Social Networks
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Rich Get Richer Phenomenon – 2
Lecture - 134
SIR and SIS Spreading Models

So, we are now going to see how we can simulate the spreading of this SIR model we just discussed on a network. So, we will be modeling this is spreading in the form of number of iterations or number of days. So, you can imagine a situation where there is this measles is spreading on network. We will be looking at what happens at day 1, then what happens at day 2, what happens at day 3 and so on.

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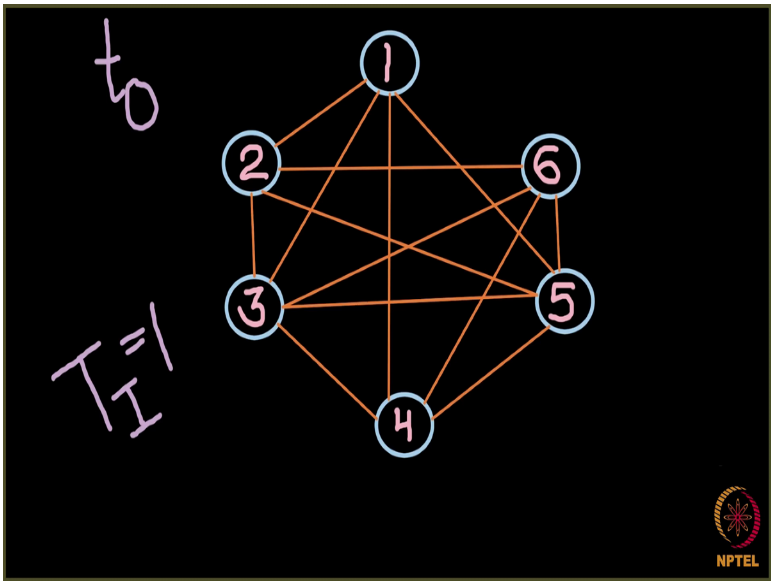

t 0; so, let us talk about day 0. t is for time; so, you are talking about day 0. At day 0, the lets say the network looks something like this. So, you see there are 6 nodes in this network. 6 people in this network and the blue color is for susceptible. So currently, each of these people is susceptible. None of them has acquired the disease and let us say measles. So, none of these people are suffering from measles.

And these are edges across which your infection can transmit and let us say the probability same across all the edges. Probability of infection is p. So, the pathogen for measles it is having a contagiousness value which is p. Now, let us see what will happen?

Assume that and yeah one more thing, the value of T I we are going to be taken to 1. So, all though it might not sound realistic, but in the case of measles we cannot say that we remain infected for just one day and after that only you just acquire life time immunity. You remain infective for a long period of time, but for just for the sake of simplicity, let us take for the time being T I equals to 1. In the next example, we increase this value and see what happens, but for this example we take the value of T I to be 1. So, here is a new kind of measles, let us say. So, this measles keep you infected just for one day and after this one day you acquire life time immunity.

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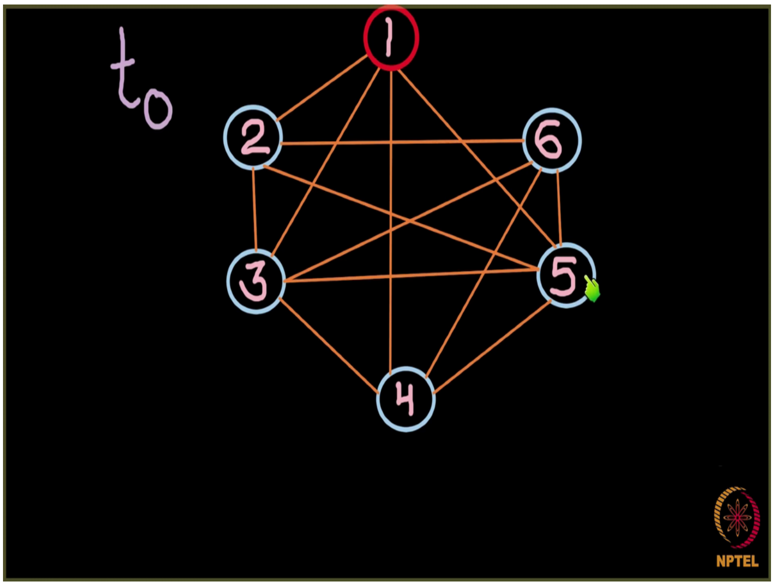

So, this is a network at day 0 and at day 0 this node 1 gets infected so, this node 1 gets measles the 0th day. What will happen on the 1st day now? Now this node 1 has 4 neighbors 2 and then 3 and then 4 and then 5. So, it has 4 neighbors and it tries each of these neighbors it tries infecting each of these neighbors with the probability of p and let us say, it is able to infect node 3 and node 5.

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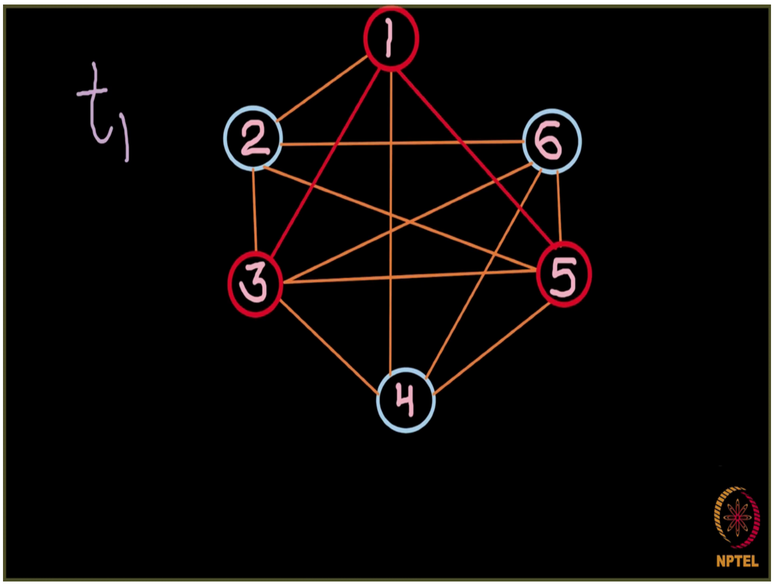

The 1st day, node 1 infects node 3 and node 5. Now you might want ask, you might ask me a question here. How do I decide which are the nodes which node 1 is infecting? Sorry.

How do I decide it is going to be node 3 and node 5 only? And I will tell you that this is a very random process; as we discussed before. So, I am going to toss a coin for each of these edges. So, if the probability of infection is 0.5, I toss up here coin for this edge, for this edge, for this edge and for this edge and here and I get a tail here, I got a head here, I got a tail here and I got a head here and I did it. And you see now, so what will happen. One simulation of this model can go like this. Where node 1 has infected node 3 and node 5, but if you simulated the second time, you again start from this graph and you again toss the coins; you might get some other result. So, it is a random process unlike in the case where we discussed how ideas and behaviors spread on a network, everything there was deterministic.

If you were given the snapshot of a network at a particular time, you would for sure with very certainty you can tell what would happen at the end. But here in this case, there is less certainty. It is more of a random process. So, let us see node 1 here, infected node 3 and node 5. Now, see node 1. Node 1 was infected at day 0 and now it is day 1. So, what is going to happen at the end of day 1? At the end of the day 1, our node 1 it is going to be recovered. So, node 1 is discovered towards the end of day 1, but it has infected these two nodes in the network, node 3 and node 5.

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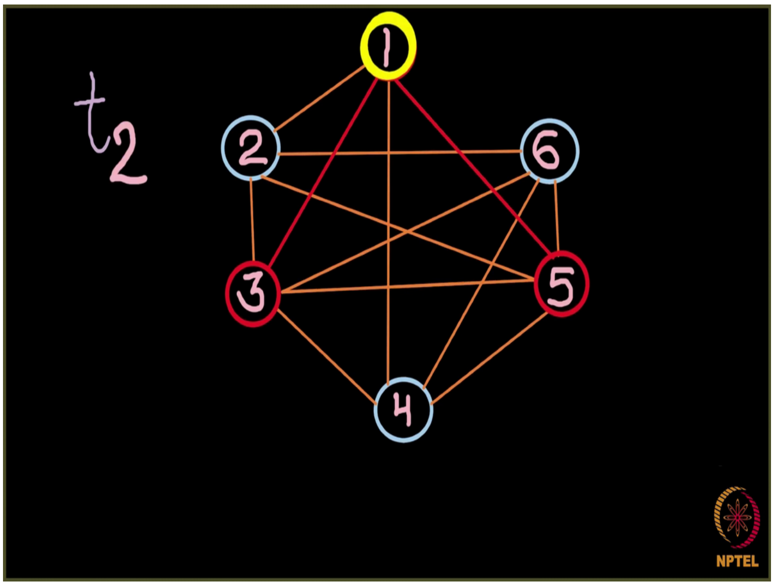

And now on day 2, node 1 do not get infected anybody, but and nodes 3 and nodes 5; node 3 and node 5 start doing their work and let us say, node 5 end up infected node 4. So, node 3 here is unable to infect any of its neighbors and node 5 here infect node 4. Node 3 here, its an able to infect node 2 and node 6 and node 4 as well. And you see, node 3 can for sure not infect node 1.

Because node 1 it has recovered from the network. Overall node 3 gets nobody it could infect, but this person node 5 here, infects node 4. What happens next towards the end of the day 2? So, these node 3 and node 5 they were suffering from day 1. They suffered at the end of day 1, right? And now, they have passed one day of infection. So, towards the end of node 2 both of these nodes will become recovered.

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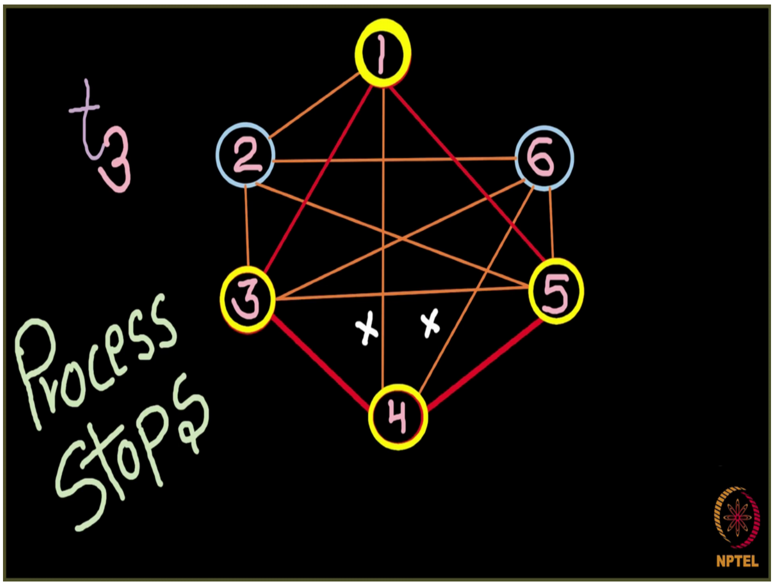

And on day 3 it is node 4 which goes around and start infecting the people and let us say, node 4 is unable to infect anybody. Node 4 obviously cannot infect node 3, node 1 and node 5 now because they have recovered. It can infect node 6, but let us say it is unable to infect node 6 and towards the end of day 3, node 4 also gets recovered.

What will happen on day 4 now? On day 4, there are these 6 people out of which 4 have recovered towards a susceptible infection gets over because for this process to go further, we need a node, we need a red node here. We need a node which is infected, but now there is no node here which is infected, no red node here. So, what will happen? The process will stop. So, this was one simulation we did where we took the value of T I that is a infection period to be 1. Every node remains infected for one day.

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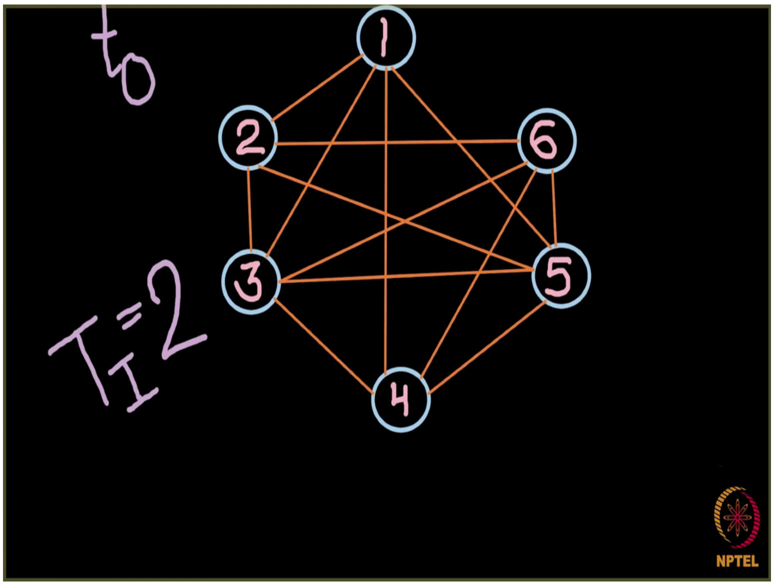

Let us now look at another example and let us say I have changed this infection period to 2. Now you remain infected with measles for 2 days and after this 2 days, you recover from the disease and again this is node 1 which catches the infection at day 0.

So, now, you see get 2 days. Days 1 and day 1 and day 2 to infects its neighbor and it will become it will recover at the end of day 2.

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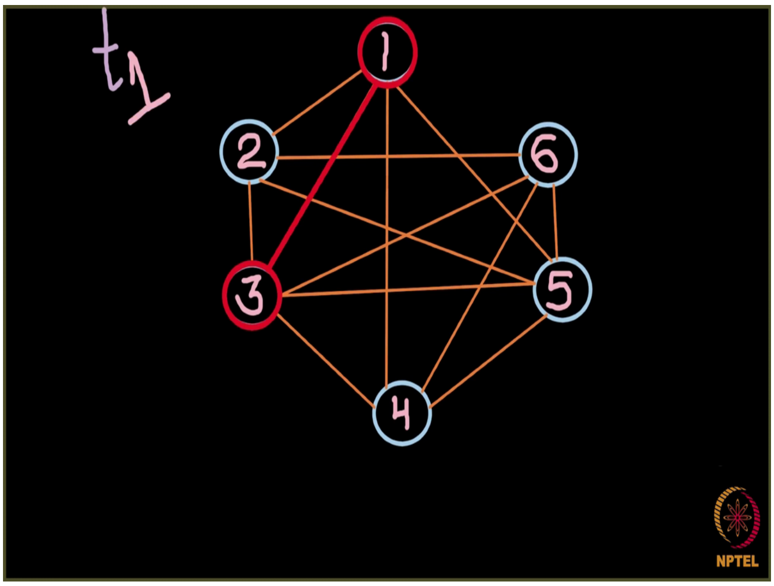

So, node 1 here, let us say day 1 it infects node 3, just node 3.

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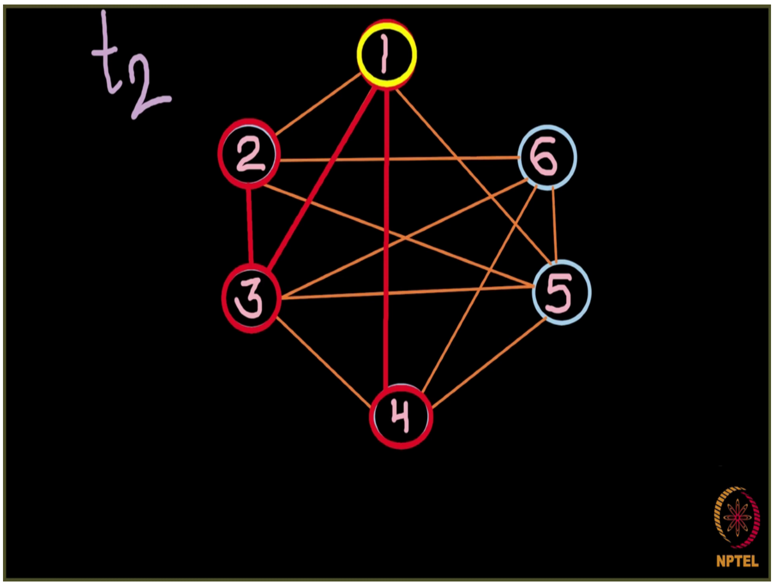

And then comes day 2. Now at day 2, both of these nodes will be infecting people. Node 1 as well as node 3. So, let us say day 2, node 3 infected node 2, node 1 is unable to infect anybody at day 2 or let us say rather node 3 infected node 2 and node 1 is able to infect node 4 at day 2. So, node 1 got day 1 to infect people and it is also getting now day 2 to infect people because it remains infected for 2 days, and towards the end of the second day, node 1 recovers.

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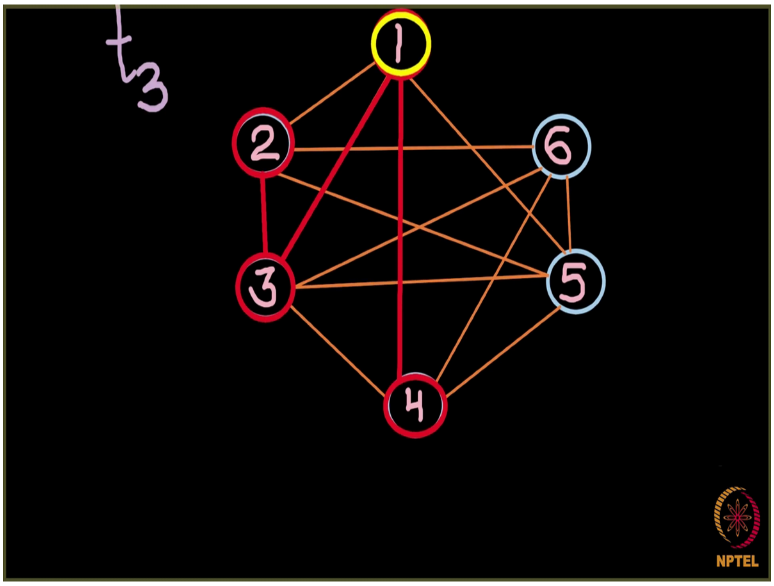

Now, during the third day, all of these three nodes, 2, 3 and 4 get infect their neighbors and let us say node 3 infects node 6.

If you look back at this network, so let me show you. So, this node 3, it was infected at day 1 and then day 2 it was it infected node 2 and again at day 3 it infected node 6. And at the end of day 3, what will happen? It will recover.

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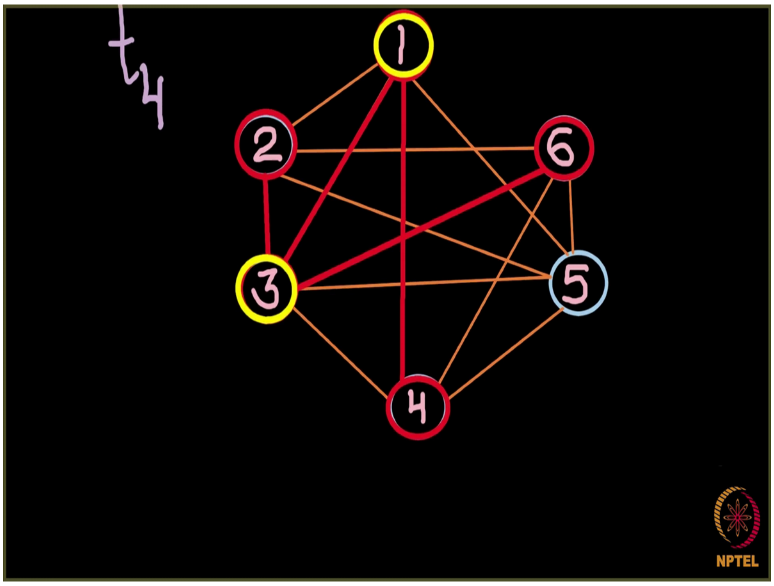

And now what will happen in day 4? Nodes 2, 4 and 6 get to infect people and let us say node 2 infects node 5 and what will happen towards the end of this day? Nodes 2 and 4 will recover.

You can easily guess what will happen next, towards day 5. So, towards day 5 also, node 6 and 5 here will be infected and towards day 6 both of these will be recovered; and towards day 6 day 6 both of these will be recovered. So, at the end all the nodes in this network will recover. So, this is how we could have stimulated it for the value T I equals to 2. So, please note that it is one possible simulation. Every time you simulated it, this network will go and it will be infected in a different way.

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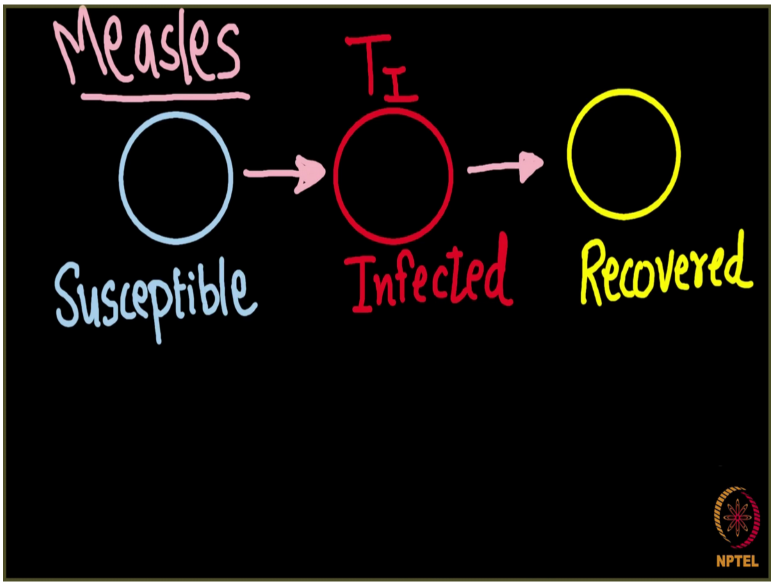

So here what we talked about lets quickly recap. It was a node, so the node can be either susceptible or a node can be infected and it remains infected for T I time during which it infects are other people and finally, the node gets recovered something like in the case of measles. Can I use the same model if I want to simulate the spread of a common flu? What will happen? let us say common cold. So, this infection might sorry. So, this model might not hold good there, right. So, in common cold yes, you become susceptible, you are susceptible and then you become infected after coming in contact with an infected person. Then will you be permanently recovered from common cold? It never happens. What happens is, after recovering from common cold, you enjoy for some days and or let us say some months. So, let us say some years, but after that again that common cold infects you.

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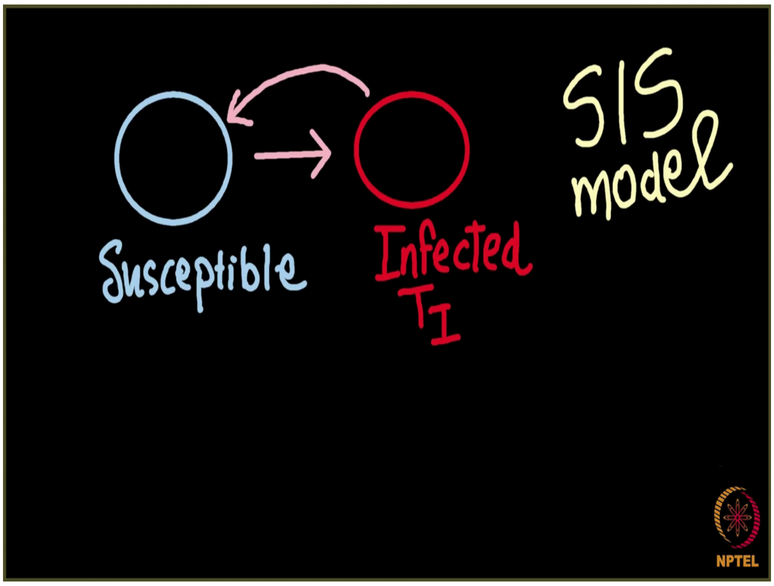

So, what happens is instead of going to this recovered state you go back to the susceptible state. So, susceptible infected and after remaining infected for T I time period, you go back to the susceptible state and this model is called the SIS model because S refers here for susceptible, I is for infected and S is again for susceptible. So, you become susceptible, you becoming infected and then you again become susceptible and this is used, this model is used for something like a common cold, which disease which can infect you again and again.

And I am quite sure that you can now create a simulation of SIS model on a network on your own, but still in the next lecture, I will show you how can we simulate a SIS model. How can we simulate an SIS model on a network. So now, we are going to look at 1 simulation of the SIS model. We have looked at the difference between the SIR model and SIS model. Let me quickly recap it.

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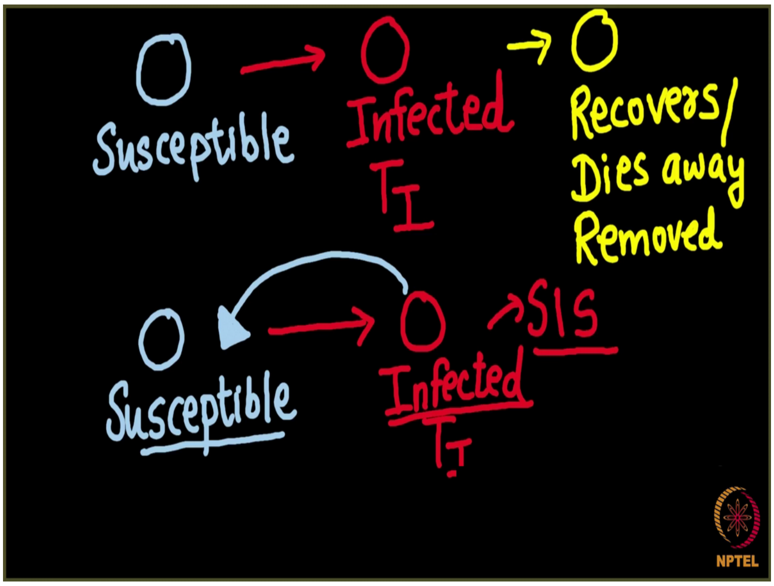

So, in SIR model here we were having a node and let us say this node is susceptible. That is, it has now got the infection and then we have seen that from susceptible, this node can go and move into an infected state. So, this happens after this node comes in contact with an infected person and this node becomes infected and it remains infected for T I period of time. During which it keeps infecting other people and finally, what happens, this node it either recovers. That is, it develops a lifetime immunity against that, against the disease, or it leaves the network. That is, let us say this node dies away in which case we say that this node has been removed.

So, this was your SIR model and SIS model was a little bit different. It was for a disease which can infect us time and again such as a common flu, cold, common cold. So here again, we have a node which can be initially susceptible and then when it comes in contact with an infected person, this node it becomes infected and it remains infected for T I period of time. And after this T I period of time, what happens is it again goes back to the susceptible state. So, there is no recovered state. After sometime, this node becomes susceptible again then it might come in contact with an infected person and again become infected and so on. Now, how will this simulation of such a model look like? So, this is our SIS model and we are going to see how will the simulation of such a model look like. So, let us see.

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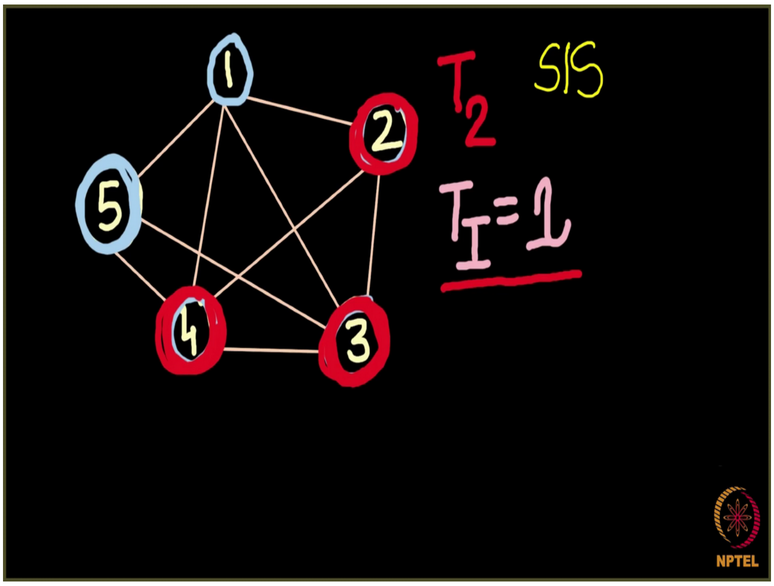

So, let us take a network again. So, I take a network here. Let us say there are 5 nodes in the network. 1 and then 2, 3, 4 and 5 and I will put some edges between these nodes. You put some edges, let us say from 1 to 5. From 1 to 2, 1 to 4, 1 to 3 let us say. And then let us say, from 2 to 3, 2 to 4, 3 to 4, 3 to 5, 4 to 5 that is it.

Now, let us say these many its a network consisting of 5 nodes and let us see how an epidemic or how a contagion will spread here and here we are talking about the SIS spreading model, SIS. Initially, all of these nodes shown in this network they are susceptible. So we will showing susceptibility by blue color. So, let us make all these nodes to be susceptible. So, 1 is susceptible and 2 is susceptible 3, 4 and 5. All these nodes are susceptible.

Now, this is T 0 and let us say, at T 0, an infection counts and infects 1. So, a node 1 is now infecting from common cold and our value of T I, that is, time period during which a node remains infected let it be 1. So, one node remains infected for one day. Now, let us see what will happen during the second day. So, we are modeling what happens during, i am i am sorry, during the first day. So, initially there was a 0th day, now comes the first day. So now first day, this node 1 it will look at all of its neighbors and try to infect some of them.

So let us say node 1 become successful in infecting this node 2 here and node 4 here. So, during day 1, node 1 infected this node 2 and node 4, and by the end of day 1 what will happen? Node 1 will recover because at T I it is equal to 1. Towards the end of this day, node 1 will recover. After recovering it will not go back to the recovered state, it will go back to the susceptible state as we have discussed. So, it loses its common cold and come back to the susceptible state; come back to the susceptible state.

First day over; let us now see what happens during the second day. So now is the second day. Second day node 2 and 4, we look at their neighbors and we will try infecting them and let us say they become successful in infecting node 3. So now at day 2, on day 2, node 3 catches the infection and again towards the end of day 2, node 2 and node 4 will go back to the susceptible state. So, node 2 and node 4, now go back to the susceptible states. So, this is node 2 here and node 4 here.

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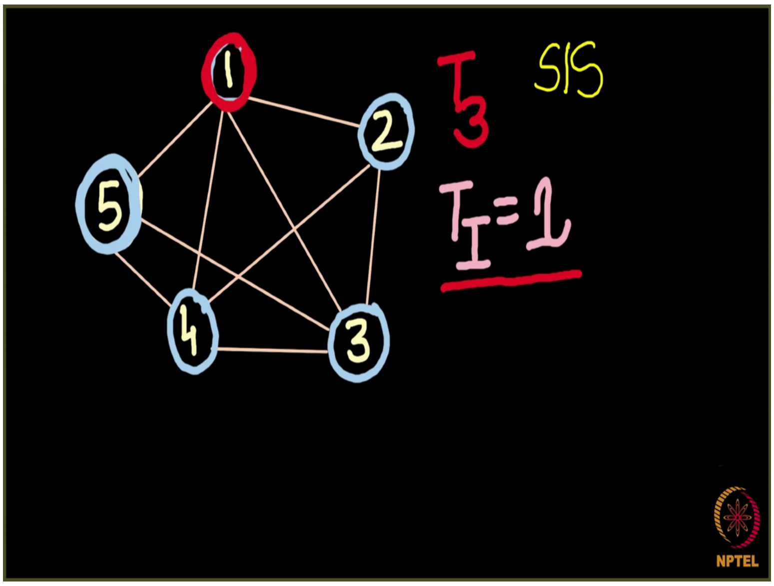

And then, what can happen during the third day let us say; now comes the third day. So, now, in the third day this node 3 is node 3 is infected. So, what node 3 will do?

Let us say it infects node 1. Do you see what happened just now? It infects node 1. So, node 1 as previously also become infected and it is infected certain people it becomes susceptible, but now this node 1 it again gets infected. So, this node 1 it gets infected here and towards the end of day 3 this node 3 now, it comes back to the susceptible state and this process keeps on going; and this process keep on going. So, node 1 may then infect certain nodes and then those nodes will infect certain nodes, but suppose at this iteration what happens is node 1 is unable to infect anybody. So, we are talking about day 4.

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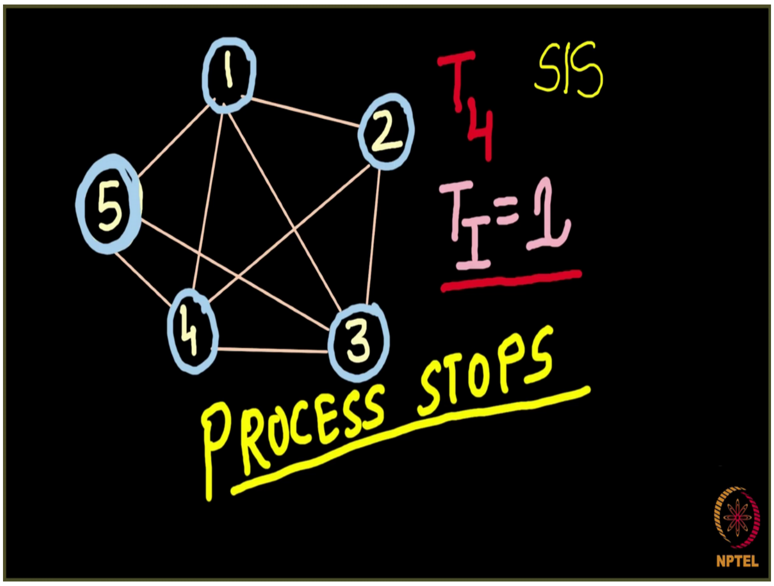

So let us say, at day 4 node 1 is enable to infect anybody and what will happened towards the end of this day; towards the end of day 4?

Node 1 will again go back to the susceptible state. And do you see now what is happened in this network? Everybody now comes back to this susceptible state there is nobody who is infected; and as soon as this happens in this network, there is not even a single node which is infected everybody is susceptible what will happen is the process stops. Now this was the simulation of SIS model on a network.