IIT Madras

ONLINE DEGREE

Computational Thinking
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Construction of a graph where trains are nodes and stations are edges

Prof. Madhavan Mukund: So, we do these graphs connecting the stations. So, we drew edges, if you can go by train from one station to another station.

Prof. G. Venkatesh: Directly.

Prof. Madhavan Mukund: Directly.

Prof. G. Venkatesh: Because train as train departures depart from this station at some point in time and,

Prof. Madhavan Mukund: And goes to the right at that station.

Prof. G. Venkatesh: Yeah,

Prof. Madhavan Mukund: Sometime later,

Prof. G. Venkatesh: Yeah.

Prof. Madhavan Mukund: But now, supposing I want to know, something the other way around,

Prof. G. Venkatesh: What is the other way round?

Prof. Madhavan Mukund: So, I am on one train and I want to know if I can continue my journey on another train,

Prof. G. Venkatesh: Connecting train.

Prof. Madhavan Mukund: So, I want to know if there is a station where I can get off and switch over to another train, supposing it is my desire to get onto a particular train, and I am on some train. So, is there some way I can get to a place where I can go

Prof. G. Venkatesh: Connect to the other train.

Prof. Madhavan Mukund: Catch that train.

Prof. G. Venkatesh: So, you are trying to now draw. But understand you are trying to draw

Prof. Madhavan Mukund: Connections between trains.

Prof. G. Venkatesh: Trains. Yes, so, the nodes are trains now.

Prof. Madhavan Mukund: Yeah. So, you want Yeah, so, the nodes are trains…

Prof. G. Venkatesh: Nodes are earlier the nodes were stations and the trains were edges.

Prof. Madhavan Mukund: Yeah.

Prof. G. Venkatesh: And now, you want to make the node the train

Prof. Madhavan Mukund: And the edge will be representing a common station.

Prof. G. Venkatesh: Common station is

Prof. Madhavan Mukund: Where I can get off…

Prof. G. Venkatesh: Where I can transit.

Prof. Madhavan Mukund: Yeah transfer is from this station to that,

Prof. G. Venkatesh: Which is this train and that train should be crossing.

Prof. Madhavan Mukund: Crossing at that thing.

Prof. G. Venkatesh: Presumably you get over that and other trains should come later.

Prof. Madhavan Mukund: Yes.

Prof. G. Venkatesh: How about?

Prof. Madhavan Mukund: Of course. Of course

Prof. G. Venkatesh: You came earlier,

Prof. Madhavan Mukund: Of course

Prof. G. Venkatesh: You can wait

Prof. Madhavan Mukund: Wait till next week,

Prof. G. Venkatesh: That does not make sense. So, presumably, you get off at the station, you wait for a few hours, maybe one hour.

Prof. Madhavan Mukund: Yeah

Prof. G. Venkatesh: I do not know something I have a cup of tea or something.

Prof. Madhavan Mukund: Yeah.

Prof. G. Venkatesh: Something to eat. And then another train comes, you get in and you go. Something like this?

Prof. Madhavan Mukund: Yeah.

Prof. G. Venkatesh: Okay, how do you do that?

Prof. Madhavan Mukund: So, we would have to, I guess, again, for like we said earlier, I mean, the way we looked…

Prof. Madhavan Mukund: The way we look at stations was, we would check if there was a station and a train and common between the two. So, each station had a list of trains…

Prof. G. Venkatesh: Take two train.

Prof. Madhavan Mukund: Now we have to take two trains and see if they have a station…

Prof. G. Venkatesh: In common, wow.

Prof. Madhavan Mukund: And then, of course, we have to worry about the date and the time and all that. But first, let us just check this if if we are not worried about the time that it takes to make this transfer? Is there at least a station where I can switch from the straight to that?

Prof. G. Venkatesh: So, you drop so. Okay, so you pick some train?

Prof. Madhavan Mukund: Yeah. So, so we have some trains, let us look at these trains, for example, this might be a good starting point. So, we have…

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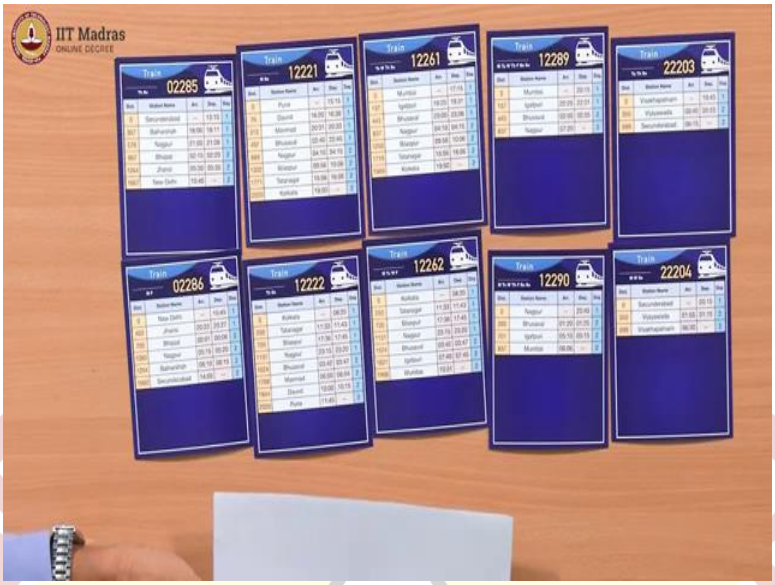

Prof. G. Venkatesh: So, going from somewhere to somewhere

Prof. Madhavan Mukund: So, some of them we had seen when we had already looked Yeah because we had seen train from Secundrabad. So, this is Secundrabad to Delhi and reverse. This is from Pune to Kolkata and the reverse. This is from Mumbai to Kolkata and then Kolkata to Mumbai. And then there is a train which goes to Nagpur which is also a station.

Prof. G. Venkatesh: Bhusaval is all right.

Prof. Madhavan Mukund: And finally, we had looked at Vijayawada. So that is a train which connects Secundrabad, Vijayawada.

Prof. G. Venkatesh: So Fine. So, it is based on what we saw earlier.

Prof. Madhavan Mukund: Yeah. So, some of these we have seen before. So now let us see what we can do with these trains.

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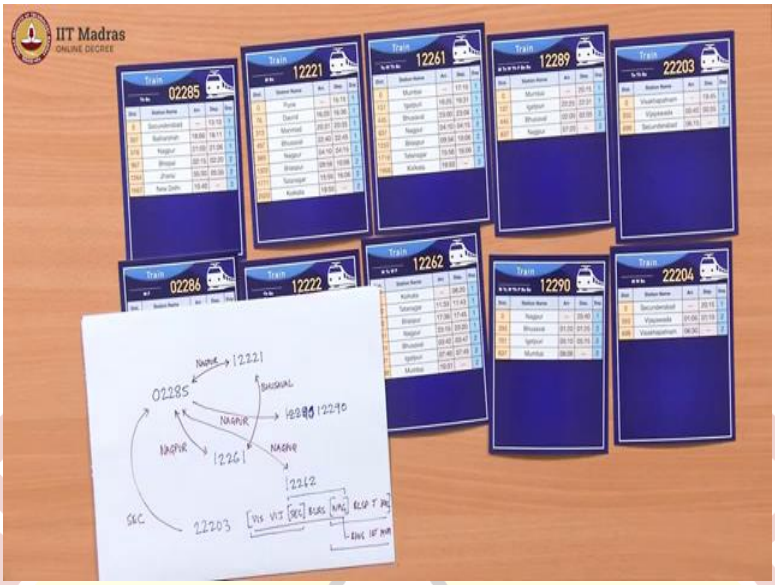

Prof. G. Venkatesh: So, what do you do draw? Do you draw every train here? One is the opposite of the right. If you draw, there are 10.

Prof. Madhavan Mukund: So maybe we can just do the one half of everything. And then it will hopefully turn out to be…

Prof. G. Venkatesh: We will see.

Prof. Madhavan Mukund: Yeah.

Prof. G. Venkatesh: So, you want to draw a note for 02285?

Prof. Madhavan Mukund: Yeah, so we are just drawing a graph. At this point, we are not doing a table. We are just doing a graph. So, we have 02285.

Prof. G. Venkatesh: That is a node now, it is not an edge.

Prof. Madhavan Mukund: Now we want to know…

Prof. G. Venkatesh: Let us say we want to go to 12221..

Prof. Madhavan Mukund: So we want to know whether this is connected to 12221 or not.

Prof. G. Venkatesh: So, to say whether 02285 is connected to 12221, there has to be a common station yet.

Prof. Madhavan Mukund: So Secundrabad, So Balharshah, Nagpur.

Prof. G. Venkatesh: Nagpur is there.

Prof. Madhavan Mukund: And we see Nagpur is there. So, we can draw an edge.

Prof. G. Venkatesh: So how would you go in from Secundrabad? So, you are taking this train you are on this train. Secundrabad you get off at Nagpur at 21:00, at 9 o'clock.

Prof. Madhavan Mukund: 9 pm. And at 4 am. But it may not be the same day. We do not check the days, that is a problem. But at least if it was every day, then you would have a few hours wait and then you will do it. So, you can draw this edge now. And maybe you could label it as Nagpur.

Prof. G. Venkatesh: You are labeling the edge with the station name now.

Prof. Madhavan Mukund: Yeah. So earlier, we had taken because earlier, we had taken the stations and label the edge with the connecting train. And now we are talking about transfer station.

Prof. G. Venkatesh: This is interesting because you can do both ways. This seems the graph is a very powerful structure.

Prof. Madhavan Mukund: So now we could do the same thing. For instance, we can look like. So, this and this, for example. So, let us look at…

Prof. G. Venkatesh: 02285, 12261.

Prof. Madhavan Mukund: So, we have 12261 and again, you see that Nagpur is there. so Nagpur seems to be a common station.

Prof. G. Venkatesh: So, you get off at Nagpur at 9:06, and then catch the 12261 at 4:10 again .

Prof. Madhavan Mukund: Also, these two trains happen to leave pass through Nagpur at the same time, the thing maybe on different days of the week, but so again, I can write this and like write Nagpur here. What about 12289 again, Nagpur. So, this is also connected. via Nagpur. So, again via Nagpur.

Prof. G. Venkatesh: This time you catch it at 7:20. This train is there everyday. Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday

Prof. Madhavan Mukund: Yeah, that at least you…

Prof. G. Venkatesh: You get off from 02285 at Nagpur 9 o lock next morning, 7:20, you can catch for sure you will get this train.

Prof. Madhavan Mukund: And then the last one is 22…

Prof. Madhavan Mukund: 03. And that is connected

Prof. G. Venkatesh: With that guy, if you want to go from Nagpur you have to take the street.

Prof. Madhavan Mukund: So, we have to go to 12290? Shall we change this 90 here? Because you are not going to go anywhere. So, I write this as 12290. And this is a train, which is starting at Secundrabad. So those trains in that Secundrabad, respectively.

Prof. G. Venkatesh: Here is one starting at Secundrabad.

Prof. Madhavan Mukund: So now how does how do we connect this? Well, you can, we can connect from there to here. So, we can say that if we were in 22203. Then we could get off…

Prof. G. Venkatesh: Visakhapatnam you can go to Secundrabad and Secundrabad, you can go to. So, you arrive at 6:15 and 1:10 wait in Secundrabad and catch the 1:10 train

Prof. Madhavan Mukund: Assuming the day is 7:26 which which may or may not happen,

Prof. G. Venkatesh: But then you go to Delhi or whatever it is.

Prof. Madhavan Mukund: So, this is one set of .

Prof. G. Venkatesh: It is there, Thursday for example you can do it. Sunday also you can do it.

Prof. Madhavan Mukund: Then, for instance, we could look at some other pairs. So…

Prof. G. Venkatesh: Take these these when we connect that to these but somewhere in the middle, we should try.

Prof. Madhavan Mukund: Yeah, sure.

Prof. G. Venkatesh: About being 12221 with 12261, 21 and 61

Prof. Madhavan Mukund: 21 and 61. So of course they both passed through Nagpur, which is not so in some sense they are connected via Nagpur. So, it depends on where the in both directions you can go Bhusaval, Nagpur. So, we could actually put more than one station on that edge if we want, is that okay?

Prof. G. Venkatesh: Yeah. SO more than one edge.

Prof. Madhavan Mukund: So now, it can go both ways. So, you can come from Pune to. You can come to Pune to Bhusaval switchover you can come from Mumbai to Bhusaval switchover. So, it is actually the edge is in both directions. It is in both directions. Even there where the edge in both directions, Secundrabad to Nagpur then switchover within Pune to down then switchover.

So again, actually, technically, should I just put both directions there? So maybe if the both directions with Nagpur, I will just draw one edge and put two arrows rather than drawing too many lines. I will draw it like this. And the same is true, I think of this and this? No, this is only one direction, right? Because 12 I cannot come from here and switch over to that.

I can only come because this is starting here. And Nagpur this is because of the starting. So, there is only one direction, or 12261. And 21 have this feature that they are both connected in both directions to this. Whereas this train and this train, have this thing that they go to Secundrabad. So, 22203 goes to Secundrabad, and then you switch over, you cannot go back the other. So now we are saying that between these two, you could switch over at Bhopal or Bhusaval or at Nagpur. Even at Bilaspur or Tata Nagar or Kolkata,

Prof. G. Venkatesh: What do you do the first one.

Prof. Madhavan Mukund: So, let us do Bhusaval.

Prof. G. Venkatesh: Pune to Bhusaval

Prof. Madhavan Mukund: Yeah, so the earliest point in some sense that you could switch over and you can do it in either direction. between these,

Prof. G. Venkatesh: Of course, you can go from Pune and Mumbai directly. You don't have to go to Bhusaval. If you wanted to with these two in this example.

Prof. Madhavan Mukund: Yeah, you could go there and then. Well, technically you can only go forward if you want to go backward. You will have to go to this

Prof. G. Venkatesh: Of course, you do not want to go to Igatpuri for example.

Prof. Madhavan Mukund: Yeah, then you will be right. Nobody will ever come to this train to go do Igatpuri. Because this train doesn't go to Igatpuri, it is coming from Igatpuri.

Prof. G. Venkatesh: So, so that would be a different.

Prof. Madhavan Mukund: So, so you would have to look at. So, you would have to put say 12262 and then connect that also in both directions. But then you have to look at the list of stations to know what this extension looks like.

Prof. G. Venkatesh: So, if you sit presumably if you have done this training, we have connected one train to another train. It says basically, that I am traveling on this train, I go on till I reach the station,

Prof. Madhavan Mukund: I reached the station, then I switch over…

Prof. G. Venkatesh: And then…

Prof. Madhavan Mukund: Then I can continue…

Prof. G. Venkatesh: But then I can try to make a kind of list of stations. Which is from this train, I take the list of stations up to the switchover point from that I take the list of stations and other trains.

Prof. Madhavan Mukund: So, we could start this like to start from here.

Prof. G. Venkatesh: Let us start let us do that…

Prof. Madhavan Mukund: So, you can do because you want to do Vishakhapatnam and then Vijayawada…

Prof. G. Venkatesh: then Secundrabad…

Prof. Madhavan Mukund: Then I do Secundrabad then I switch over to come here, then in Balharshah. Then Nagpur then Bhopal

Prof. Madhavan Mukund: No, but I am going to switch over to this train, and then I do Bilaspur. And then I do Tata Nagar and then I do Calcutta, So, I can go a very roundabout way from Visakhapatnam all the way around and go to Kolkata instead of just going up the coast.

Prof. G. Venkatesh: This does not make sense if you want to visit a few other cities.

Prof. Madhavan Mukund: Yeah. And on the other hand, if I switch over to the other train 12261 also the same thing would happen. But we saw that this is also connected to 12262 via so for example, this would be connected to 12262 via Nagpur. And so there is also a connection from here to here via Nagpur. So, if you have followed that connection, I would

come up to Nagpur and then I would switch over to 12262 and then I could do Bhusaval Igatpuri, Mumbai. So, I can go from Visakhapatnam to Mumbai.

Prof. G. Venkatesh: So, you know for example; I want to and I am in Visakhapatnam now. I want to go to both Mumbai and Kolkata. What I could do is I could go from Vishakhapatnam to one Vijayawada, Secundrabad, Balharshah Nagpur get off at Nagpur. Book a hotel stay there Yeah, go to Bhusaval, Igatpuri, Mumbai. Visit Mumbai enjoy the Mumbai Gateway of India whatever it is all the things come back Igatpuri, Bhusaval, Nagpur. Go back to my hotel. Stay there. And then go there again. Bilaspur, Tata Nagar, Kolkata. See Kolkata

Prof. Madhavan Mukund: And then come back.

Prof. G. Venkatesh: And see a cricket match or something. Tata Nagar, Bilaspur, Nagpur stay at the hotel again.

Prof. Madhavan Mukund: Yeah, and then maybe.

Prof. G. Venkatesh: I can do that, this is useful this kind of thinking

Prof. Madhavan Mukund: Correct. So, you have basically these lists so they are interesting. So, you have this list which comes from one train and then it will overlap at that so we have this overlap.

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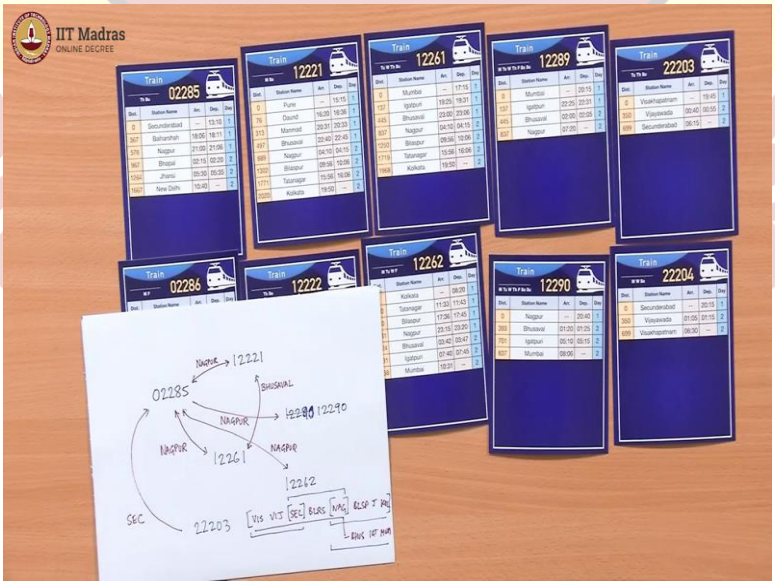

Prof. Madhavan Mukund: So, this goes up to Nagpur and then Nagpur. So, we have these three lists you have this one list and you have this other list and then you have this third list.

Prof. G. Venkatesh: And fourth on the bottom.

Prof. Madhavan Mukund: And then at the bottom, you have another fourth list which also starts at Nagpur and goes up…

Prof. G. Venkatesh: So, it is basically the segments of…stations.

Prof. Madhavan Mukund: Yeah, so you have this you have a list and then you have another list which overlaps at the changing point and then you have another list with all changing points… and by this

Prof. G. Venkatesh: Stringing together. It is a long word. long word by taking.

Prof. Madhavan Mukund: So some you know this word building you know, I my word ends in E you must start a word with E. Like if you think of all those words, so I started I stopped at a station now you must get on at that station continue like that. So yeah, so you could actually play this game, and see how long you could have how long you could go without getting stuck.

Prof. G. Venkatesh: Is there is there a way of finding out whether I can visit let us say two days I started today morning, early morning and I am ready to go up to tomorrow night. What is the maximum number of stations I can visit, maximum, like this you got yet I do not know if it is the same day. But I want to do this in this limited amount of time. I only two days on a visit as many stations as possible, via train only some places I may get off.

Prof. Madhavan Mukund: So, so you should, first of all, I guess start your journey as close to midnight as possible.

Prof. G. Venkatesh: Okay, all right.

Prof. Madhavan Mukund: So, you must look at stations where there are departures close to midnight soon after midnight.

Prof. G. Venkatesh: Okay

Prof. Madhavan Mukund: Then look at those trains, which are leaving at that time from these stations. So, let us pick any one station. We start, you list out all the stations,

Prof. G. Venkatesh: We will pick Delhi.

Prof. Madhavan Mukund: Let us pick Delhi. So, we start looking at the trains, which leave soon after midnight at Delhi.

Prof. G. Venkatesh: Okay,

Prof. Madhavan Mukund: So, you take one train,

Prof. G. Venkatesh: Look at it is going keep going,

Prof. Madhavan Mukund: keep going, and see how far you can go on one day.

Prof. G. Venkatesh: That may not have too many stations is not it?

Prof. Madhavan Mukund: Yeah. So, then we might also want to switch over to smaller trains because they stop at most stations. So, I think you will have to check every one of these possibilities, right? Do you either you either you either you have to go straight through…

Prof. G. Venkatesh: And then you take a train and see which train has the largest number of stations in one day.

Prof. Madhavan Mukund: Okay, and then you can say where where to get off…

Prof. G. Venkatesh: In fact, you should not even just do one day, you should do segments of the day. Let us say the morning, afternoon, evening, something divided into some segments.

Prof. Madhavan Mukund: Okay.

Prof. G. Venkatesh: Then if I have a way of stringing together. Like we did stringing.

Prof. Madhavan Mukund: Yeah.

Prof. G. Venkatesh: I think in the morning, let us say there is one train which has got a large number of stations. In afternoon there is another train which is doing large number of stations.

Prof. Madhavan Mukund: So, can I get from this train to that train, that would that this graph will tell us.

Prof. G. Venkatesh: Something like that.

Prof. Madhavan Mukund: Is there a way to transfer from this train to that train.

Prof. G. Venkatesh: Let us string together or something like that.

Prof. Madhavan Mukund: Yeah, so that is a possibility. Yes. So, one could use this kind of information, to first look at these kind of dense segments where the train stops at a lot of places.

Prof. G. Venkatesh: A lot of stations.

Prof. Madhavan Mukund: Within a day, within a half a day. And then put these two segments from two different trains together to get a long segment of a lot of stops. It is possible, We could do that.

Prof. G. Venkatesh: Okay, not right now, but it is gonna take a long…

Prof. Madhavan Mukund: But you can do some kind of…

Prof. G. Venkatesh: Processing.

Prof. Madhavan Mukund: Processing. Yeah. So, you can first process all the trains, as you said, Look, for those which have I mean, obviously, you will not pick up these trains, which have only two-three stations. Yeah. So, you look for trains, which have more stops, and then try to string them together to form these segments.

Prof. G. Venkatesh: Have another question, I mean, occurred to me when we are doing this stringing of trains and things like that. Often the we saw this segment, then one train is coming behind.

Prof. Madhavan Mukund: Yes.

Prof. G. Venkatesh: So, one train goes, then the other train comes waiting for this train to have crossed, then it will cross right like that. They come on, we had other in those segments. If the first train is delayed,

Prof. Madhavan Mukund: Then the second train is very likely to get off.

Prof. G. Venkatesh: In fact, there is a third train coming great, that also is delayed say delay, one train gets delayed, and then it creates delay,

Prof. Madhavan Mukund: For a number of…

Prof. G. Venkatesh: Number of trains. So, if, if I know one train is delayed, and I find out which other trains will get delayed, how much delayed with there also. So, I can tell people know. So, for example, I know this train is delayed, if I can predict, predict that not only is this train delayed, there are going to this train delayed down the road.

Prof. Madhavan Mukund: Yeah

Prof. G. Venkatesh: This train in various stations is going to come late. But because it is coming late in those stations, other trains which are going to come behind it in those stations will also delay. So, I can inform people, I can send them an SMS or something telling them that yes, a train is going to be delayed. Oh, so they do not waste their time. So, if there is a way to predict really nice,

Prof. Madhavan Mukund: Yeah.

Prof. G. Venkatesh: How to do that?

Prof. Madhavan Mukund: So again, you could .. similar. You could I would say the following you take a train. And you see if there is station first of all there should be a sequence of stations maybe that they are following the same route that I saw here. Like right here, for instance, like there is Nagpur, Bilaspur, Tata Nagar, Kolkata. And then you see…

Prof. G. Venkatesh: Even if one station they are overlapping, they are likely to be overlapping more than one. But even if they are one station overlapping and one guy is coming, just likely behind the other guy, in that station. So, the station tells you actually look at the station.

Prof. Madhavan Mukund: Yeah, it tells you straight to the train which train is coming next.

Prof. G. Venkatesh: So, let us take one example of a station, let us take Nagpur for example.

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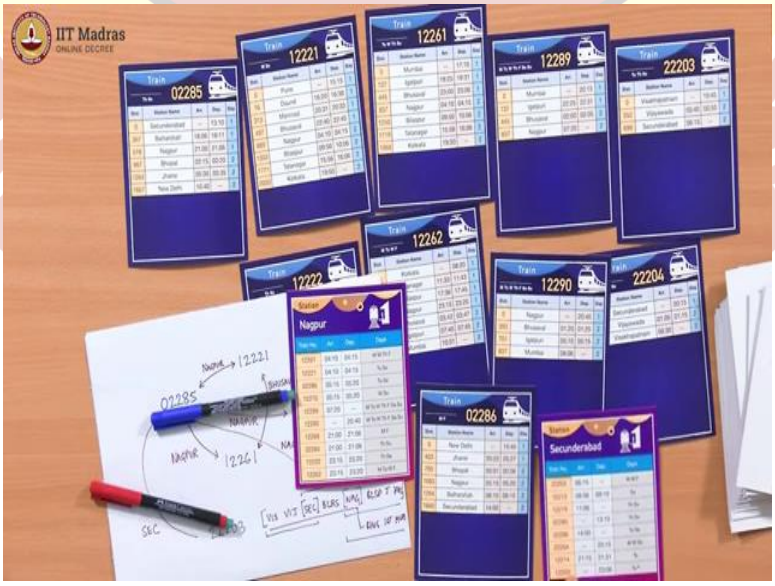

Prof. Madhavan Mukund: Nagpur will have trains.

Prof. G. Venkatesh: He saw Nagpur as a lot of things.

Prof. Madhavan Mukund: Yeah.

Prof. G. Venkatesh: Nagpur, Bhusaval and all that, right.

Prof. Madhavan Mukund: So, what you are saying is that, for instance, if this 12221 is delayed.

Prof. G. Venkatesh: Well, 12221 is delayed.

Prof. Madhavan Mukund: Then this thing will also possibly…

Prof. G. Venkatesh: Let us say it is delayed 1 hour, 4:15. It is supposed to arrive at 4:10. It is delayed by 1 hour. So, it arrives at 5:10 and it waits for 5 minutes, so it leaves at 5:15. So this guy can come actually, in principle, it can come at 5:15 no delay, but instead of being delayed by one hour, it is delayed by two hours.

Okay, one possibility is that this fellow arrives and goes away and then that guy come later, but usually that never happens because they are coming from.., right? But it is either okay. Yeah. Or assume that for example, that is not the case that this guy is going to wait yeah, then this fellow comes at 4:10 instead of 4:10 he comes at 6:10 then this train is delayed 6:15, and this train, then only this guy can come.

Prof. Madhavan Mukund: So, one-hour delay…

Prof. G. Venkatesh: 1 hour delay.

Prof. Madhavan Mukund: So two-hour delay then means or translates to one-hour…

Prof. G. Venkatesh: 1 hour delay for 2286. So, so, this guy is now 6:15 he leaves at 6:20 this guy is also 6:15 6:20. Different platform, I guess presumably I don't know what it is or not different days, different days. Then this guy is at 7:20 so no problem. So, the delay only has propagated to this train, does not propagate to this train.

Prof. Madhavan Mukund: yes.

Prof. G. Venkatesh: But because this guy is delayed to 6:20 now 2286, even this guy is delayed this guy is delayed.. you have to see where all 2286 is going.

Prof. Madhavan Mukund: Yeah. So, for instance, you see this has to be we have to do 2286 for example. Then you have to go and see whether, after this and Balharshah, there will be some other train perhaps which…

Prof. G. Venkatesh: Balharshah is a small station…

Prof. Madhavan Mukund: Secundrabad.

Prof. G. Venkatesh: What happened in Balharshah? Let us take Balharshah Okay. So Balharshah we got. So, he got delayed by 1 hour. So, Balharshah 2286 arrived at 8:10 instead of arriving at 8:10 later, now, he came at 9:10 unless he made up the time sometimes make up the time as you get 1 hour if did not makeup. So, you came at 9:10. So, because he came at 9:10 and departed 9:15 it did not have any impact on other things.

Prof. Madhavan Mukund: Yes.

Prof. G. Venkatesh: No problem with Balharshah. But what is the next one?

Prof. Madhavan Mukund: Secundrabad.

Prof. G. Venkatesh: Okay, Secundrabad. So, what is the train?

Prof. Madhavan Mukund: 2286.

Prof. G. Venkatesh: 2286 supposed to arrive at 2 it came at 3 again no problem. So, we can therefore like this one can propagate I presume?

Prof. Madhavan Mukund: Yeah. So, at that station first, you look at it within the station, if I have a certain delay, how many trains are arriving within that delay and therefore, what is the amount the minimum they will get pushed by this delay, then you can go to the next station and those trains and say now this train is going to reach those stations assuming that the delay is not made up, you can say that this will therefore reach one hour later at the next station, then again, do the same.

Prof. G. Venkatesh: Do the same thing.

Prof. Madhavan Mukund: Propagated and see how many other trains at that station will get pushed.

Prof. G. Venkatesh: Yeah.

Prof. Madhavan Mukund: And then look at their corresponding next station and so on until we reach a situation in its illustration where it says okay, this next train is sufficiently far away that it is not affected by this. So, this will kind of…

Prof. G. Venkatesh: Propagate the…

Prof. Madhavan Mukund: Yeah. So, do you have this kind of influence? So, they have one delay here, which influences trains at this station that influences trains at neighboring stations, that influences other trains, which influences more neighboring stations, and then hopefully, this eventually, Peters out, it becomes because there are gaps in between trains, which are longer than the delays then you get. But yeah, so this is…

Prof. G. Venkatesh: Interesting. So if you think about it, made a graph, right? You made a graph of trains, actually trains and stations, either made the node stations, edges, stations or nodes, trains are edges or whatever it is, or it could be just what we saw in the dictionary thing, have a dictionary of train, which linked to station a list of stations, you have a district Dictionary of stations which link to a list of trains, whichever way something, so they have representations, then what we are doing basically is that this graph, you are actually propagating the delay.

Prof. Madhavan Mukund: Yes, pushing it through…

Prof. G. Venkatesh: Pushing it through the graph. It is like water.

Prof. Madhavan Mukund: Yeah, the pipe pipes…

Prof. G. Venkatesh: And put it goes through the pipes it is going through the pipes or edges of the graph put the water on the node it went drying it went through the edges. And then after some time…

Prof. Madhavan Mukund: It dries up.

Prof. G. Venkatesh: It dries up water goes anywhere it stops, the delay stopped.

Prof. Madhavan Mukund: Yeah, so that is something else that you could do yeah correct.

Prof. G. Venkatesh: So, this graph is a very powerful thing and you can do a lot of things with it looks like.

Prof. Madhavan Mukund: Yeah,

Prof. G. Venkatesh: You can use it for calculating distance we saw, calculating time we saw.

Prof. Madhavan Mukund: Correct.

Prof. G. Venkatesh: Doing this stringing of stations together and doing something with it. And now right now, we saw basically also delay propagation which is useful, right because…

Prof. Madhavan Mukund: Yeah, definitely you want to know the impact.

Prof. G. Venkatesh: Know the impact yeah.