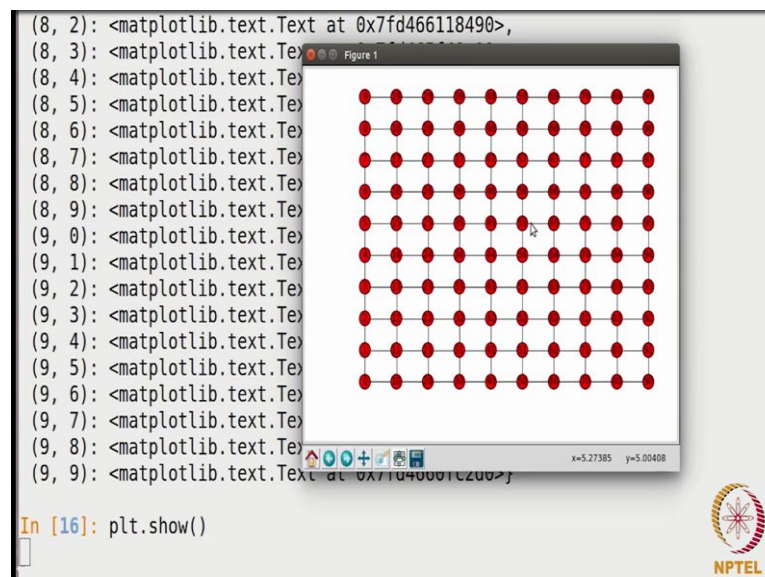
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```
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(8, 8): <matplotlib.text.Text at 0x7fd466914b50>,  
(8, 9): <matplotlib.text.Text at 0x7fd4660fcf90>,  
(9, 0): <matplotlib.text.Text at 0x7fd46611c090>,  
(9, 1): <matplotlib.text.Text at 0x7fd466963210>,  
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(9, 5): <matplotlib.text.Text at 0x7fd466921410>,  
(9, 6): <matplotlib.text.Text at 0x7fd4660de9d0>,  
(9, 7): <matplotlib.text.Text at 0x7fd465fa3690>,  
(9, 8): <matplotlib.text.Text at 0x7fd4660b6e90>,  
(9, 9): <matplotlib.text.Text at 0x7fd4660fc2d0>}  
  
In [16]: plt.show()
```



Now, So, we have the labels from 0 1 2 3 up to 99. So, it will be nice to refer to them when we do the later manipulations.

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Now, one thing that is important to note here is that I told in the explanation of scaling model that every node which is an internal node that is node on the boundary should have 8 neighbours right. Now here if you look at this node number 45 it has 3; 35, 46, 55, 44; it has only 4 neighbours it is not neighbours with the diagonal nodes as you can see. So, this is the kind of grid that the function provides as by default.



But this is not serving our purpose our purpose is that this 45 should be connected to 56 as well as all these 4 nodes 36, 34, 54 and 56 now how do we do that. So, we would have to add them the edges manually which are not already present here now how can we do that I want to show you.

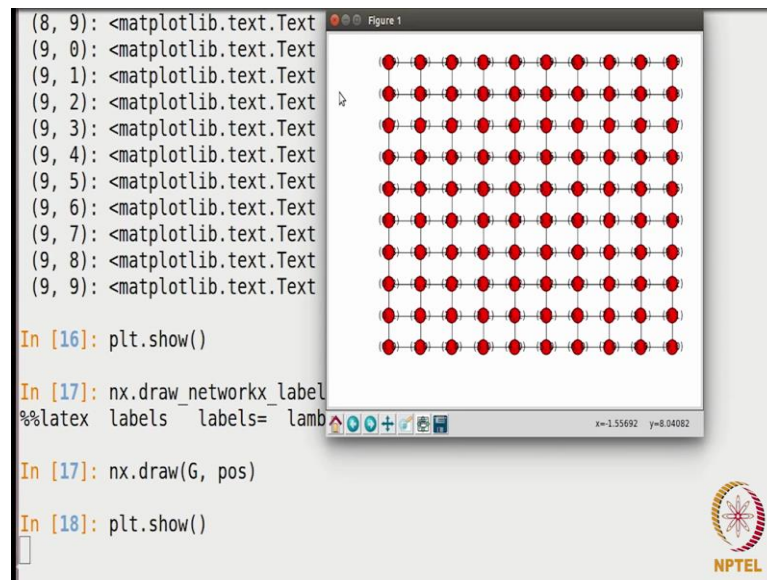
(Refer Slide Time: 10:40)

```
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```



The previous representation of the graph because that will help us understand how we can add the edges, so, what I am going to do is I am not going to use this command `nx.draw` the usual function that we will use and this position we were using I would like to display this only.

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I am showing you the previous version of the graph for a reason because I want to show you how can are the edges with diagonal edges now if you look at this 1 1 node we have to connected to 2 2 this 2 2 has to be connected to 3 3 and if you look at some other node this 2 6 has to be connected to 3 7 4 8 3 7 has to be connected to 4 8.

So, if you observe carefully the node  $(i, j)$  has to be connected to  $(i + 1, j + 1)$  if you look at 6 7 it has to be connected to 7 8 which is again  $(i + 1, j + 1)$ . So, we will take all the nodes  $(i, j)$  and we will connect them to the nodes  $(i + 1, j + 1)$  that should be half of the work done. So, let us see one thing that we have to node here again is that when we are doing  $(i + 1, j + 1)$  it should never cross the 9 right we cannot connect 9 9 to 10 10. So, that limit we have to take care of, so that we will take care of that thing.

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```
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```

In [16]: plt.show()

In [17]: nx.draw\_networkx\_labels(G, pos, labels = labels)  
%%latex labels labels= lambda

In [17]: nx.draw(G, pos)

In [18]: plt.show()

In [19]: for (u,v) in G.nodes():  
.....: if (u+1 <= N-1) and (v+1 <= N-1):  
.....: G.add\_edge((u,v),(u+1,v+1))  
.....:

In [20]: nx.draw(G, pos)

In [21]: nx.draw(G, pos)

So, I will write for (u, v) let say for (u, v) in G.nodes what do we want to do (u, v) has to be connected to (u + 1, v + 1), but again we have to take care that u + 1 and v + 1 does not exist does not exceed N - 1. So, I will write if u + 1 <= N - 1 and we say to be done for v. So, I will write v + 1 <= N - 1 then only we will do this otherwise you will not add that edge. So, I will write G.add edge which edge (u, v) edge to (u + 1, v + 1) edge this should work let us see let me show you in the graph at this stage I will write nx.draw and then (Refer Time: 13:16) plt.show, yeah.

(Refer Slide Time: 13:16)

```
(9, 9): <matplotlib.text.Text at 0x7f... Figure 1
```

```
In [16]: plt.show()
```

```
In [17]: nx.draw_networkx_labels(G, pos,
%%latex labels= lambda
```

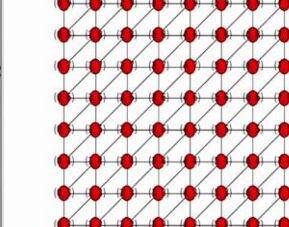
```
In [17]: nx.draw(G, pos)
```

```
In [18]: plt.show()
```

```
In [19]: for (u,v) in G.nodes():
.....:     if (u+1 <= N-1) and (v+1
.....:         G.add_edge((u,v),(u+1
.....:
```

```
In [20]: nx.draw(G, pos)
```

```
In [21]: plt.show()
```



So, we have 1 p of half of the diagonal edges in corporate already the other direction of the diagonal edges is still yet to be added for example, we must connect this 3 9 2 4 8 4 8 to 5 7. So, that must be done.

Now, if you observe carefully 4 6 has to be connected to 5 5 which means  $(u, v)$  has to be connected to  $(u + 1, v - 1)$  yeah that that whole's true for every node. Now again one thing that we have to take care of here is that while doing  $v - 1$  it should not be less than 0, so that part we will take care of let see how we can do that.

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```
In [18]: plt.show()

In [19]: for (u,v) in G.nodes():
.....:     if (u+1 <= N-1) and (v+1 <= N-1):
.....:         G.add_edge((u,v),(u+1,v+1))
.....:


In [20]: nx.draw(G, pos)

In [21]: plt.show()

In [22]: for (u,v) in G.nodes():
.....:     if (u+1 <= N-1) and (v-1 >= 0):
.....:         G.add_edge((u,v),(u+1,v-1))
.....:

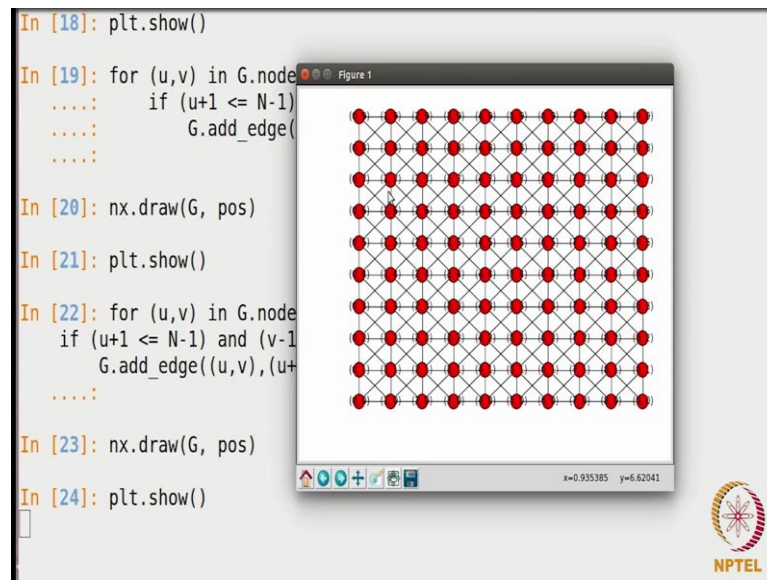
In [23]: nx.draw(G, pos)

In [24]: for (u,v) in G.nodes():
.....:     if (u+1 <= N-1) and (v-1 >= 0):
.....:         G.add_edge((u,v),(u+1,v-1))
```



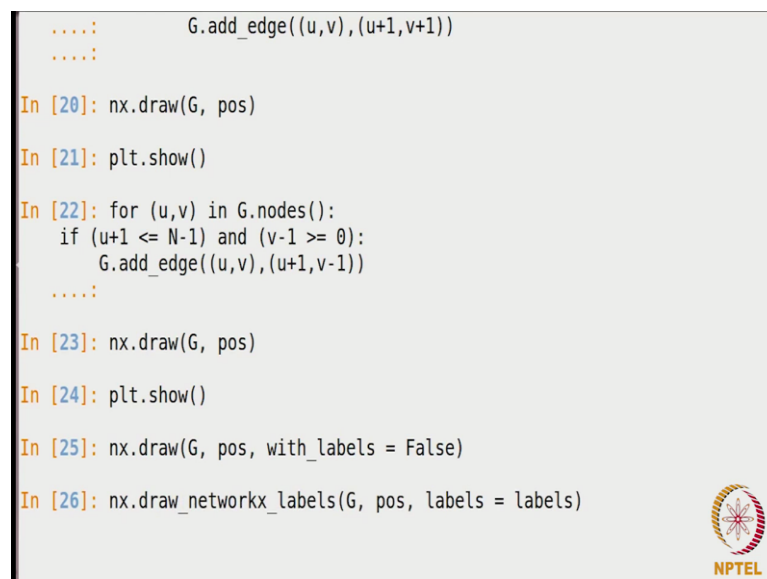
I am going to make changes here itself or yeah. So, what I will do is I will go back here and if  $u + 1$ . So,  $(u, v)$  must be connected to  $(u + 1, v - 1)$ . So,  $u + 1$  should be this and  $v - 1$  should be less than equal to now should be greater than equal to 0 it should not be less than equal to. So, this we must check and if this is true than we will have N h from  $(u, v)$  to  $(u + 1, v - 1)$ ; they should work.

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Doubtful about the in indentation but let me see if there is work if it works fine, yeah. So, here you see all the edges have been incorporated all the diagonal edges are there now the graph seems complete.

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Let me just show you the labels they updated labels that we recently showed which command it will be use yeah, we use this and then we used this one yeah let us see.

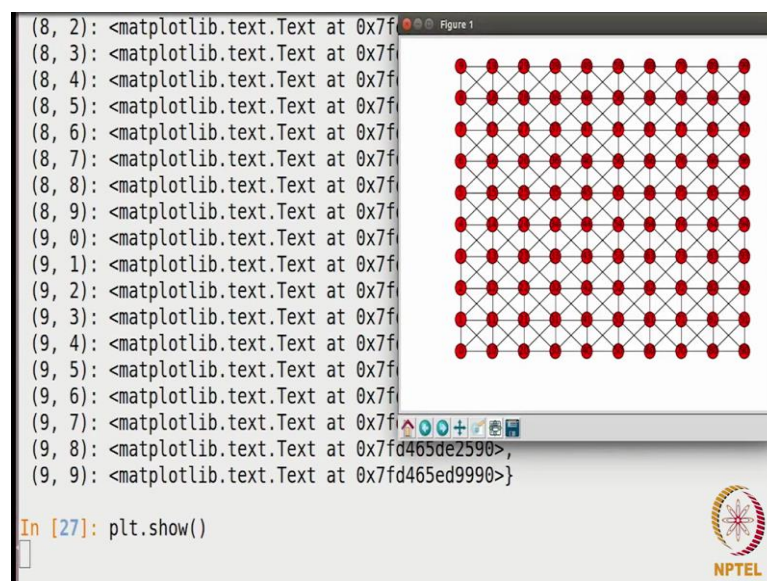
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```
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(8, 7): <matplotlib.text.Text at 0x7fd465d3b810>,  
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(9, 9): <matplotlib.text.Text at 0x7fd465ed9990>}
```

In [27]:



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This looks nice. So, we have the great we have the diagonal edges we have the nodes now we have said the playground for playing with these nodes where we will put the people of different types there will be some people of type 0, there will be some people of type 1; there will be some nodes its will be empty we will not put any people there. So, that is how we are going start in the next video I will be using all these commands that I would show shown you already in the ipython console. So, I will use them in the editor and then we will get started with manipulating the nodes.