Social Networks
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The Small World Effect
Lecture - 148
Decentralized Search – II

So, we asked a question in the previous lecture, the question is how is this happening?

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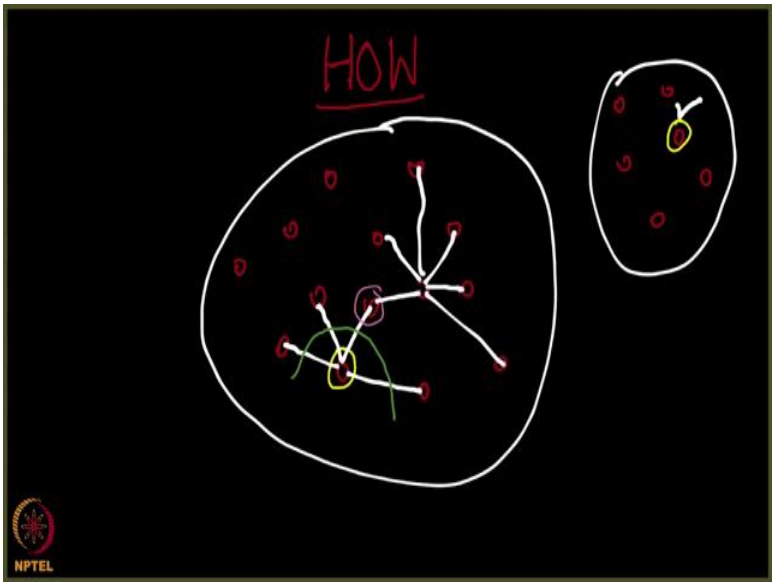

How is the search happening on the small world network? Right, it is very intriguing you see I mean how can someone just pass on a piece of information to someone else and in 6 hops you can reach the destination anywhere in the world, the reason actually is pretty simple. In fact, we gave a intuition of it in one of the previous lectures; we are going to go in detail with it right now. As you know in the real-world network you know how its it happens how a real-world network is created, we saw the Watts-Strogatz model right.

There are several nodes and several links. How do links form? Assume this is you, how will you make friends? You will basically be friends with your immediate neighbors, your classmate, your schoolmate maybe your gym partner, you're the person whom you know in your painting club or may be in your biking club and so on and so forth. You know the local people really well, but then as you know there are some people who

might know someone outside their locality right. So, whenever you are asked to send a piece of information let us say to some other part of the globe.

All you will do is you will choose one of those friends of yours who probably is closer to this destination, who is possibly closer to this destination. And that person in turn chooses another person, another person and this person might see you see how and why, how and why probably he was chosen. Why did this fellow chose this fellow? Probably because this fellow here this guy might actually know this guy or someone in this particular region that is why this fellow chose this fellow, while he actually knew maybe several people.

He purposefully chose him of all people to send right he knew several people, but right he knew several people. But he chose to send it to only this person that is because he suspects this person might really know someone from this region.

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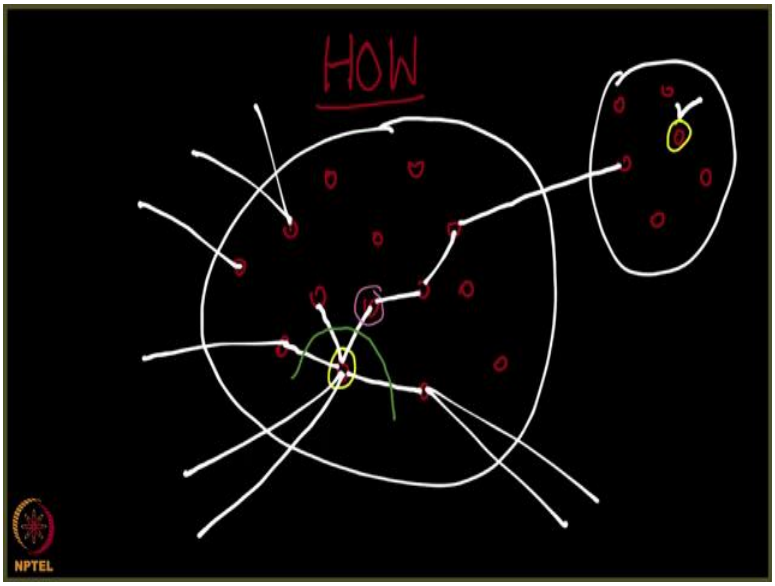

Did you think this happens, if you want to send a piece of parcel to someone in Afghanistan or let us say someone in Dubai or someone in some Arab country. You probably will know a friend of yours in your college who is from one of these countries right. And, you may want to send it to this friend and ask him to send it to someone in let us say Dubai which will help the packet reach the destination, which is probably in one of those Arabian countries right.

So, that is the whole idea behind this local algorithm, where a person starts from here and then intelligently tries to reduce the distance on the destination. We all have a sense of what is the destination, how close we are getting, and we try to achieve it. So, now how do we simulate and see this?

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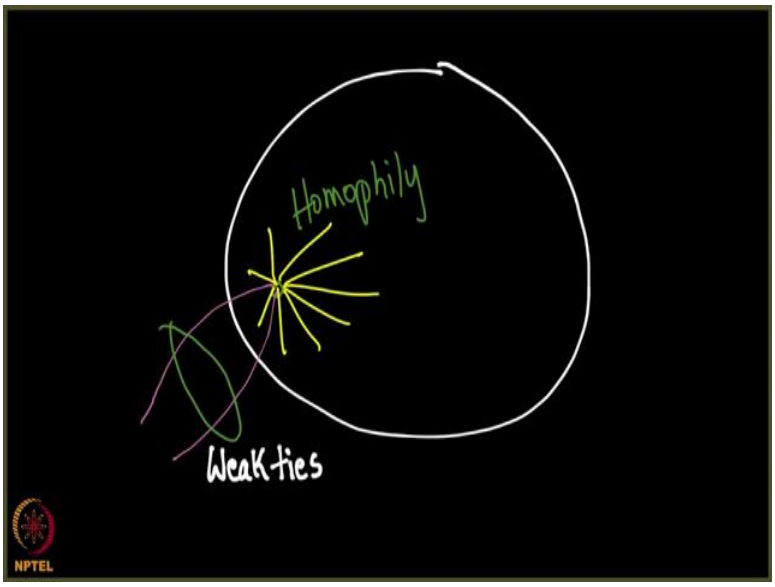

We first take a Watts-Strogatz model. Now, before anything let us go back to the previous slide and then see. So, this kind of edges actually common in the Watts-Strogatz generative model that I told you which depicts the real world networks; you see basically we make friends with our localities in our localities people who are around us. But, then couple of links will actually be to outside places example this fellow although is friends from, is friends with people who are close to him right next to him; he might also have a couple of friends outside. This fellow might have couple of friends outside, this person might have someone person outside, 2 friends outside, someone outside this always happens you see.

So, let us say if we have a person here with some links inside a lot of links will; obviously, be in his locality itself, but a few links will actually be outside. Isn't that true? We know a lot of people in our country, but we also do you know let us say 1 or 2 percent of our friends will be outside our country. They form as you all know what is called the weak ties, they form the weak ties and how would we simulate this algorithm

on such a network? Let me let me revise what has happened so far. All I have stated is there is homophile because, of which we are friends with people who are right next us.

There is also the weak ties that we have because, it is only intuitive that 1 or 2 percent of us will always have some friends outside the country, outside our geographic location correct and that is what makes passing of this packet becomes very easy. How do we simulate and see this? I will just be, just to complete I will write this as these are this constitutes homophile ok. How do we program this and see it? What we should initially do is, I will give this as an exercise problem for you all you should be able to do it. In case you are unable to do it please let us know we will help you out.

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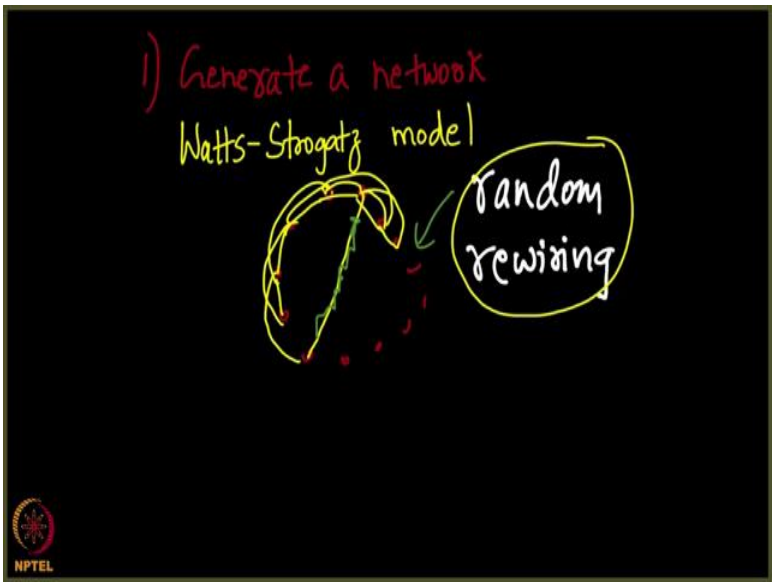

So, first thing is we need to generate a network with small world property, we know how to generate that. This is called the Watts-Strogatz model, where if you remember you take nodes right, you take nodes and you put edges to your immediate neighbours, who are geographical closer to you correct. So, this goes on like this other if it is closer to you this happens for on every single node here so on and so on and so on because, these are all connected like this so on. And, you do what is called some random rewiring, isn't it? You do what is called the random rewiring.

So, what you do is everybody's friends with their locality people only their immediate neighbors, but a few people random rewiring means you take some 1 percent of the friendships and shift them randomly; you resort of relocate them randomly right we have

discussed this before. So, if there was a node from let us say here to here you basically remove it and then put it somewhere from here to here. That way this becomes what is called let us say a teleportation channel; a person who is here might only know people in his local neighborhood, but then by this random rewiring what you do is you connect him to a person who is otherwise geographically far away from him.

And that is what the Watts-Strogatz model tells you, for you to get this small world property in such a random rewiring should happen. What do you mean by, what do you mean by random rewiring should happen? Who makes it happen? The point here this is how the real-world network functions. So, you might ask me who does random rewiring, nobody does random rewiring. This is how it you know things are I told you the fact that you have a couple of people right outside your geographical location, while most of your friends are, we within your geographical location.

You might have a couple of friends outside your country, outside your continent right and that is equivalent of the random rewiring here right. When such a thing happens, we can actually try implementing our own search algorithm.

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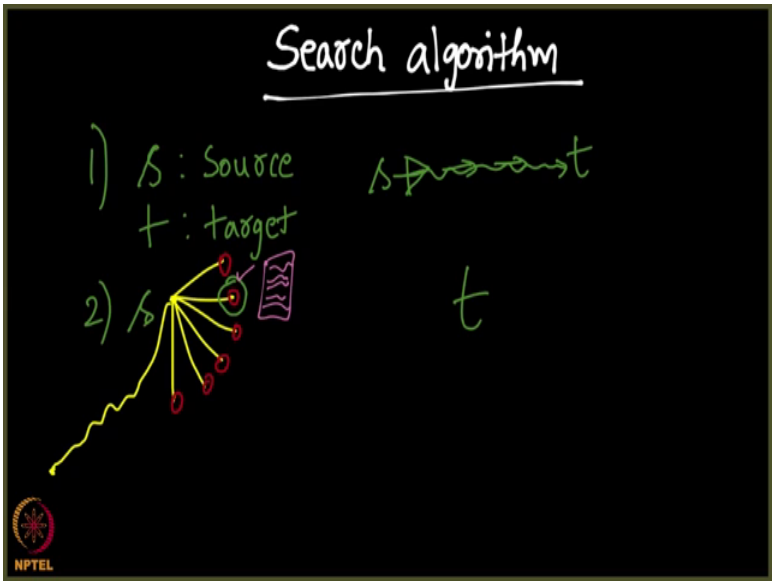

So, what we do is the following, we are first you are asked to go from a source node s, let us say a source node s and a target node t and a target node t ok. And, then what you do is I will write the second point you should go from s to t, s to you have to go to t and what you do is you will go to t, this direction, this direction, this direction. So, what you

do is you pass on you find that you find all nodes of s, you see s is of course, adjacent to many nodes. But you are on the lookout for that node which might be closer to t. As I have stated before as I have stated before there is this always this couple of people who are connected outside couple of your friends who are outside your geographical location.

So, you might find you may not find, but certainly amongst these friends of s that you have, some one of them would probably be close to t right. Someone would possibly be close to t and will pick that person who is close to t close to t and pass on the letter to him as simple as that, will pass on the letter to this very person right. And, as you know this sort of continuous and goes on. Now, let us think about this algorithm for a minute. What if this s is you ok, you are this s and t is in Australia, but you have friends see as you are in India and you need to send something to Australia? How does search algorithm work?

Let me try to confuse you people with a question here. What if s has all his friends in India with a couple of friends outside and that friend who is outside is let us say one from Indonesia and one from United States of America right. If you were to pass any of these; if you were to pass the letter to any of the people within India either you are not sure it will to go to Australia correct. But, at the same time if you try passing it to Indonesia or we should type United States you will be you will go further away from it right.

So, like going further away from t if you were to pass it to some someone else right. So, this random rewiring may not; this random rewiring may not necessarily guarantee you teleportation points, as I was telling you to nodes of your choice. So, that you can send the letter easily correct; these weak ties may not really connect you to the desired destination. They may not take you close right? they may not take you close. So, how does search still work? Right, it still works right we then in that case you know we just pass on the information to anyone here who is anyone here, who is close to t; he could be a fellow from India itself.

Or if the closest is actually someone from Indonesia to t we of course, do pass it to that person right. But, the question here is may be it would get complicated all the more complicated and you may not reach the destination at all, you might go away and away

from the destination well and fact is this never happens and the reason follows. So, what we will do is let us take a grid ok.

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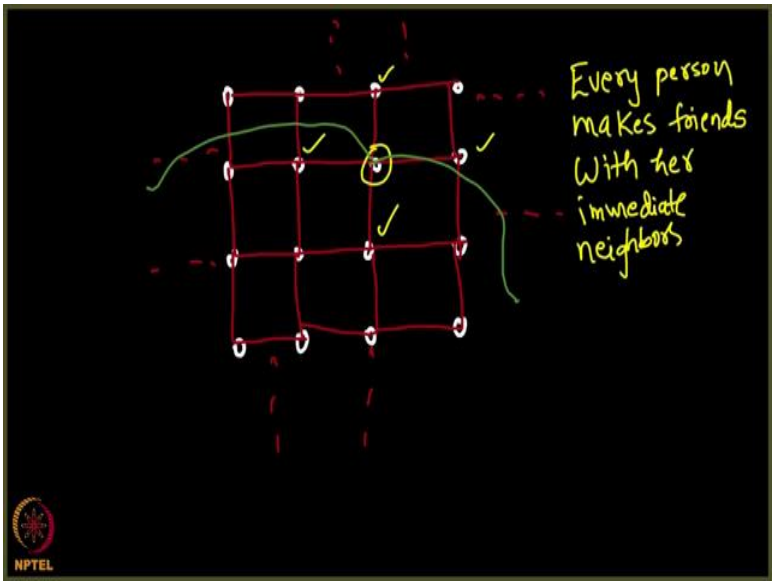

Just take a 4 cross 4 grid like this right and then complete the grid. So, every node has so many friends and as you can see a person has 4 neighbors and assume they are people on all the sides; it is a huge grid it is a huge grid. And, this represents that you are friends with; you are friends with these 4 people 1 2 3 not the one I am sorry yeah you are friends with these 4 people. But, then you are also friends with a couple of people away from you something like that right. So, assume every person let me write that down every person makes friends, I am writing it slowly because it is important. This better sink into our minds every person makes friends with his or her immediate neighbors right.

It will be necessarily be the 4 neighbors which are these, he might make friends with the nearest neighbors who are let us say 2 distance away from him. So, he might be friends with him 2 distance away, 2 distance away, 2 distance away etcetera. In his vicinity he makes friends, a couple of links is always way outside his vicinity which is far away ok. Let us assume this is the friendship network in 2 dimension and I will even write a code let us say to define what exactly are these green lines here. What exactly are these green lines? They are links to far away nodes. Let us come out with the way in which we

define these far away nodes ok. Let us come out with a way in which we define these far away nodes. So, how we define it?

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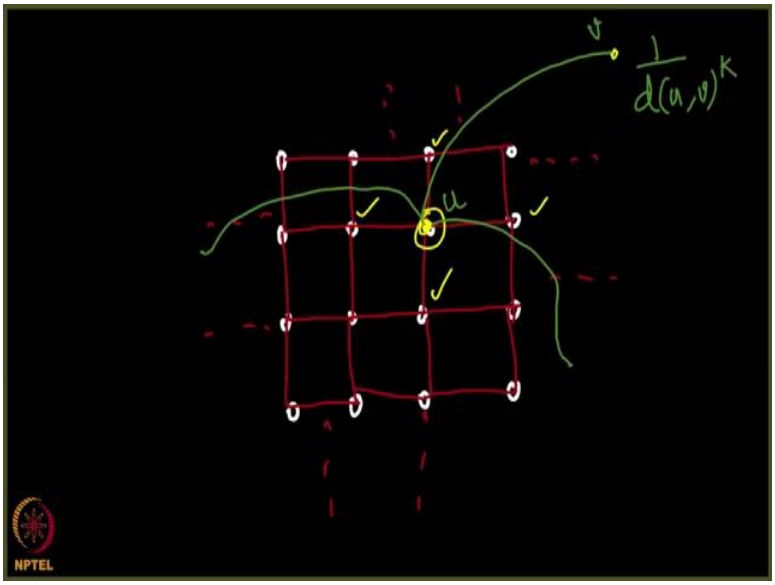

What I do is I pick a node far away from this node and then I put an edge with probability. Let us say 1 over distance between this is u and this is v, distance between u comma v to the power of k.