Social Network Analysis
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So, let us start the discussion on sign network ok. We have already you know understood what is a sign network, sign networks have edges with signs it. Generally, we think of we can think of two three types of signs positive negative and neutral. But when we discuss here in this particular lecture we assume that there are two types of signs positive and negative ok.

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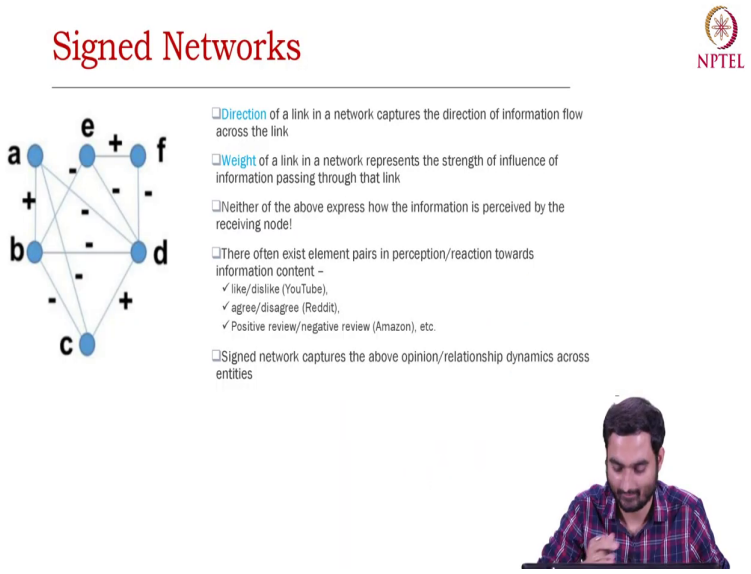

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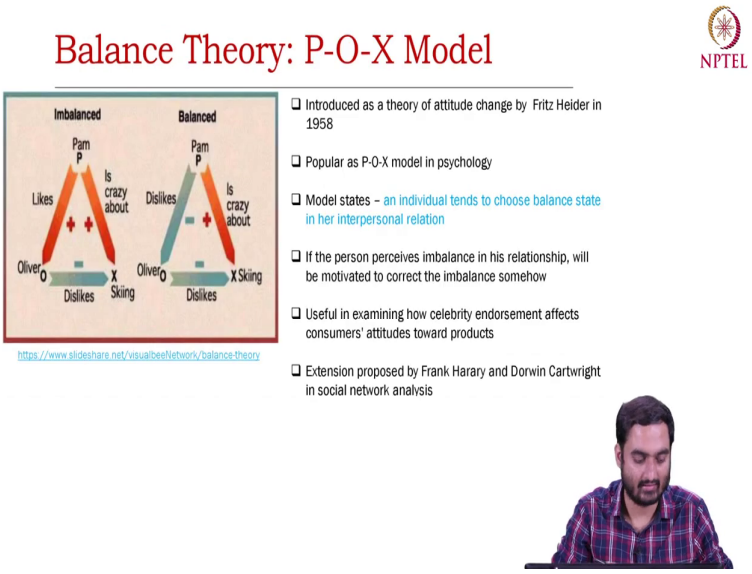

So, in the sign network when sign comes into the picture right, you can actually think of different ways to analyse it right. In social science theory there are two ways to analyse a sign network. One is called a balance theory another is called status theory right.

Now in balance theory what we try to understand we try to look at you know friends and enemies kind of relations right and we look at the network as a whole right. We look at a specific portion and then we see that ok you know this pair of nodes this particular pair of nodes have say positive relation, this pair has a negative relation and so on and so forth.

So, how can we how can we think of a notion called balance right. I mean when a network is not balanced what happens? You so that imbalance part right of a network will gradually split will gradually decentralized get decentralized and then you know nodes may move from one part of the network to another part of the network. So, therefore, it is always important to study the stability of a network ok, because if we know that let us think about telecommunication network right.

Let us say this Jio BSNL right Airtel, they have their own telecommunication network. And if you know that ok the Jio network is not that stable. In the sense like nodes I mean users are not very happy right. It may happen that a node can move from Jio network to say Airtel network or to say BSNL network right and this is called node churning. So, node is basically moving from one you know one part one sub part of a network to another sub part of the network ok.

So, now the question is if this actually happens can we quantify the stability in some ways ok. So, of course, there are multiple ways to quantify stability it basically comes under electrical engineering I will not talk about that aspect of it, but what I will talk about here, I will talk about more of a social science aspect right social science perspective here about stability ok.

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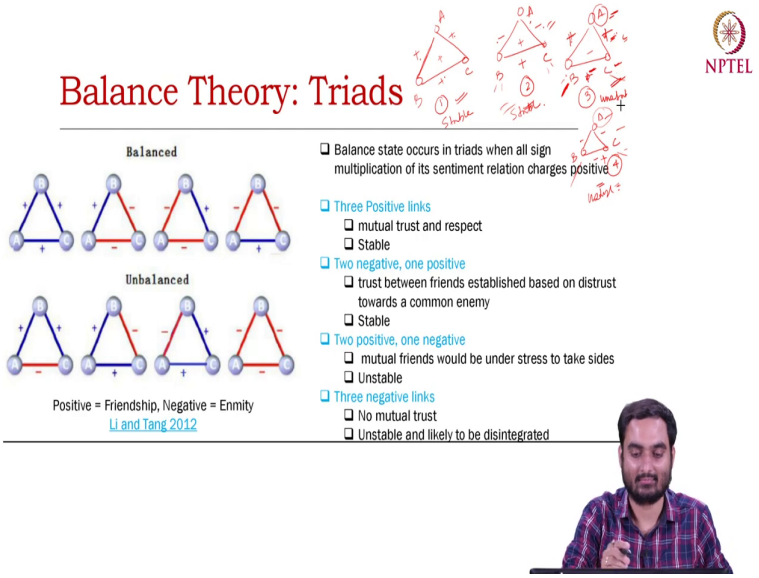

So, let us think of you know let us think of three node motive a triangle ok. What are the possible you know possible ways you can assign signs to different edges? It can be plus plus plus right.

Let us say this is A B C and I am assuming that each edge is undirected therefore, the relation is symmetric ok. So, it means that A and B are friends B and C are friends C and A are friends ok. This is 1 structure right. Structure 2: Right, let us say; let us say you know let us say this is structure 1 and now we have structure 2 where this is again A B and C and this is minus minus and plus right.

Meaning that B and C are friends where whereas, A and B are enemies and A and C are also enemies ok. Structure3: A B c and then positive positive negative right. This is structure 3. A B are friend A C are friend, But B C are enemies right and structure 4. A B C minus minus minus this is structure 4. So, these are the 4 possible ways you can you assign signs to edges ok.

Now, let us analyse these structures one by one ok. So, let us look at structure one this one ok. It basically says that this is a triad a triangle. It consist of you know three positive signs right and this is balance, because I mean all of them are mutually friends of each other ok. So, when everyone is friend of others there is a mutual trust and respect and therefore, the structure will be stable. So, this is a stable this is a stable you know stable triad.

Now, let us look at 2 right. In the second structure we see that there is a mutual enemy B and C are friends, but A is a mutual enemy ok. So, what does it mean? So, the mutual enemy towards the you know third party towards the third party between two friends that provides a common ground of interactions. Say B and C are friends and they keep talking about their enemies right, which is also quite natural in our society right. Whenever two friends meet they actually start talking about their enemies right the individuals who they who they do not like and so on and so forth.

So, therefore, you know this part would also be stable meaning that B and C will always remain friends whereas, A and B will always remain enemy and A and C will always remain enemy right. So, this is also stable. Let us look at the third one right. So, here two enemies B and C they share a common friend A and let us try to understand the meaning of this structure right. So, this is a triad consisting of two positive and one negative sign ok and this is unbalanced this is imbalanced ok.

The mutual friends B and C they would be under stress they would be under stress to make you know sides and support one friend over the other right. And what happens is that you know while you know 2other two other individuals B and C, they you know they keep maintaining their animosity ok.

So, the structure remain balanced only if the common friend is able to influence right, this common friend. We will able to influence right, the enemy one of the enemy nodes to become friends as well ok. Say this guy A convince C right to become B's friend. So, this would become positive then if this happens then this would become a stable otherwise not right or one of the enemy nodes one of the enemy nodes right exert some sort of greater pressure on the common friend right.

So, say for example, this guy B he starts pressurising A right to make an animosity with C. What would happen? Then this edge becomes negative for example. If this edge becomes negative then this structure is same as this structure. If B is able to convince this then

structures 3 will become stable otherwise unstable till this part. I mean if this is positive if this is you know this is positive this is positive this is negative then this is unstable right. And what about this one? What about the fourth one?

So, this triad consist of three negative signs and this is an unbalanced triad. So, when there is a there is no mutual trust among nodes, the structure is unstable right and will disintegrate unless two enemies come together and conspire against the third party.

For example, I mean you can think of it as you know different parties in political election and say A B and C they are all oppositions of each other right. But, you know but they also understand that I mean all the say particularly B and C they also understand that they would not be able to defeat A right if they you know participate in the election individually right.

So, what they would do? They would you know possibly collude right. They would collaborate in the in the election right and so that they together you know defeat A right. So, eventually what would happen? B and C would become positive and we you have two other negative edges. Therefore, this would become stable ok. So, this would this would be same as this one. But, in the otherwise in general if three edges are negative then this is essentially unstable triad right.

So, now how do we easily understand it? The easy way to the easy way to understand it without going deeper into the meaning of it, you just look at you multiply signs. So, plus times plus plus times plus is plus ok. Minus times minus is plus and times plus is plus right.

So, here plus times plus is plus and plus times minus is minus and the fourth one is also minus right. So, if the aggregated sign is that this is a very bad way of interpreting it in general, but you know in this way you can easily understand. So, if the aggregated sign is negative. It means the structure is unstable. If it is positive the structure is stable ok.

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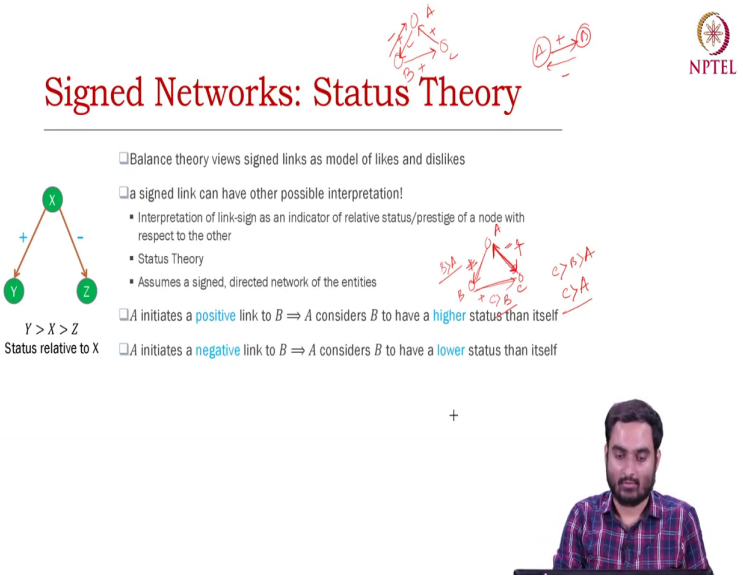

Now, this is called balance theory. In balance theory we try to understand the stability of a network the stability of our society based on the friendship and animosity kind of relationships ok. Now let us look at another philosophy through which we explain the stability, but this philosophy is called status theory. So, status theory is more of a kind of a local property of a network. What do we mean by this? Say if I say that A feels say let us say there are three nodes A B and C and A feels that B is superior to A. So, A feels that B is superior to A right. So, there would be an edge from A to B and this kind of direction.

So, the edge pointing to the person pointing to the node which is superior to the other one right, but remember this is A's belief. B's belief can be different B may think that no A is more superior to B right. So, we essentially look at every pair and with respect to one part of the one node of the pair we judge the sign. So, if A thinks that B is superior to A, there will be positive link from A to B and the sign would be positive. Let us say B thinks that C is to superior to B we will sign like there is an edge from B to C and the sign would be positive.

Let us say C thinks that A is superior to C, there will be a link like this right. So, I mean you can see the difference between status and balance theory right. Status theory by default considers directed networks. Status theory looks at an individual's opinion and based on that you can draw edges ok.

Say let us say B thinks that B thinks that A is superior to B, there will be edge from this to this and then minus. This is one way and other way is this. I mean if there is an edge from A

to B it is same as with the positive link. This is same as A link from B to A with a negative link ok.

Now, in status theory we try to analyse the same thing, we try to analyse the stability ok. So, let us see right let us assume again triad A B and C. Let say A thinks that B is superior to A there is a positive link like this. B thinks that so you see here B is greater than A. B is superior to A.

B also thinks so B thinks that so B thinks that C is superior to B. So, C is greater than B. So, by default if you look at the transitivity, this is the case. So, by default right C is superior to A C is superior to A. So, by default there would be a link from this from A to C ok.

So, the status theory actually says that if a positive link exist here and a positive link exist here, there will be a positive link there will be a negative link from C to A because the positive link is there from A to C. So, there is a negative link from C to A right.

And if this structure exists you can say that this is stable, but what about I mean what would the balance theory suggest here? The balance theory suggests that if there is an edge from A to positive edge from A to B a positive edge from B to C. In order to make this thing balance there should be a positive link from C to A whereas, the status theory says that there will be a negative link from C to A. So, there is a contradiction right.

So, therefore, it basically you know we say that balance theory overestimates the positive links. You see here that according to status theory this should have been negative, but balance theory says that this is positive. So, balance theory overestimates the positive link some cases. You can also say that status theory underestimates the negative link that is fine, but you see the kind of a contradiction between these two kind of two I mean two ways to look at the stability ok.

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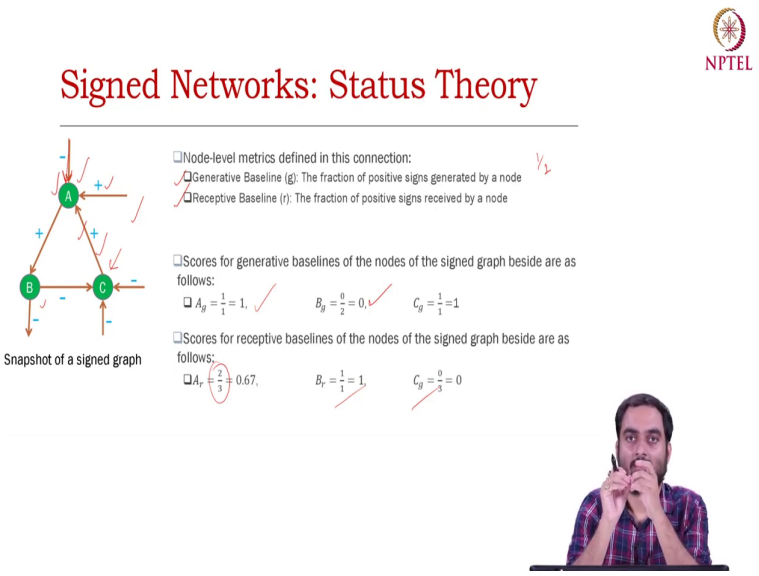

So, in status theory we also discuss two quantities, one is called generative baseline and another is called receptive baseline. So, what is generative baseline? Let us look at this example here. Generative baseline is the number of positive signed edges generated by a node number of positive signed edges generated by a node. Let us say let us say this edge C. So, how many nodes are generated from C generated by C? So, we will only look at those edges which are moving out of C right.

So, we look at this edge and that is all. So, there is one edge generated by C and that too is positive. So, therefore generative baseline is 1 by 1. Generative baseline for C is 1 by 1. What is the generative baseline for B? B generates two edges and both of them are negative right. So, the generative baseline of B is 0 by 2. Out of 2 edges 0edges are 0 edge is positive. What about A? Only one A edge has been generated and that too is positive so 1 by 1. Similarly receptive baseline captures the opposite thing. What is the fraction of positive sign edges received by a particular node ok?

So, A there is only one edge received by A and that too is negative. So, there are two other edges which are positive. So, there are three edges received by A and out of 3 2 edges are positive therefore, 2 by 3 is the receptive baseline. Similarly for B and C.

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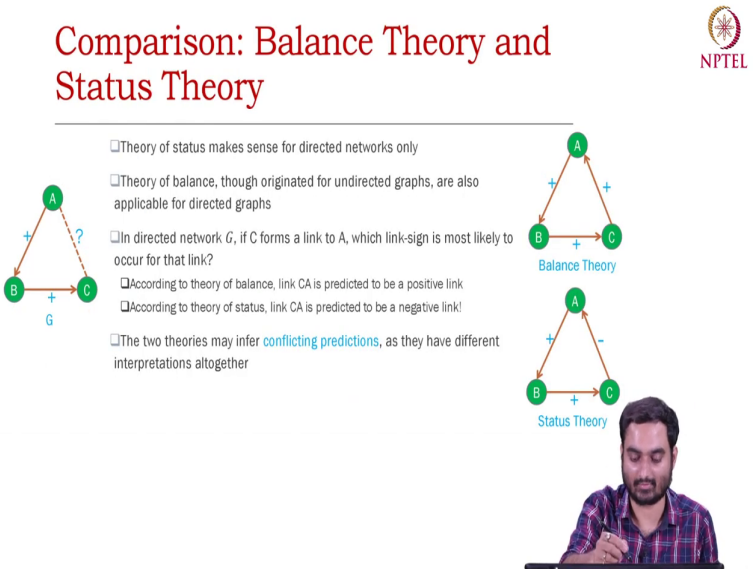

Now, why these things are important? Generative baseline and receptive baseline. So, for a particular node if you see that you know that node has high generative baseline right, but low receptive baseline, what does it mean?

It basically means that guy feels because high generative baseline, that guy feels that he is inferior to others. Therefore, the guy has generated a lot of positive links. So, that person believes that he or she is inferior to other persons that is why that is why positive links have been generated ok. At the same time if the receptive baseline is also low, it means that the other individuals also feel that this guy is an inferior person ok.

Now, let us think of another scenario, where an individual thinks I mean the generative baseline is low and the receptive baseline is high. It means that the guy feels that he is also superior the other guy is also feel that he is superior. Now generative baseline is high and receptive baseline is also high.

So, the guy feels that he is not that superior, but the other guy is feel that he is superior. It is more of a modest kind of behaviour right. So, the that the person you know he is a very modest person he always feels that he is not that superior, but others feel that he is superior ok.

Now, based on these notions you can understand different properties of nodes different behaviours of nodes, social behaviours of nodes ok, also the stability. So, status theory is

more of a local property. It captures local properties whereas, balance theory captures global properties ok.

So, we stop here and the next lecture we will discuss you know more technical part like page rank and other quantities.

Thanks.