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PJM 6025

Project Scheduling and Cost Planning

Week 3/Lecture 2

Schedule Development/Part 1 (Critical Path)

In this lecture, we will cover Schedule Development.

In Part 1 of this lecture, we focus on the Critical Path.

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Learning Outcomes

- Determine the Critical Path for a project as well as describe and understand its importance
- Describe the differences between Critical Path and Critical Chain
- Understand the differences between Fast Tracking and Crashing and be able to apply the appropriate Schedule Compression technique
- Use Microsoft Project tools, filters, and Network Diagrams to identify, interpret, and analyze the Critical Path of a project

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In this lecture, you learn to:

• Determine the Critical Path for a project as well as describe and understand its importance.

• Describe the differences between Critical Path and Critical Chain.

• Understand the differences between Fast Tracking and Crashing and be able to apply the appropriate Schedule Compression technique.

• Use Microsoft Project tools, filters, and Network Diagrams to identify, interpret, and analyze the Critical Path of a project.

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Schedule Management Knowledge Area

Key Process	Key Deliverables
Activity Definition	Activity List Define Activities Milestone List
Activity Sequencing	Project Schedule Network Diagram
Resource Estimating	Activity Resource Requirements Resource Breakdown Structure
Duration Estimating	Activity Duration Estimates
Schedule Development	Project Schedule Baseline Schedule
Schedule Control	Performance Metrics Change Control

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In this lecture, we will look at the 5th key process in the Schedule Management Knowledge Area, Schedule Development and in particular the Project Schedule.

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PMBOK 6.6 – Schedule Development

Inputs	Tools & Techniques	Outputs
Project management plan • Schedule management plan • Scope baseline **Project documents** • Activity attributes • Activity list • Assumptions log • Basis of estimates • Duration estimates • Lessons learned register • Milestone List • Project schedule network diagram • Project team assignment • Resource calendars • Resource requirements • Risk register **Agreements** **Enterprise environmental factors** **Organizational process assets**	**Schedule network analysis** **Critical path method** **Resource optimization** **Data analysis** • What-if scenario analysis • Simulation **Leads and lags** **Schedule compression** **Project management information systems** **Agile release planning**	**Schedule baseline** **Project schedule** **Schedule data** **Project calendars** **Change requests** **Project management plan updates** • Schedule management plan • Cozt baseline **Project Document Updates** • Activity attributes • Assumptions log • Duration estimates • Lessons learned register • Resource requirements • Risk register

From PMI's A Guide to the Project Management Body of Knowledge, Sixth Edition (2017)

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Schedule Development is exactly what it says, developing the schedule for the project.

We are going to use all of the information we have collected up to this point, starting with the WBS, the Activity List, and the Network Diagrams which sequence the activities. We have completed analyzing activity sequences, developed estimates for activity durations, resource requirements, cost estimates and now are ready to create a project schedule.

We will be covering these tools and techniques during this lecture:

Schedule network analysis is a technique that employs all of the techniques here and also helps identify the early and late start dates as well as the early and late finish dates for each Activity and for the Project.

Critical Path is the longest path in the network diagram and represents the shortest time to complete the project.

What if Scenarios are a technique used to ask this simple question and analyze what the impacts are, good to do one last time before you baseline the schedule

Schedule Compression techniques that can be used to shorten the schedule without changing the project scope used to show to shorten timeline compress

Leads and Lags – Will either add time to or shorten the project duration.

In the end, the Outputs of this process include:

The **Project Schedule** – Start and finish dates for all activities

The **Schedule Baseline** – This is the point in time when the key stakeholders agree with the schedule.

Schedule data – includes such items as milestones, assumptions, constraints, alternative schedules

After completing schedule development, you will update any related project documents.

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Understanding the Big Picture

- When can we start? When is it due?
- What is driving the deadline?
  - What are the business drivers?
- What are the Constraints?
  - Calendar, Schedule, Resources, Budget, Customer Requirements
- What are the Assumptions?
- Schedule from the Start Date or Finish Date.

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It is extremely important for the Project Manager to understand the big picture.

These are basic questions that go all the way back to the Business Case and Project Charter.

This is a good time and place to revalidate the answers to each of these questions.

In most cases you will build your schedule from the designated Start Date of the project.

In doing this, you will then be able to estimate when the project can finish by.

However, there will be times when you must meet as strict deadline. Then you can also build a schedule by starting with the Finish Date and working backwards to determine when you must start the project by.

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Schedule Network Analysis

- Network Diagrams
  - *PDM*
  - *Microsoft Project*
- Analytical Techniques
  - *Critical Path Method*
  - *Critical Chain Method*
  - *Resource Optimization (Leveling and Smoothing)*
  - *What-If Analysis*

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There are a number of techniques that can be used to analyze the schedule in order to develop an optimized schedule.

The Precedence Diagramming Method (Activity On Node) is the diagram we developed back in the sequencing phase. This can be reexamined to make sure we have the right sequence and dependencies and if there are any areas of improvement.

Microsoft Project can be used to display a network diagram of the activities.

We will look at some other techniques in the upcoming slides.

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Critical Path

- The **longest duration path** of all of the paths in the network diagram
- It establishes the **earliest completion date** of the project
- Path with **zero float**, or slack time
- If any activity on the Critical Path take longer to complete than planned, the planned schedule end date will be missed

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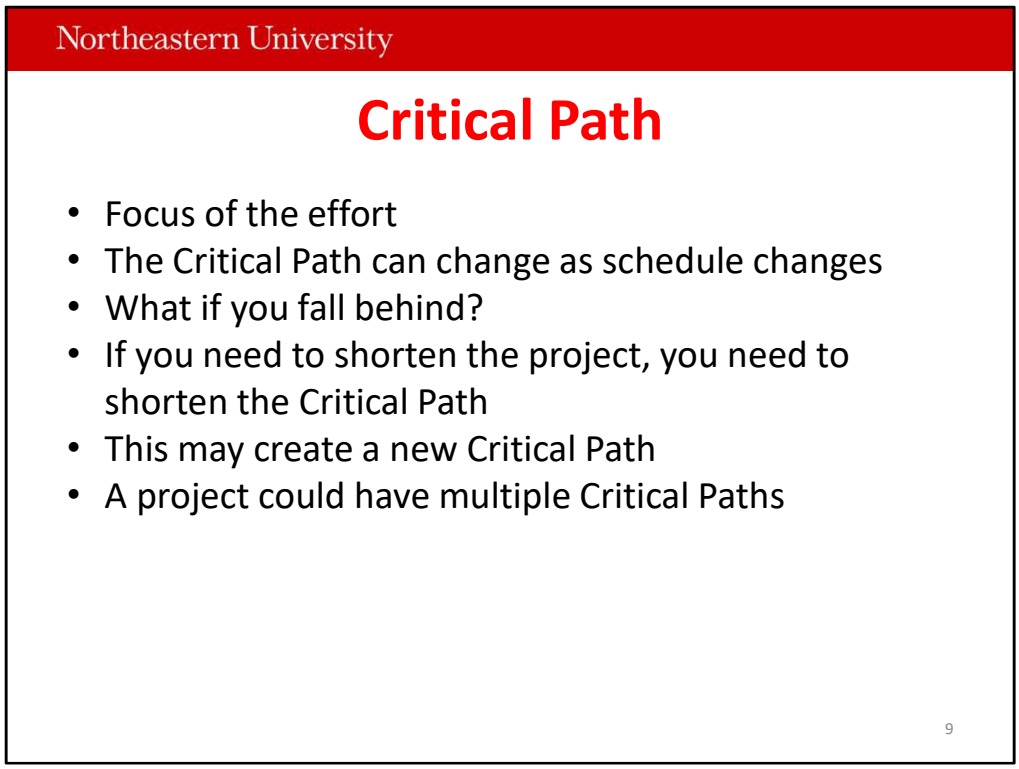
Understanding the Critical Path is important in developing and managing the project schedule.

Of all of the paths in a Network Diagram, the Critical Path represents the longest path in terms of duration. It establishes the earliest completion date of the project assuming all Activities are completed on time.

The critical path has no schedule flexibility, no float or slack time.

All activities on the Critical Path are considered critical Activities. If there is a delay to completing any Activity on the Critical Path, that the project end date will be extended.



The Activities on the Critical Path should be your focus of effort.

This is where you should spend more time with monitoring and controlling the successful on time completion of events, as changes to the schedule here could extend the entire project schedule.

The Critical Path can change as events change. For example, an Activity not on the Critical Path today may be on the path tomorrow if the situation changes.

Is it every OK to be behind on the Critical Path? Yes and no. You do not want this to happen but it will. You will have options for recovery with either the activity that is causing you to fall behind or future activities that you may be able to compress later to make up for any lost time.

The key is early detection and immediate actions.

It is important to keep your sponsor and key stakeholders informed of any changes to the schedule and the Critical Path.

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Critical Path - Terminology

- **Project Early Start Date** – The earliest date that the project can start (Day 0)
- **Project Early Finish** – The date that the project will finish if every activity on begins in time (ES) and every activity on the Critical Path completes on time (EF)
- **Project Late Finish Date** – The very latest date that the customer will accept completion of the project.
  - The Critical Path Method will set the Project Late Finish Date to EF on the last activity

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In the Critical Path Method, there are 3 key dates that will define the overall project dates:

We need to determine the **Start Date**, and this date can be predetermined by the Project Sponsor

The **Early Finish Date** will be calculated using the network diagram and duration estimates

The **Late Finish Date** is determined by the customer or the Project Sponsor. It is usually set it to the **Early Finish Date** .

In most cases, the customer will want the project to be completed as soon as possible.

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Critical Path - Terminology

- **Early Start (ES)** – The earliest date that an activity can start
- **Early Finish (EF)** – The earliest date that an activity can finish
  - EF = ES + Duration
- **Late Start (LS) –** The latest that an activity can start without delaying the Project End Date
  - LS = LF - Duration
- **Late Finish (LF)** – The latest time that an activity can finish without delaying the Project End Date.

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To identify the Critical Path, go through the network logic and duration estimates using a Forward Pass and then later a Backward Pass determine the:

- **Early Start** – Is the earliest an Activity can start
- **Early Finish** – Is the earliest an Activity can finish based on the Early Start and duration
- **Late Start** – Is the latest an Activity can start without delaying the Project End Date
- **Late Finish** – Is the latest an Activity can finish without delaying the Project End Date

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Types of Float

- **Float/Total Float/Slack (MS Project – Total Slack)**
  - The amount of time that an activity can be delayed without delaying the project finish date
  - Only available on non-Critical Path activities
- **Free Float (MS Project – Free Slack)**
  - The amount of time that an activity may be delayed without delaying the early start of any successor activity
  - Can only occur in the path where there is a merge activity

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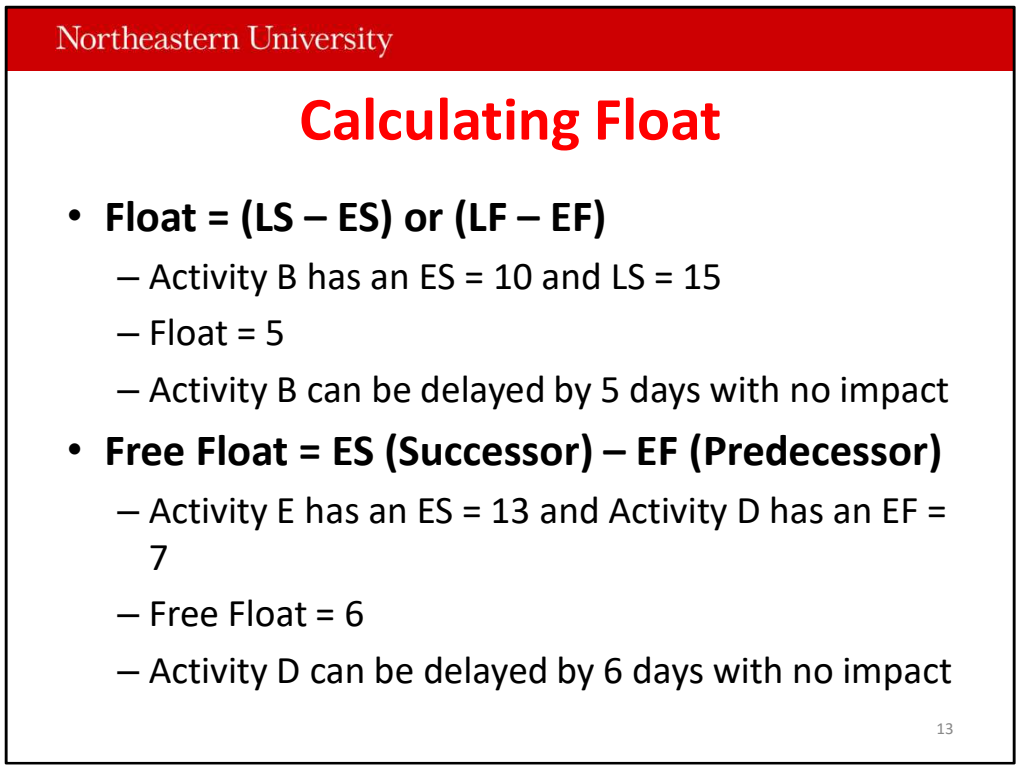
In a moment, we will look at Forward Pass and Backward Pass.

After completing the Forward and Backward Passes, you will calculate the Float of each activity. Float is also known as Slack.

Float is the amount of time that an Activity can be delayed without delaying the Project Finish Date. Float is also known as Total Float, Slack or Path Float. In Microsoft Project, it is referred to as **Total Slack**. Only activities that are not on the Critical Path will have float. Activities on the Critical Path have no float (zero) as the Early Start = the late Start and the Early Finish = the Late Finish.

Free Float is the amount of time that an Activity may be delayed without delaying the Early Start of any Successor activities, also sometimes know as Independent float. In Microsoft Project, Free Float is referred to as **Free Slack**.

While Float (or Total Float) will not impact the project's Finish Date, activities that have more Float than Free Float may impact the Start Date of other activities. Free Float will only occur where there is a Merge activity, where you can move the Start Date of activities that have Free Float without impacting the Start Date of other activities.



Float is calculated for each Activity using the formula on this slide.

Float equals the Late Start Date of the activity minus the Early Start Date of the activity or the Late Finish Date minus the Early Finish Date

For example, Activity B has an Early Start of Day 10 and a Late Start of Day 15

By subtracting 15 from 10, you get a Float = 5

So, Activity B can be delayed by 5 days with no impact to the Project End Date

Free Float is the amount of time that an Activity may be delayed without delaying the Early Start of any successor Activities.

Free Float equals the Early Start Date of the successor activity minus the Early Finish Date of the predecessor.

For example if Activity E has an Early Start of Day 13 and the previous Activity D has an Early Finish of Day 7. You would subtract 7 from 13 to get a Free Float of 6 days. Activity D can be delayed by 6 days without changing the Start Date of Activity E.

Free Float only exists for Merge Activities where an Activity is waiting for multiple activities to be completed before proceeding.

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Critical Path Method (CPM)

- **Pure CPM** – Critical Path has **Zero Float**, while non-Critical Path has **Positive Float**
- Network Analysis Technique
  - **Forward Pass** – calculate the Early Start (ES) and Early Finish (EF) on all activities
  - **Backward Pass** – calculate the Late Start (LS) and Late Finish (LF) on all activities
  - Calculate the Float to identify the Critical Path
  - Focus on the duration, sequencing, and dates

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The Critical Path Method is a network analysis technique that is use to identify and display the overall project duration.

This method uses the PDM to analyze the sequence of Activities. In a Pure CPM, the Critical Path will have zero float while all other paths normally will have positive float.

To identify the Critical Path, you conduct what is called a Forward and Backward pass. Early dates are calculated using a Forward Pass. Late dates are calculated using a Backward Pass.

There is no focus on resources, availability, or priorities at this time. The focus is only on duration and network logic.

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Critical Path Float/Slack Analysis

- Examine all network paths
- Network Path Analysis
  - Float/Slack > Zero (Time is available)
  - Float/Slack = Zero (No time is available)
  - Float/Slack < Zero (Project is behind)

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Float is analyzed on all the paths in the Network Diagram.

• If float is greater than zero (or Positive Float), it indicates that time is available

• If Float is Zero, this indicates that the activity is on the Critical Path.

• If there is Negative Float (Float that is less than zero) than the Fixed End Date is earlier than the network driven date and the project is behind schedule.

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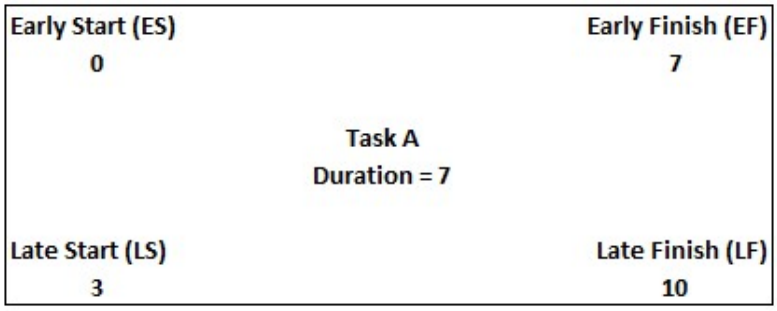
Basic Scheduling



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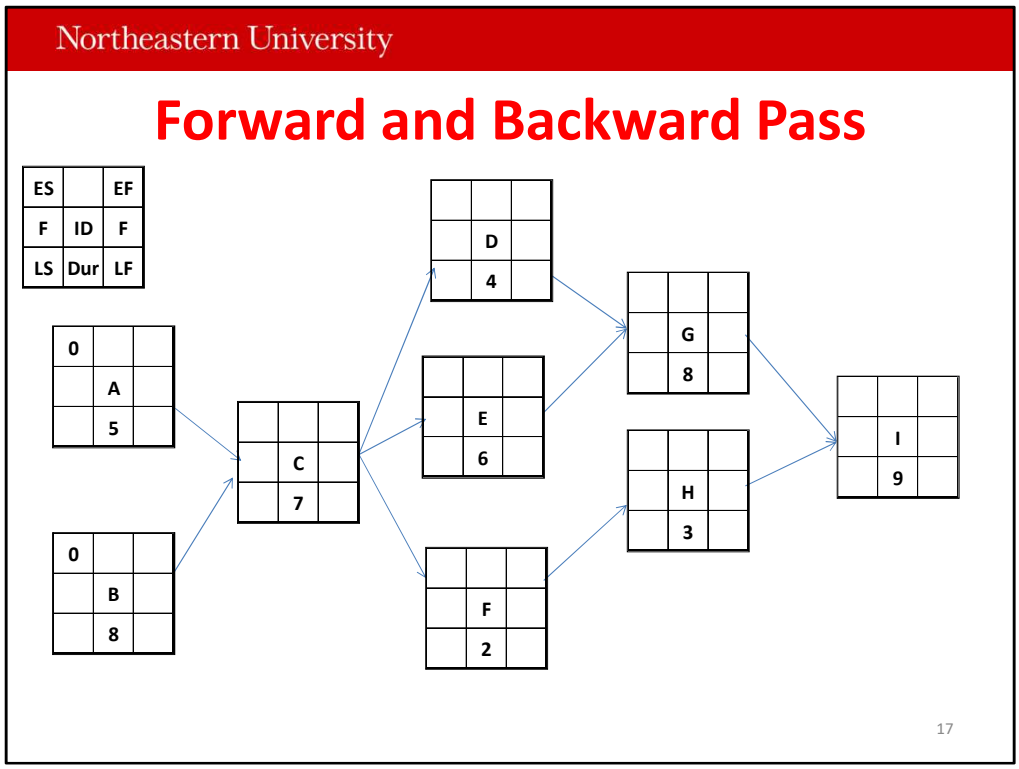
In this slide, let's take a look at an Activity Box (or Node) and how it is laid out.

- Typically, the Early Start is notes on the upper left corner of the box.
- The Early Finish is in the upper right corner of the box.
- The Late Start is in the lower left corner of the box.
- and the Late Finish is in the lower right of the box.

The Activity Name and Duration are in the middle.



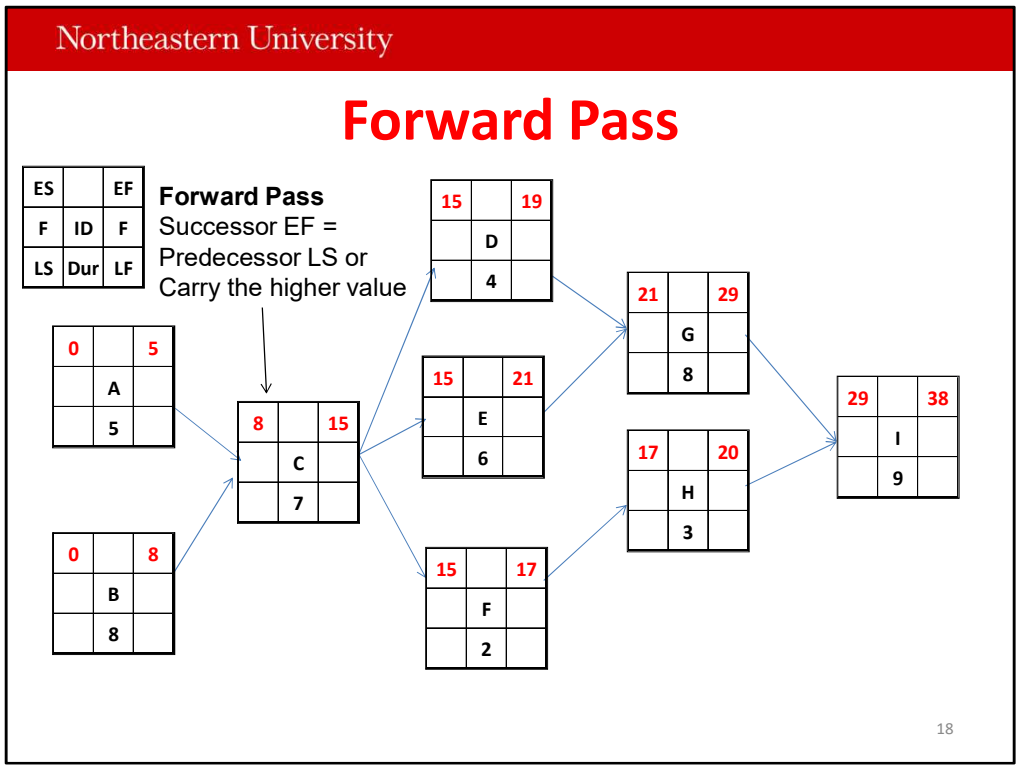
In determining the Critical Path of a project, start with the Network Diagram for the project. Here is a simple example.

For each box representing an activity in the Network Diagram, break the box into parts to enter the Activity Name, the Duration, Early Start Date, Early Finish Date, Late Start Date, Late Finish Date, and Float.

Here we start with the Activity Names and Durations for each activity. For the first activities, we are with the Early Start of 0.

• The **Forward Pass** starts with the Early Start and Early Finish.

• The **Backward Pass** is needed to determine the Late Start and the Late Finish.



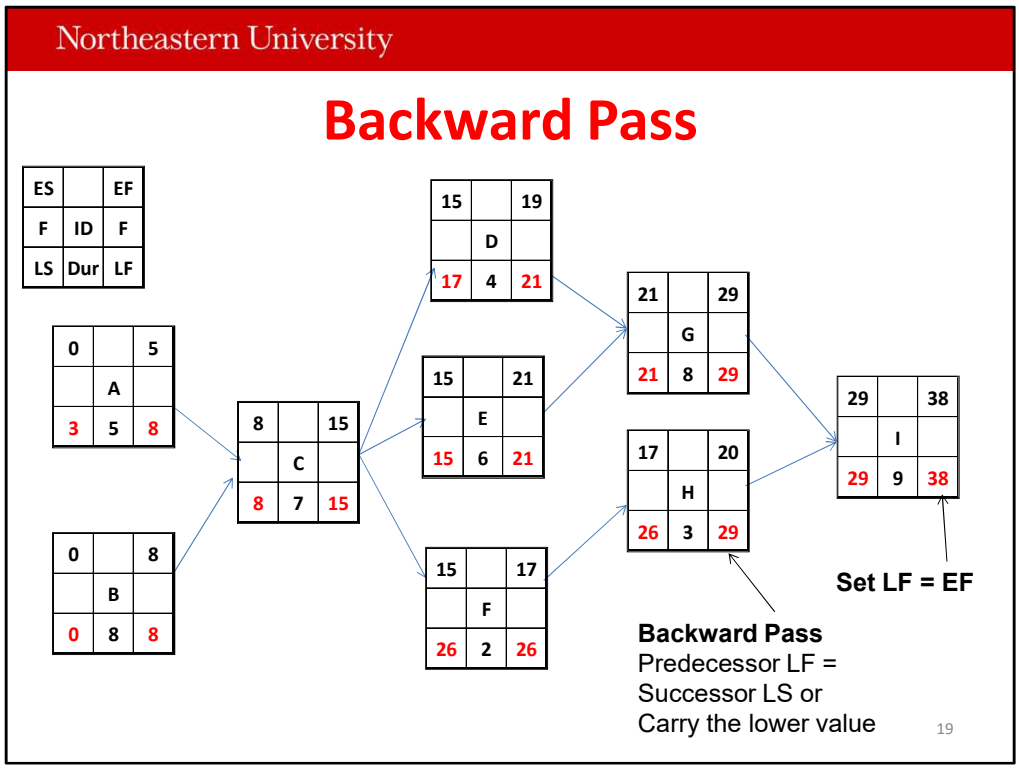
In going through the Forward Pass, we identify the Early Start and Early Finish Dates.

Starting with the first activities that start at Day 0, add the duration to the Early Start to get the Early Finish for that activity. In Activity A, add 5 to 0 to get an Early Finish of 5. Doing the same for Activity B, you get an Early Finish of 8 as the duration of that activity is 8.

Since Activity C is dependent on both Activities A and B, you take the latest Early Finish, which is 8, and make that the Early Start for Activity C. Since Activity C has a duration of 7, add 7 to 8 to get an Early Finish of Day 15.

Activities D, E, and F are all dependent on the Finish of Activity C, so the Early Finish of Day 15 for Activity C will become the Early Start for Activities D, E, and F.

You continue this until you get to the final activity of the project. In this case, Activity I is the final activity of the project. The Early Finish for Activity I is Day 38, which becomes the Early Finish for the entire project.

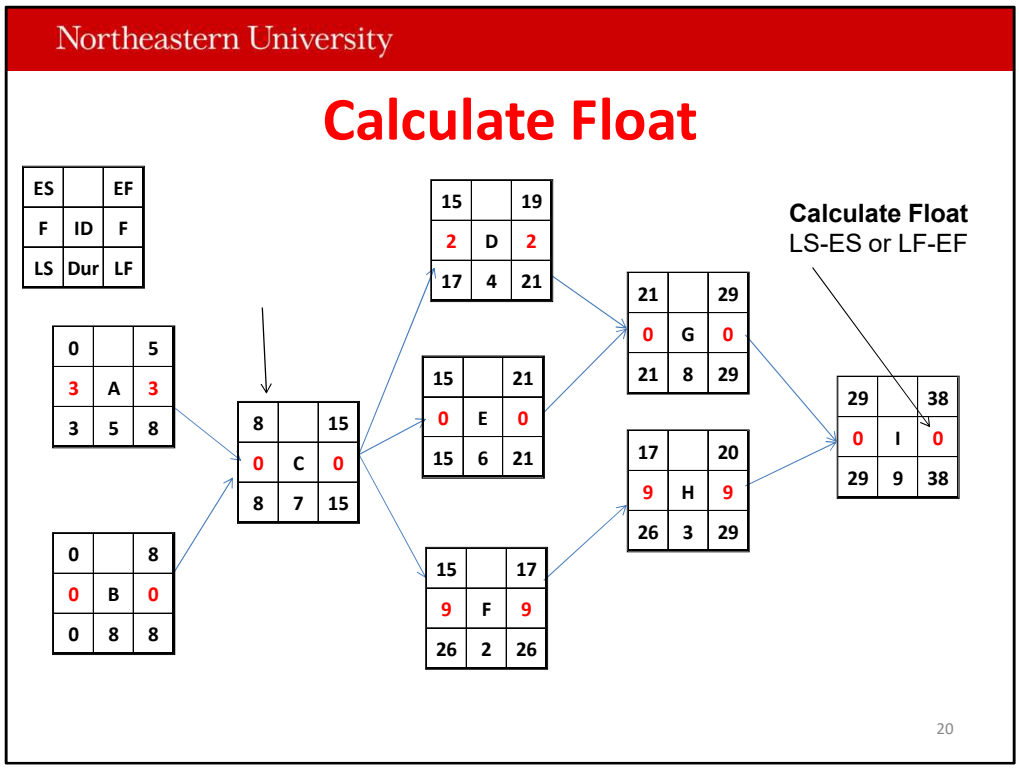


As we start the Backward Pass, we use the Early Finish Date for the last activity to be the Late Finish Date for that activity. In this case the Late Finish is Day 38. To get the Late Start for the activity, subtract the duration from the Late Finish. In this case of Activity I, activity the Late Finish of Day 38 and subtract the Duration of 9 days to get the Late Start of 29 day.

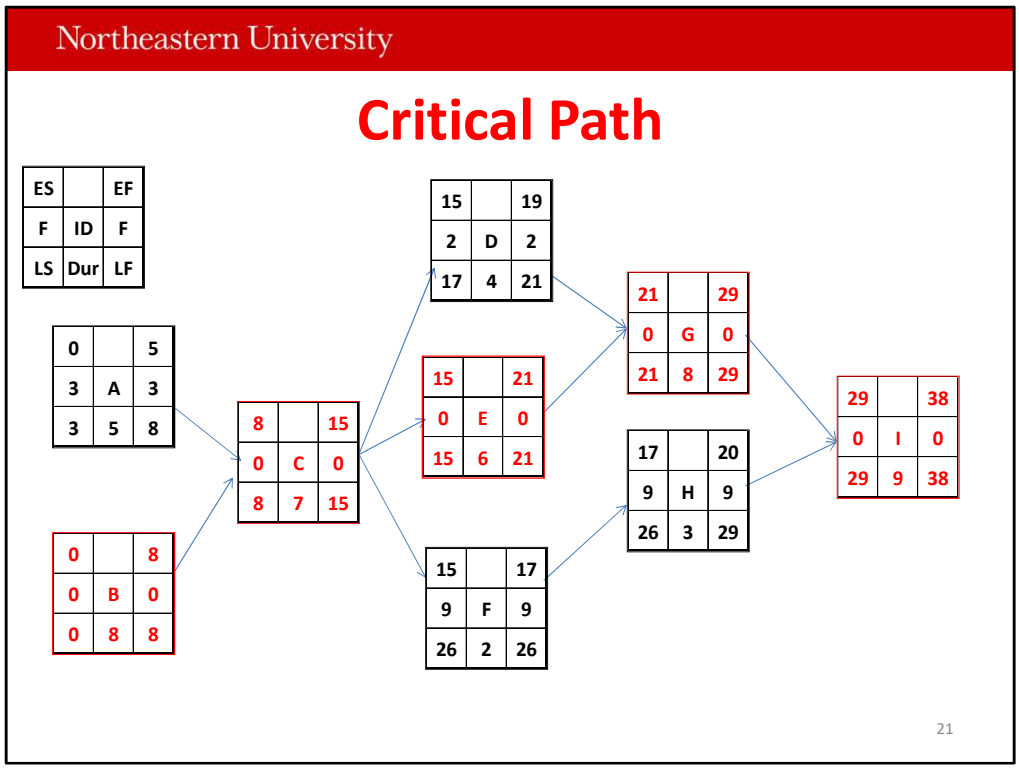
As Activities G and H both feed into Activity I, the Late Start of Activity I becomes the Late Finish for both Activities G and H. For Activity G, take the Late Finish of Day 29 and subtract the duration of 8 days to get a Late Finish of Day 21. For Activity H, take the Late Finish of Day 29 and subtract the duration of 3 days to get a Late Finish of Day 26.

As we get to Activity C, it is an activity that will launch Activities D, E, and F. Since Activity E has the earliest Late Start of Day 15, this becomes the Late Finish for Activity C. As we get back to the first activities, we finish the process.

Now, we go to each activity and subtract the Late Start from the Late Finish (or the Early Start from the Early Finish). This will calculate the Float for each activity.



Now, we go to each activity and subtract the Late Start from the Late Finish (or the Early Start from the Early Finish). This will calculate the Float for each activity.



The Activities that have a Float of zero will be part of the Critical Path.

Here you can see that Activities B, C, E, G, and I are on the Critical Path as each of these activities have zero Float. A delay in any of these activities will push out the Finish Date for the project.

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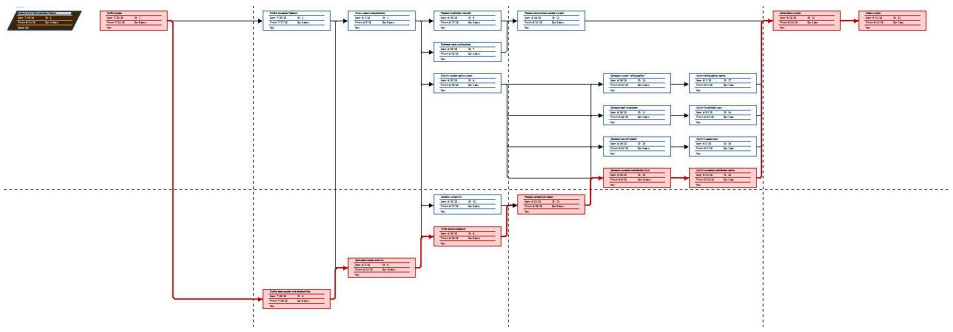
Microsoft Project – Network Diagram



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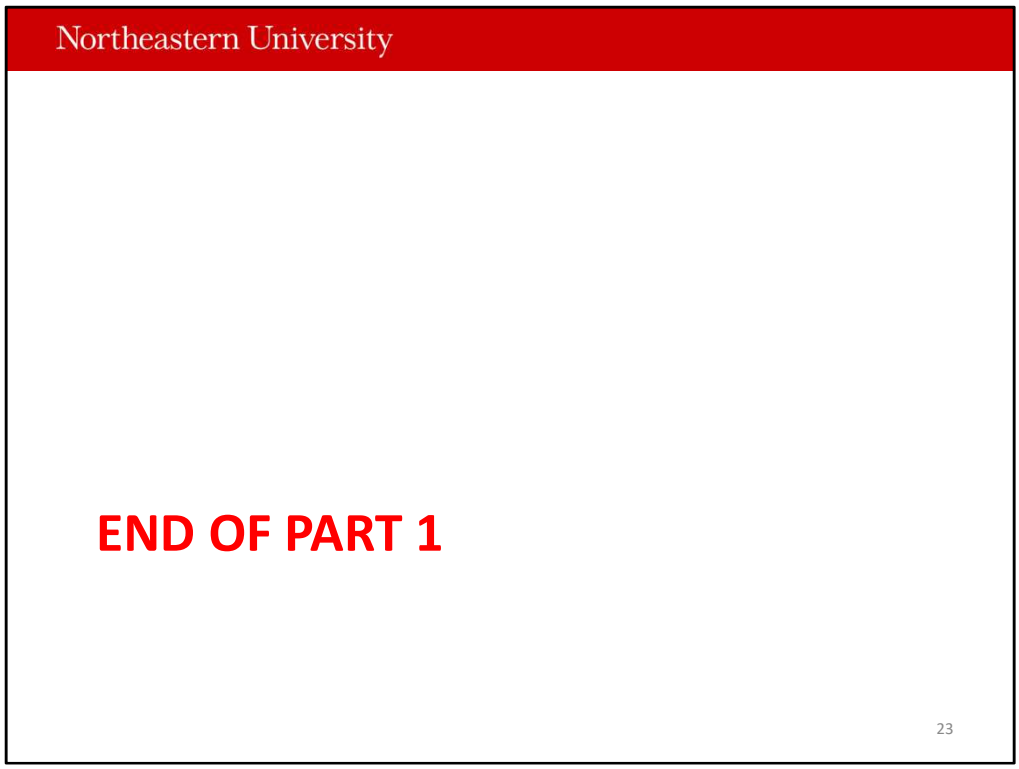
Here is an example of the Network Diagram view of the project in Microsoft Project.

You can check this view with one of the projects you have created in Microsoft Project.

Notice the activities in **red** are part of the critical path.



This concludes Part 1 of this lecture. In Part 2, we will cover Critical Chain and Schedule Compression.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