00 Hi, it's Margaret Maloney. I thought we would take some time together and revisit the network diagram.

0:07 For many of us, creating the network diagram can be very complicated and daunting, especially the first few times through it. There are a few of you who can look at a list of activities along with their estimates. And you can see the schedule right in your head. You get the picture right away. But most of us need to practice creating a network diagram multiple times, multiple times. More than one, more than two. More than once, more than twice. With this thought in mind let's walk through it again and be sure to pause this video as many times as you want. And watch parts of it over as many times as you want. Because it's for you. So this is about you and your learning. Please don't cheat yourself. What you have is you've got, see this area here? I'm gonna highlight it here for a minute. This is work. Now, this is a project for building a stage. Allegedly cuz it's simplified for us, so I'm sure that building a stage is more than this.

1:08 And what we have is the activities with just their numbers, their IDs. We have a description of them. For example, activity one is hiring workers.

1:19 And then we have a duration. And I'm gonna say days, even if that's crazy. Maybe it's a really big stage. But I'm just gonna use days cuz it's simple to talk that way for me. And then what we have over here is predecessor, what comes before. What comes before. And you remember that if an activity has no predecessor, which is true of items one and two then they are the first pieces of work that can occur. So keep that thought in mind.

1:47 Over here, let me highlight this, we have a legend, and that legend is showing us these rectangles that we're using to map out different fields, because we are going to be like computer project scheduling software and we're gonna do some calculations. And the calculations that you and I are doing are what your scheduling software does actually do for us. So we have the rectangles divided up with little legends, see in this top corner here, top left-hand corner, it's ES. That means early start, what is the soonest that this piece of work can begin? Here we have just an identifier, which is the activity number.

2:27 Here we have EF, EF like Frank early finish. How soon can the activity finish? Here we have something called float, you will also hear people use the word slack.

2:40 Float and slack are used interchangeably.

2:44 And then we have LS or late start. What is the latest that this activity can start? I know that sounds weird but as we go through this, it will hopefully begin to make more sense.

2:55 Duration, which just comes from the table over here. How long is it gonna take. Just like the activity number came from the table over here. And LF light, again, LF like Frank or finish which is what it is, late finish. What is the latest this can finish? And we mean, without delaying the project, or without delaying the work that happens after it as well. Now, what we do to find out the path of the project is we do what's called a forward pass, and we do what's called a backward pass. And the forward pass involves you and I going through this network diagram down here from left to right. And that is the forward pass. And we go through each activity and were gonna calculate, on a forward pass, what is the early start and what is the early finish for each piece of work.

3:56 When we do a backward pass, then we are going from right to left, so we're going from the end to the beginning, and we are calculating the late start and the late finish. So we need the forward pass and then the backward pass. When we have finished both, then we can calculate the float. So where did this diagram come from? That, just, this, Here, comes from this up here. So remember when I said if an activity has no predecessor, it means that could be the first work, so activity 1 and 2 neither have predecessors, so when we draw our network diagram, we know that 1 and 2 can both happen at the start of the project, and that also means since they don't have a predecessor, they can both happen in parallel, so that's how we draw them.

4:46 Now activity 3 has predecessor of 1 and 2. So activity 3 cannot start until 1 and 2 finish. And by the way, when we do draw these, we do assume a finish start relationship. So 1 must finish before 3 can start. 2 must finish before 3 can start.

5:06

Now, activities four, five, and six, look at them. 3 is a predecessor to all of them, and since they have no other predecessor, we know that, all other things being equal, those three activities, installing the lights, installing the sound, and installing the seats can all happen at the same time, they just have to wait for 3 to finish.

5:29 Then, when we get to cleaning this stage, which is the last thing we do, cleaning

5:34 this stage cannot be accomplished until we finish 4, 5, and 6.

5:40 That's how we got this flow here, this network diagram. That's how we came up with the way in which things are ordered.

5:48 I do recommend that you might practice that as well and that you take this table here and you give yourself some time and you practice drawing this diagram down here without looking at it. We have our network laid out.

6:11 We have parts of our legend for each one filled in, cuz we have the activity and the duration filled in on each item. And by the way, I always recommend that. Do the easy stuff first. So go in, once you have the work mapped out, once you have this structure drawn. Go into each one and fill in the activity and the duration for each one, because it helps you, because you're gonna use it in the calculation, now, let's begin our forward pass.

6:40 On the forward pass, the early start, and we're using the approach where we start with day 1 the early start is always 1. We start on day 1. So that's easy, for the first activity or activities.

6:58 To get the early finish, we take the early start plus the duration minus 1.

7:07 So let's fill that in and then we'll come back and talk about that for a minute. So early finish goes here. It's the early start which is 1, plus the duration which is 20. Which is now that makes that 21 minus 1, which makes it 20. That goes there, over here 1 plus 10 minus 1, gives me 10.

7:31 Now why do we subtract out the 1? Because this 1, this stray 1 that follows us through the forward pass and the backward pass, this is the thing that usually confuses most of us.

7:44 Think of it this way, we're gonna start the work at the beginning of the day. And when we finish, we finish at the end of the last day. Okay. Now I'm gonna use an easy example now, because I'm gonna run out of fingers otherwise. And I will often do this on my fingers, that if I'm standing in front of a group of people, I will actually count it out on my fingers. But think about this, let's say we had a piece of work and it was five days. We started on the first day.

8:17 Do we call that six days? In other words, do we take day one, and add in the duration, and say that we finished on the sixth day?

8:26 Now think about it. If it's five days, and I really finish it at the end of the last day, Here's how it works. I work one day, I work two days, I work the third day, I work the fourth day, and I work the fifth day. At the end of the fifth day, I'm done.

8:43 So therefore, my early finish is five.

8:47 Okay?

8:49 That's why we're netting out for the one.

8:53 So now with activities one and two set up, we have to look at activity three. Now activity three, how do I get the early start for a successor? So now I wanna look at successor, because three is the successor to one and two.

9:07

9:07 Okay. Well, here is the formula, but you know, we have a little typo here, here's the formula.

9:16 But, what if an activity has more than one predecessor? And that happens to be true right off the bat. We have to use this rule here, what if an activity has more than one predecessor rule.

9:28 We use the highest early finish, of the predecessors, the highest early finish. That means we're gonna use the 20, because 20 is greater than 10. See, that's not hard. That's not difficult. We use the 20. Now, what's the formula? The formula is that predecessor plus 1. So I take 20,and I add in 1. So I start activity three on day 21, and that makes sense because activity one ended at the end of day 20. So we come back in the next morning, and we start off activity three. Now why would I take the predecessor, the highest early finish? Why would I take the highest number? You know this, of course. Because, if I have to wait for two things to finish, both these items have to finish before I can start three,

10:27 I cannot start until the last one finishes. There you go. So that's that trick. Now, to get the early finish, I'm really just taking the early start plus the duration minus 1. Right? So 21+20 is 41-1 is 40.

10:48 Now activity four, five, and six. They're early starts.

10:55 They all have one predecessor which is three. Yay, so this one's more simple, yay, happy about that.

11:03 And they all inherit their early start from the predecessor plus one. So that's this formula right here.

11:12 So that means, they all get their early starts are equal to,

11:19 the early finish of the predecessor, which his 40, plus 1, which is 41. They get the same thing because the work ended at the end of day 40, so we pick up again at the beginning of day 41.

11:33 Now, to do the early finish. It's our same old thing again, we take the early start. Here's our formula again. Plus the duration minus 1. So 41+5 is 46-1 is 45. 41+10 is 51-1 Is 50. 41+7 is 48-1 is 47, and there we go. Now we're at the very last activity. And again, I have to make a choice, because there's more than one predecessor.

12:10 So again, I used the highest early finish, because if it must wait for everything, all three of those activities, to finish before it can start. It cannot start until the last one begins. So that means I used the early finish of 50, because that's the highest one.

12:33 And now it's 50+1. It's 51.

12:38 And now I apply my earlier calculation which is becoming easier for you and I. And that's just the early start plus the duration minus one. So 51+2 is 53-1 is 52.

12:52 Yay. Now that is our forward pass, so step back. Now we're gonna do the backward pass. Now, again, the backward pass means you go from the end to the beginning, or from right to left.

13:05 And we're going to figure out the late start and the late finish.

13:11 Now, the late start of the last activity, which is right here.

13:16 This is easy.

13:18 It's the same number as the early finish. I said late start, didn't I? Pardon me, late finish. The late finish of the last activity is easy, because the late finish is the same as the early finish. We either finish or we don't. There's not two finish dates. So that's nice. That's 52. Now how do I get my late start, which should go right here?

13:44 My late start, is the late finish minus the duration, plus 1. So I'm just working backwards. So 52-2 is 50+1

is 51. Awesome.

14:03 Now, I have my late finishes here, and my late finishes all are going to be from the late start, they all get inherited from the late start of the successor.

14:22 And that means that, late finish is equal to the late start minus 1.

14:31 So 51-1 is 50. So all of these have a late finish of 50.

14:42 Now I have to figure out the late starts for all of them, and it's the same thing again. Which is the late start is the late finish minus the duration plus 1. So 50- 5 + 1. So 50- 5 is 45 + 1 is 46. Now, here we go. 50- 10 + 1. 50- 10 is 40 + 1 is 41. And now I have 50- 7, 43. Getting dingy here, and that's 43- 1 is 42. So let's step back and make sure that's correct.

15:22 So we have, late finishes all came from the predecessor, the late start of this one. That makes sense.

15:32 Now, our late start, again, is equal to late finish minus duration plus 1. So that's how we got our 50- 5 + 1 is 46. My 50- 10 + 1 is 41. And my 50- 7 + 1 I have a hard time doing it sometimes too, you guys, I apologize for that. Let's look at this last one, I think this last one is wrong. 50 minus 7 is 43, plus 1 is 44, that's where were off. Yep, there we go. Okay, thank you for being patient with me. Now, we have an activity that has more than one successor, and that's this guy right here. So activity three has three successors,

16:27 and that means we have to make a choice in terms of what late start to use to work backwards because there's three choices. I could use 46, 41, or 44. So what do you think I should use? When we are doing the backward pass, we use the lowest number. We use the lowest number. So let's do that and form the calculation. What's the lowest late start over here?

17:02 It's the 41, right?

17:05 So now, I get my late finish here is equal to 41 minus 1. Whew, I can do that one. It's 40. And now to get my late finish, again, I am, or my late start, I apologize that I keep messing this up. To get my late start, I now take 40, which is the late finish, minus the duration, which is 20, plus 1. So that gives me 21. Whew, okay, now back here I have only one late start to move forward to make it into the late finish, right? So, this becomes 20, and this becomes 20. Because remember the formula for late finish is to take the late start and subtract one. And now, thank goodness we're on the very last two where we're working backwards, and we're figuring out our late starts. And so we take that late finish, subtract out the duration, and add in one. So 20 minus 20 is 0, plus 1 is 1. And 20 minus 10 is 10, plus 1. Now you see the picture that's being painted here?

18:20 At first it may not have made sense that

18:26 we could have a different start and a different finish. Why wouldn't we just start and finish all at the same time? But what this picture is showing us, what we've just figured out, is that there are some times where there are pieces of work activities that can be delayed, and it won't delay the end of the project. So if we're calling these days, and we're saying right now this is day 52, we don't want anything to happen to make it go to day 53. And so what we have is work that has to happen exactly on certain days in order to make it to day 52. That's the critical path.

19:02 That is the critical path. The definition for the critical path is weird because it's that definition which is the critical path is the most amount of time it takes to get you through the network. And therefore, it is the minimum amount of time it will take to finish the project.

19:20 When we look at some of the pieces of work here, we can see that there's a difference between some of their late starts and early starts, and late finishes and early finishes. And when that happens, we have a value for float. And so what we wanna do next is go through and calculate float. And float is gonna go in here, this section. And float, you can use two different calculations, cuz if I've done this correctly, and I hopefully corrected my errors that I had earlier, I'm gonna get the same number. So float is either late start

minus early start, or late finish minus early finish. Now, let's step back. Your critical path is the tasks or activities that have zero float. Those are the items that have to absolutely finish per plan, or we're gonna be late. And now you can see here, if you've been wondering why some of this was highlighted, that's because I had left some of the highlighting in. The items that have float are actually shaded in yellow on here. And so if you just now go back to the beginning, and we look at these first two activities, activity one and two. They both could start at the beginning, but one took 20 days and one took 10 days. Right away, you probably knew that that meant that the second activity which took ten days which was buying supplies probably could wait a few days. Because what was really driving the schedule, was the 20 days we needed just to take to hire the workers. Then, since activity three is next and it is the only next thing, it makes sense that that's the critical path. Then when we get to installing the lights, the sound, and the seats, what drives the completion of the project is whichever one of those items is going to take the longest amount of time. Which one is going to take the longest? Installing the sound.

21:11 So installing the sound must go as scheduled, and installing the lights has five days of float.

21:19 And installing the seats has three days of float. Now the last activity has no float, and that makes sense as well. If it's the very last thing that happens and it's the only item that happens at the end, it can't have float. It needs to finish in order for us to finish up on day 52. So that's our forward pass, our backward pass, our floats, our critical path, and that's our day one approach using. Whew, all right, great job. Thank you for sticking with it. And remember, for most of this, the network diagram takes practice, practice, practice.

22:00 It's worth it though because when you understand the critical path and where you have float, and what is driving your project schedule, you have mastered one of our critical project management concepts. So thanks for hanging in there.

22:12 And you know what I say, bye for now.