Calculations on a Network Model

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Supplemental Material for Construction Management: Planning and Scheduling

The following information outlines the basic steps required to run calculations on a Precedence Network to determine *Early Start* and *Early Finish, Late Start* and *Late Finish*, *Float*, and to identify the *Critical Path*. This discussion uses a beginning-of-day convention whereby each activity starts and ends on the beginning of the listed day; i.e. if an item begins on Day 10 and has a duration of 1 Day, it will begin on Day 10 and end on Day 11. All relationships used in this discussion are Start-to-Finish relationships.

1. **Assign *Early Start (ES)* and *Early Finish (EF)***
   a. Begin by assigning Day 1 as the *Early Start* day of the first activity
   b. Calculate the *Early Finish* for this activity by adding its *Duration* to its *Early Start* (EF = ES + Duration)
   c. The next activity on the network is assigned an *Early Start* that is equal to the *Early Finish* of its Immediately Preceding Activity (IPA)
      i. In Figure 1 – The first activity begins on Day 1 and has a Duration of 2 days, so its *Early Finish* is the beginning of Day 3, meaning the next activity can start at the beginning of Day 3 – remember when doing this by hand to stick with a single convention (in this case beginning-of-day) when referring to activities

Terms & Definitions

Early Start (ES) – the earliest time that an activity can start based on the latest of the Early Finish times of all its IPA's

Early Finish (EF) – the earliest time that an activity can finish, calculated by adding the activity's Duration to its Early Start (EF = ES + Duration)

Late Start (LS) – the latest time that an activity can start without delaying the completion of the project, calculated by adding the Float of an activity to its Early Start (LS = ES + Float)

Late Finish (LF) – the latest time that an activity can be finished without delaying the completion of the entire project, calculated by adding the activity's Float to its Early Finish (LF = EF + Float)

Duration – the value assigned to an activity that represents the time it will take to complete that activity

Float – the amount of time that an activity can be delayed before it impacts the completion date of the project (also referred to as Total Float)

Lag – the amount of time that exists between the Early Finish of an activity and the Early Start of its successor activity ($LAG_{AB} = ES_B - ES_A$)

Critical Path – the sequence of linked activities for which the Float value of each activity in the path is zero

d. If an activity has more than one IPA, its *Early Start* is the latest of the *Early Finish* days of all of its IPA's
e. Repeat this process making a complete forward pass through the entire network
    i. At the end of this step, all activities should have *Early Start* and *Early Finish* calculated

2. **Calculate *Lags* for each link**
    a. Each activity should be linked to one or more predecessors (IPA's) unless it is the first activity on the project
    b. Each activity should be linked to a successor activity unless it is the last activity to be completed on the project
        i. A construction project will typically need a final activity in the schedule to represent demobilization; things like clean-up and hauling off equipment and trash. Ideally, all other activities should be finished before this final activity is started.
    c. Calculate the *Lag* for each link by determining the difference between the *Early Start* of each activity that follows a link line, and the *Early Finish* of the activity that precedes it - *Lags* must be either 0 or a positive number
        1. In Figure 1 – the *Early Start* of the Activity that follows "Inst Net Hardware" is Day 23 (Clean/Move Out) and the *Early Finish* of "Inst Net Hardware" is Day 13, so the *Lag* is 10 ($Lag_{AB} = ES_B – EF_A$)
    d. Repeat this process for each link in the network

3. **Calculate *Float* for each activity in the network (also referred to as Total Float)**
    a. Begin by assigning a *Float* value of 0 to the last activity in the network
    b. Calculate the *Float* value of that activity's IPA(s), by adding its *Float* value to the value of the connecting Lag line(s)
        i. In Figure 1 – The last activity is "Clean/Move Out", and it has three IPA's: "Landscape", "Inst Net Hardware", and "Inst Benches".
            1. The *Float* value of "Landscape" is calculated by adding the *Float* value of "Clean/Move Out" (0) to the *Lag* value of the link line connecting the two activities (0) – in this case *Float* for "Landscape" is 0 + 0 = 0
            2. The *Float* value of "Inst Net Hardware" = 0 + 10 = 10
            3. The *Float* value of "Inst Benches" = 0 + 8 = 8
    c. Repeat this process making a complete backwards pass through the network
        i. At the end of this step, all activities should have a value (either 0 or a positive number) entered for *Float*

4. **Calculate *Late Start* and *Late Finish***
    a. Begin with the first activity in the network model – calculate its *Late Start* by adding the *Float* value to its *Early Start* (LS = ES + Float) – Calculate its *Late Finish* by adding the *Float* value to its *Early Finish* (LF = EF + Float)
    b. Repeat this process for each activity, making a complete forward pass through the network

5. **Identify the *Critical Path***
    a. Determine the *Critical Path* by identifying the sequence of linked activities for which the *Float* value for each activity in the sequence is 0

i. In Figure 1 – The *Critical Path* consists of five activities: “Place Concrete”, “Surfacing/Coating”, “Install Fence”, “Landscape”, “Clean/Move Out”
    1. “Inst Net Hardware” and “Inst Benches” are not in the *Critical Path* – they have *Float* and can move by the number of days equal to the *Float* without effecting the completion time of the project

6. **Assign Dates to each activity**
    a. The values currently entered in the network model are days; i.e. Day 1, Day 2, Day 3, etc. – To turn the network model into a schedule, these vales need to be converted to dates on a calendar
    b. This conversion from Working Days to dates on a calendar will depend on the definition of a Working Day for the project, and on the planned start date for the project – In other words, if Day 1 is Monday, Day 2 is Tuesday, etc., Day 6 might be Saturday or it might be the following Monday depending on the plan of for the project – Similarly, Day 1 could be any day of the week that is chosen for the start date of the project, it’s not necessarily always a Monday

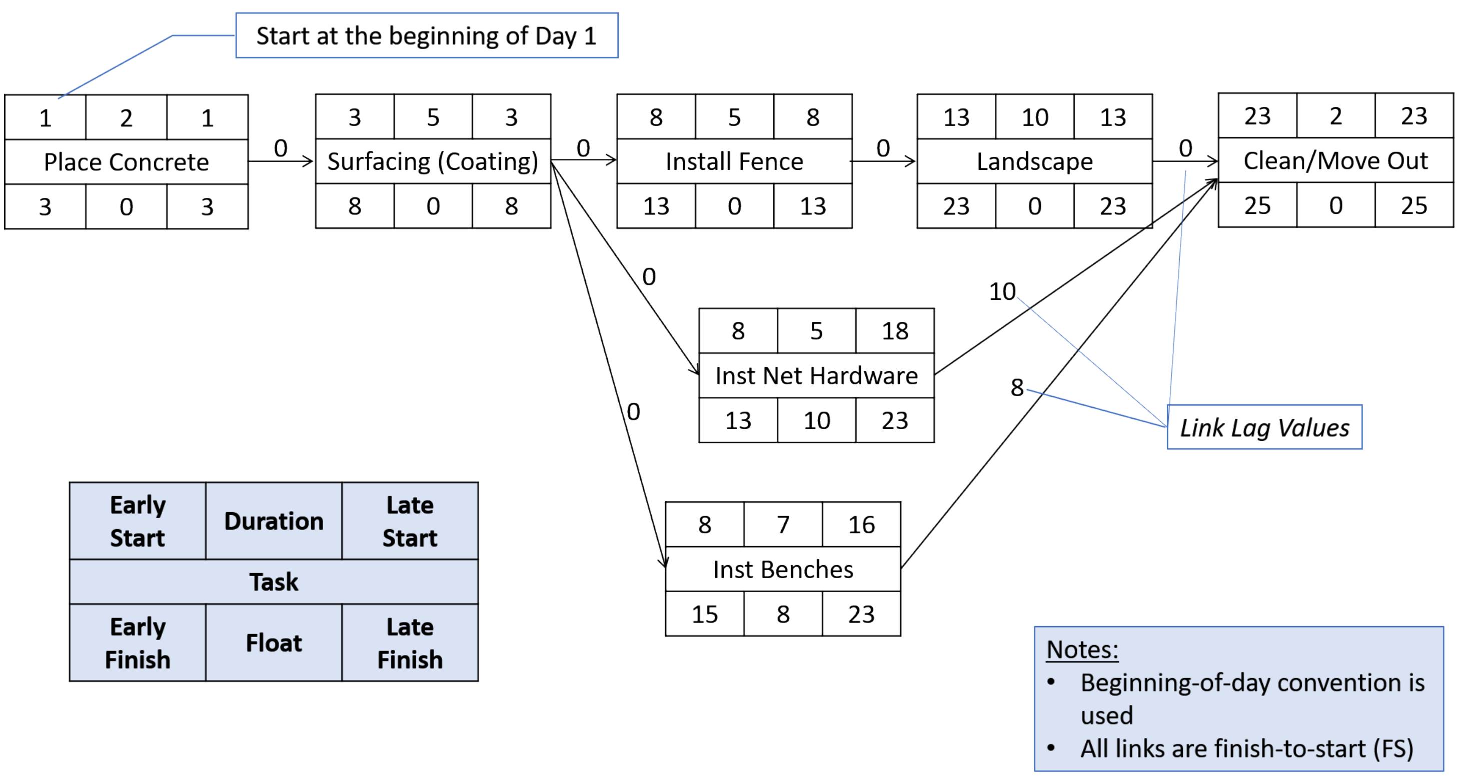

Figure 1 – Calculations on a Precedence Network