

Project Monitoring

Lecture 4

PMG 333

Developing a Project Plan



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Learning objectives

1. Understand the linkage between WBS and the project network.
2. Diagram a project network using AON methods.
3. Calculate early, late, and slack activity times.
4. Identify and understand the importance of managing the critical path.
5. Demonstrate understanding and application of lags in compressing projects or constraining the start or finish of an activity

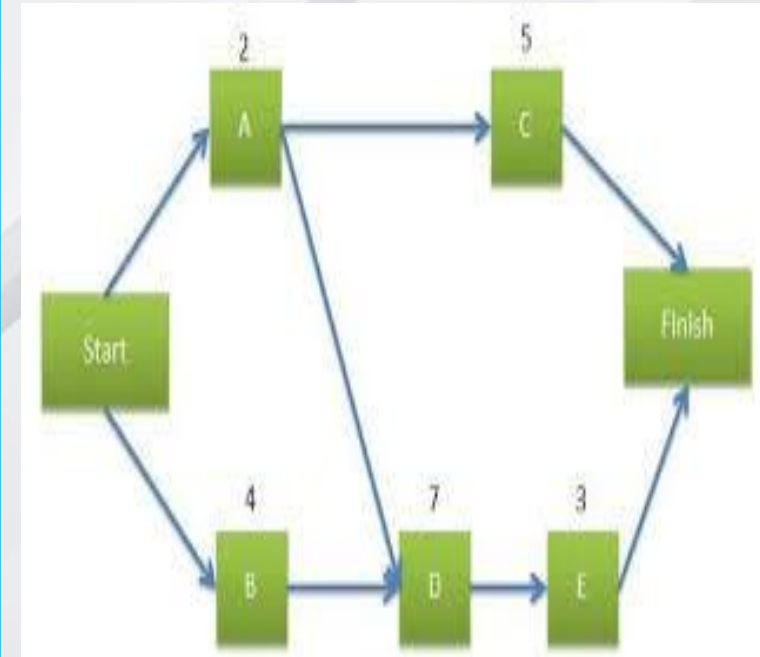


Outlines

1. Developing the Project Network
2. From Work Package to Network
3. Constructing a Project Network
4. Activity-on-Node (AON) Fundamentals
5. Network Computation Process
6. Using the Forward and Backward Pass Information
7. Level of Detail for Activities
8. Practical Considerations
9. Extended Network Techniques to Come Closer to Reality

4.1 Developing the Project Network

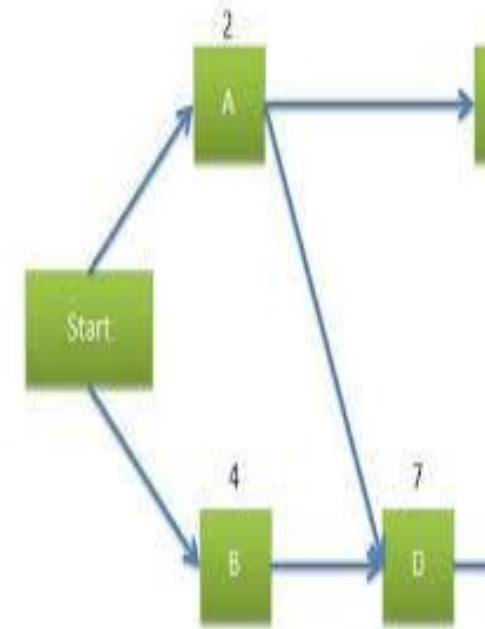
- The project network is the tool used for planning, scheduling, and monitoring project progress.
- The network is developed from the information collected for the WBS and is a graphic flow chart of the project job plan.
- The network depicts the project activities that must be completed, the logical sequences, the interdependencies of the activities to be completed, and in most cases the times for the activities to start and finish along with the longest path(s) through the network—the critical path.
- The network is the framework for the project information system that will be used by the project managers to make decisions concerning project time, cost, and performance.



- Developing the project networks takes time for someone or some group to develop; therefore, they cost money! Are networks really worth the struggle? The answer is definitely yes, except in cases where the project is considered trivial or very short in duration.
- The network is easily understood by others because the network presents a graphic display of the flow and sequence of work through the project.
- Once the network is developed, it is very easy to modify or change when unexpected events occur as the project progresses.
- For example, if materials for an activity are delayed, the impact can be quickly assessed and the whole project revised in only a few minutes with the computer.
- These revisions can be communicated to all project participants quickly (for example, via e-mail or project website).

Developing the Project Network – Cont..

- The project network provides other invaluable information and insights.
- It provides the basis for scheduling labor and equipment.
- It enhances communication that melds all managers and groups together in meeting the time, cost, and performance objectives of the project.
- It provides an estimate of project duration rather than picking a project completion date from a hat or someone's preferred date.
- The network gives the times when activities can start and finish and when they can be delayed. It provides the basis for budgeting the cash flow of the project.
- It identifies which activities are “critical” and, therefore, should not be delayed if the project is to be completed as planned.
- It highlights which activities to consider if the project needs to be compressed to meet a deadline.



Developing the Project Network – Cont..

- There are other reasons project networks are worth their weight in gold.
- Basically, project networks minimize surprises by getting the plan out early and allowing corrective feedback.
- A commonly heard statement from practitioners is that the project network represents three-quarters of the planning process.
- Perhaps this is an exaggeration, but it signals the perceived importance of the network to project managers in the field.

4.2 From Work Package to Network

- Project networks are developed from the WBS.
- The project network is a visual flow diagram of the sequence, interrelationships, and dependencies of all the activities that must be accomplished to complete the project.
- An activity is an element in the project that consumes time—for example, work or waiting. Work packages from the WBS are used to build the activities found in the project network.
- An activity can include one or more work packages. The activities are placed in a sequence that provides for orderly completion of the project.
- Networks are built using nodes (boxes) and arrows (lines).

From Work Package to Network – Cont..

- Integrating the work packages and the network represents a point where the management process often fails in practice.
- The primary explanations for this failure are that;
- (1) different groups (people) are used to define work packages and activities and
- (2) the WBS is poorly constructed and not deliverable/output oriented. Integration of the WBS and project network is crucial to effective project management.
- The project manager must be careful to guarantee continuity by having some of the same people who defined the WBS and work packages develop the network activities.

From Work Package to Network – Cont..

- Networks provide the project schedule by identifying dependencies, sequencing, and timing of activities, which the WBS is not designed to do.
- The primary inputs for developing a project network plan are work packages.
- Remember, a work package is defined independently of other work packages, has definite start and finish points, requires specific resources, includes technical specifications, and has cost estimates for the package.
- However, dependency, sequencing, and timing of each of these factors are not included in the work package.
- A network activity can include one or more work packages.

4.3 Constructing a Project Network

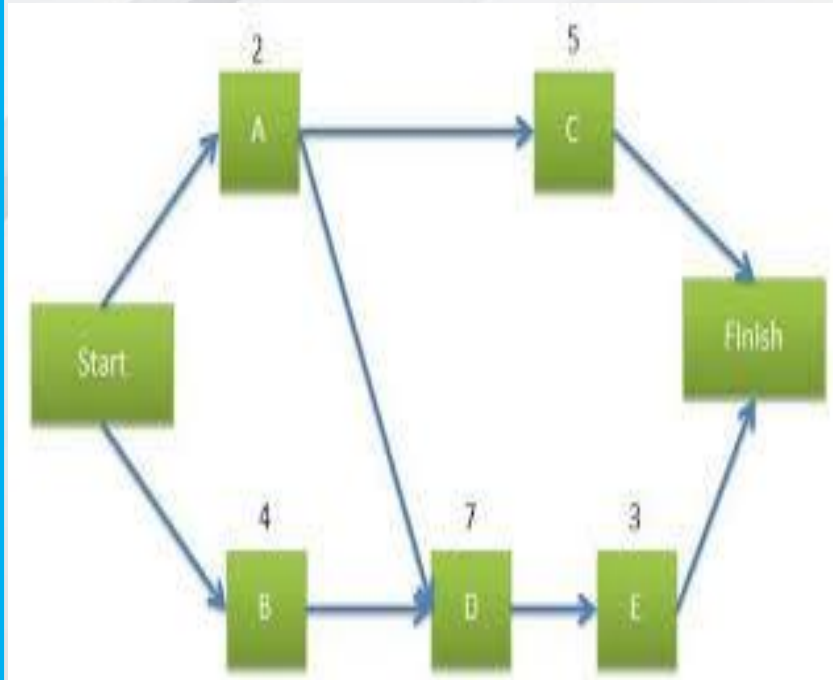
- Terminology Every field has its jargon that allows colleagues to communicate comfortably with each other about the techniques they use. Project managers are no exception. ***Here are some terms used in building project networks***
- **Activity:** For project managers, an activity is an element of the project that requires time. It may or may not require resources.
- Typically an activity consumes time—either while people work or while people wait.
- Examples of the latter are time waiting for contracts to be signed, materials to arrive, drug approval by the government, budget clearance, etc.
- Activities usually represent one or more tasks from a work package. Descriptions of activities should use a verb/noun format: for example, develop product specifications.

4.3 Constructing a Project Network

- **Merge Activity:** This is an activity that has more than one activity immediately preceding it (more than one dependency arrow flowing to it).
- **Parallel Activities:** These are activities that can take place at the same time, if the manager wishes. However, the manager may choose to have parallel activities not occur simultaneously.
- **Path:** A sequence of connected, dependent activities.
- **Critical Path:** When this term is used, it means the path(s) with the longest duration through the network; if an activity on the path is delayed, the project is delayed the same amount of time.
- **Burst Activity:** This activity has more than one activity immediately following it (more than one dependency arrow flowing from it).

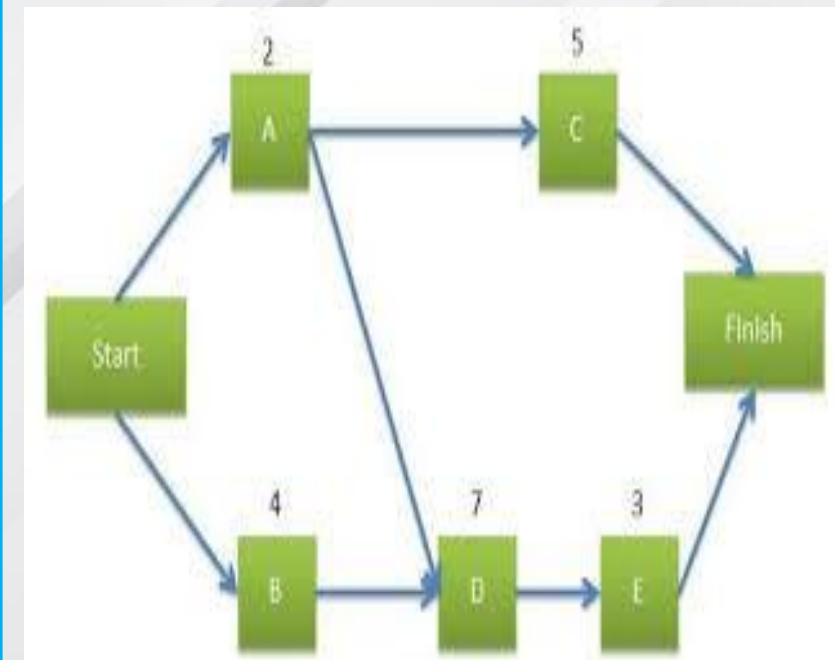
**Basic Rules to Follow in Developing Project Networks

- The following eight rules apply in general when developing a project network:
 1. Networks flow typically from left to right.
 2. An activity cannot begin until all preceding connected activities have been completed.
 3. Arrows on networks indicate precedence and flow. Arrows can cross over each other.
 4. Each activity should have a unique identification number.



Basic Rules to Follow in Developing Project Networks – Cont..

5. An activity identification number must be larger than that of any activities that precede it.
6. Looping is not allowed (in other words, recycling through a set of activities cannot take place).
7. Conditional statements are not allowed (that is, this type of statement should not appear: If successful, do something; if not, do nothing).
8. Experience suggests that when there are multiple starts, a common start node can be used to indicate a clear project beginning on the network. Similarly, a single project end node can be used to indicate a clear ending.



4.4 Activity-on-Node (AON) Fundamentals

- Historically, two methods have been used to develop project networks:
- Activityon-node (AON) and Activity-on-arrow (AOA).
- Over time the availability of advanced computer graphics improved the clarity and visual appeal of the AON method.
- Today, the activity-on-node method has come to dominate nearly all project network plans.
- For this reason, we have limited our discussion to AON methods.
- Figure 6.2 shows a few typical uses of building blocks for the AON network construction.

Activity-on-Node (AON) Fundamentals – Cont..

- An activity is represented by a node (box).
- The node can take many forms, but in recent years the node represented as a rectangle (box) has dominated.
- The dependencies among activities are depicted by arrows between the rectangles (boxes) on the AON network.
- The arrows indicate how the activities are related and the sequence in which things must be accomplished.
- The length and slope of the arrow are arbitrary and set for convenience of drawing the network.
- The letters in the boxes serve here to identify the activities while you learn the fundamentals of network construction and analysis.
- In practice, activities have identification numbers and descriptions

Activity-on-Node (AON) Fundamentals – Cont..

- There are three basic relationships that must be established for activities included in a project network.
- The relationships can be found by answering the following three questions for each activity:
 1. Which activities must be completed immediately before this activity? These activities are called predecessor activities.
 2. Which activities must immediately follow this activity? These activities are called successor activities.
 3. Which activities can occur while this activity is taking place? This is known as a concurrent or parallel relationship.

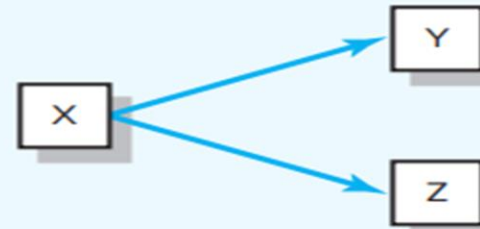
FIGURE 6.2

**Activity-on-Node
Network
Fundamentals**



(A)

A is preceded by nothing
B is preceded by A
C is preceded by B

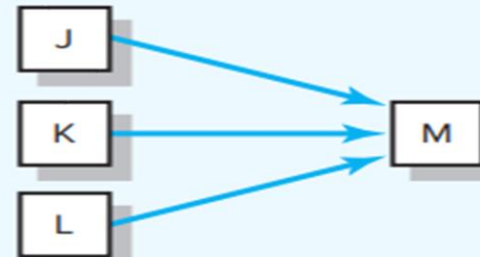


(B)

Y and Z are preceded by X

Y and Z can begin at the same time, if you wish

X is a burst activity



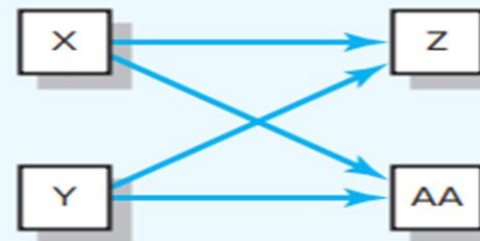
(C)

J, K, & L can all begin at the same time, if you wish (they need not occur simultaneously)

but

All (J, K, L) must be completed before M can begin

M is a merge activity



(D)

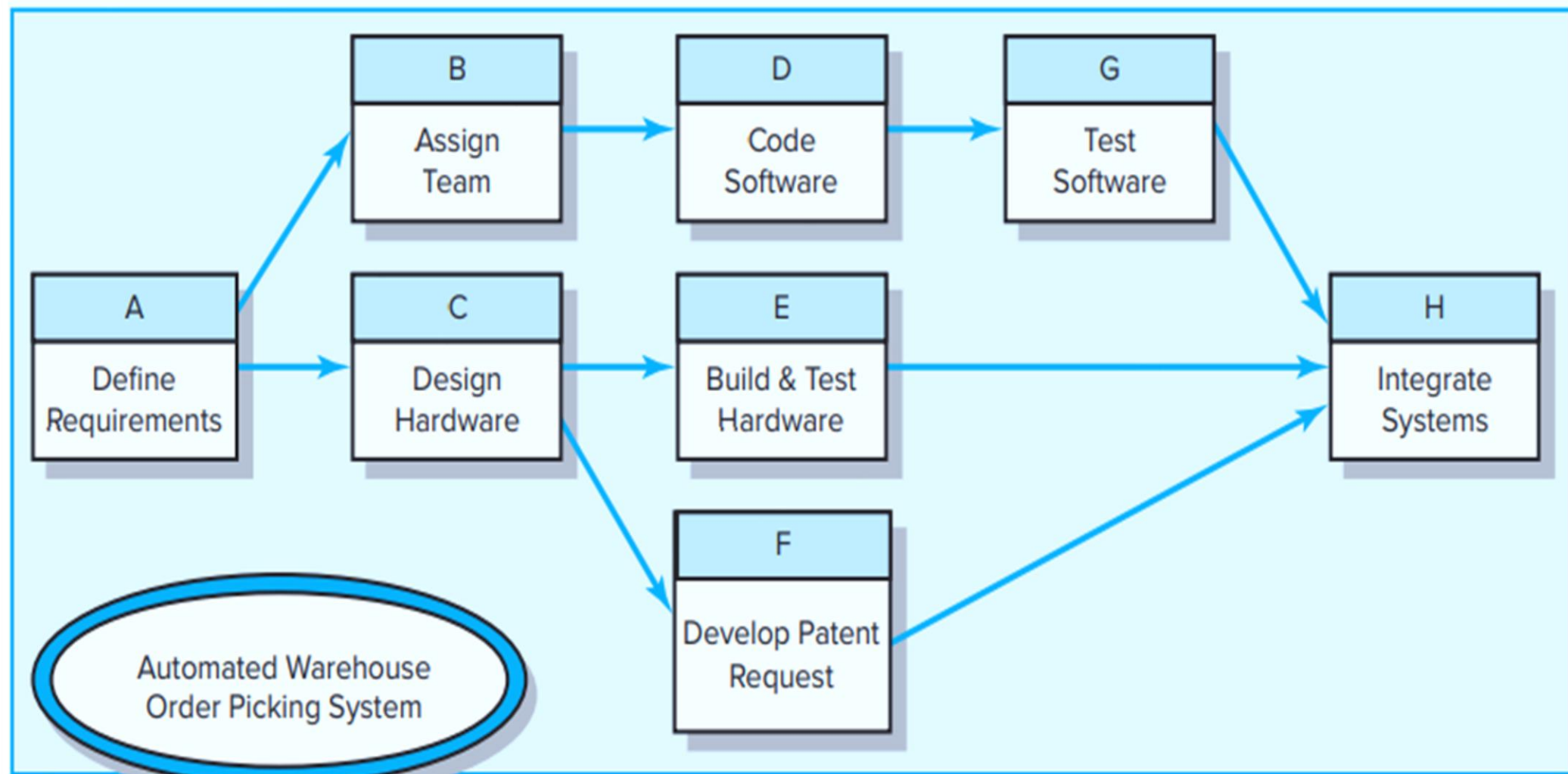
Z is preceded by X and Y

AA is preceded by X and Y

TABLE 6.1**Network Information**

AUTOMATED WAREHOUSE Order Picking System		
Activity	Description	Preceding Activity
A	Define Requirements	None
B	Assign Team	A
C	Design Hardware	A
D	Code Software	B
E	Build and Test Hardware	C
F	Develop Patent Request	C
G	Test Software	D
H	Integrate Systems	E, F, G

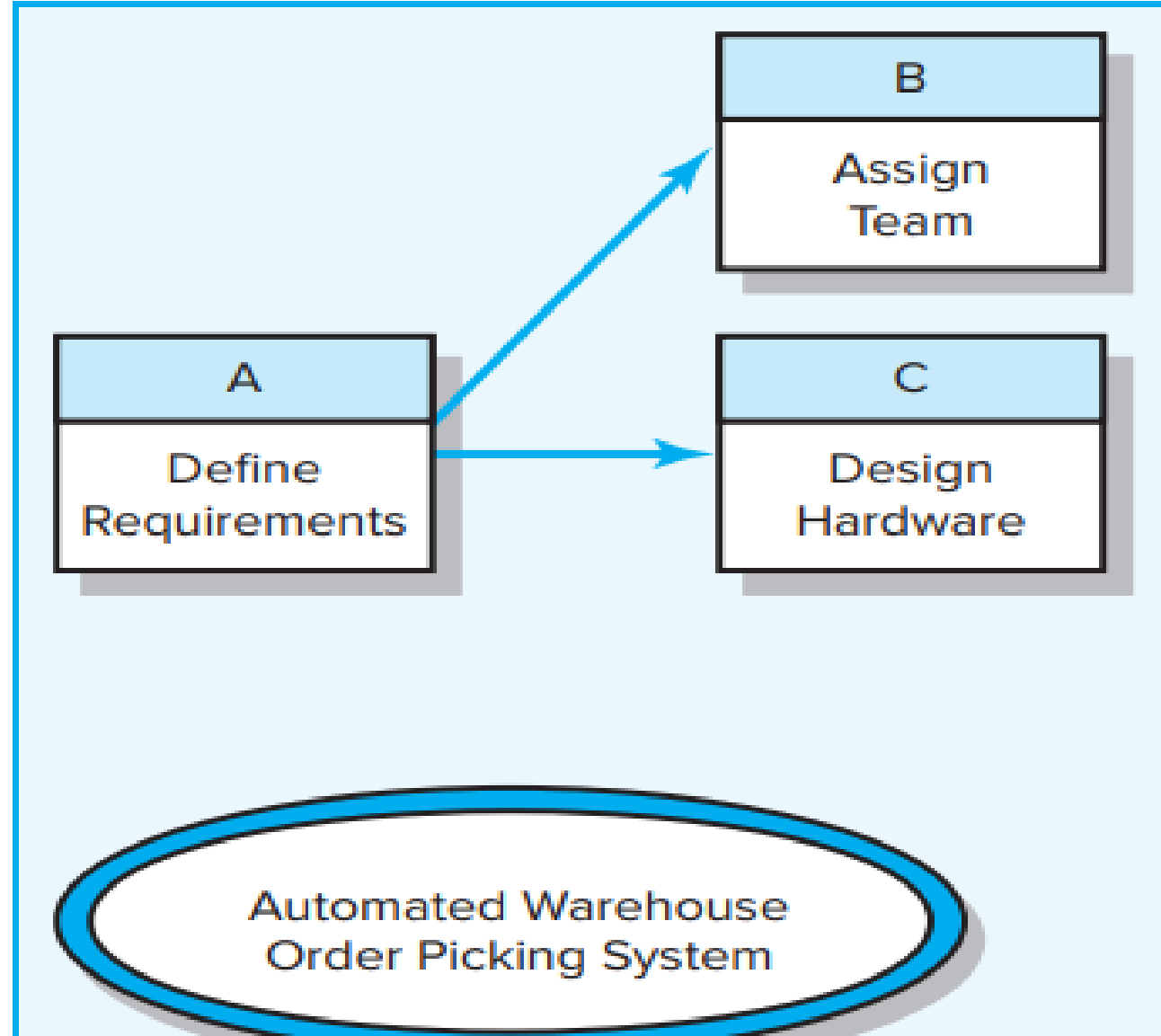
FIGURE 6.4 Automated Warehouse—Completed Network



Examples

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- Figure 6.3 shows the first steps in constructing the AON project network from the information in Table 6.1. We see that activity;
 - A (define requirements) has nothing preceding it; therefore, it is the first node to be drawn.
 - Next, we note that activities B and C (assign team and design hardware) are both preceded by activity A. We draw two arrows and connect them to activities B and C.
 - This segment shows the project manager that activity A must be completed before activities B and C can begin.
 - After A is completed, B and C can take place concurrently, if desired.

FIGURE 6.3
Automated
Warehouse—Partial
Network



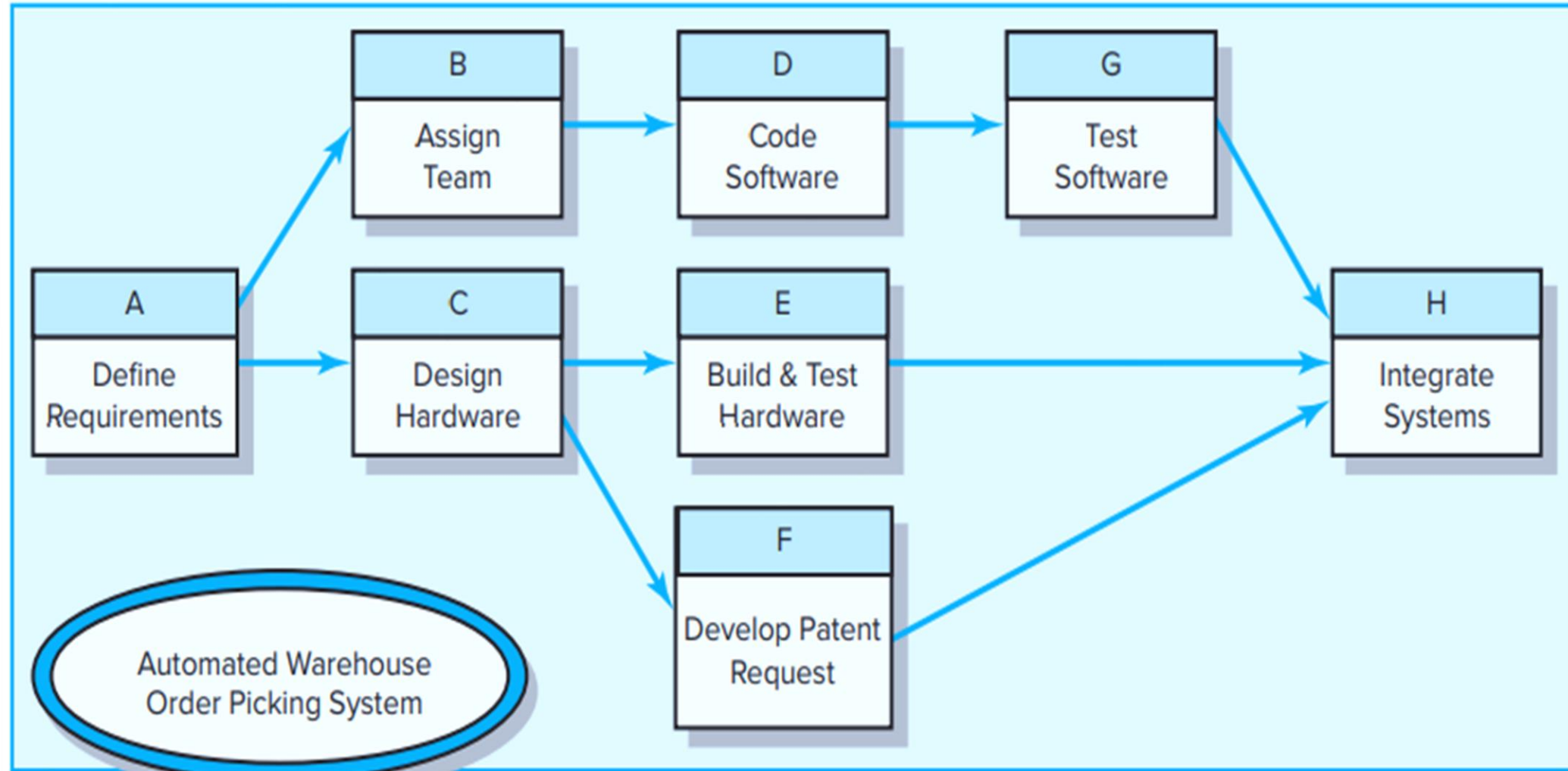
Examples

- Figure 6.4 shows the completed network with all of the activities sequences and dependencies.
- The information in Figure 6.4 is tremendously valuable to those managing the project.
- However, estimating the duration for each activity will further increase the value of the network.
- A realistic project plan and schedule require reliable time estimates for project activities.
- The addition of time to the network allows us to estimate how long the project will take.

Examples – Cont..

- When activities can or must start, when resources must be available, which activities can be delayed, and when the project is estimated to be complete are all determined from the times assigned.
- Deriving an activity time estimate necessitates early assessment of resource needs in terms of material, equipment, and people.
- In essence the project network with activity time estimates links planning, scheduling, and controlling of projects.

FIGURE 6.4 Automated Warehouse—Completed Network



4.5 Network Computation Process

- **Forward Pass—Earliest Times**

1. How soon can the activity start? (early start—ES)
2. How soon can the activity finish? (early finish—EF)
3. How soon can the project be finished? (expected time—TE)

- **Backward Pass—Latest Times**

1. How late can the activity start? (late start—LS)
2. How late can the activity finish? (late finish—LF)
3. Which activities represent the critical path (CP)? This is the longest path in the network which, when delayed, will delay the project.
4. How long can the activity be delayed? (slack or float—SL)

(1) Forward Pass—Earliest Times:

- The forward pass starts with the first project activity(ies) and traces each path (chain of sequential activities) through the network to the last project activity(ies).
- As you trace along the path, you add the activity times. The longest path denotes the project completion time for the plan and is called the critical path (CP).
- Table 6.2 lists the activity times in workdays for the Automated Warehouse project example we used for drawing a network.



(2) Backward Pass – Latest Times

- The backward pass starts with the last project activity(ies) on the network.
- You trace backward on each path subtracting activity times to find the late start (LS) and late finish (LF) times for each activity.
- Before the backward pass can be computed, the late finish for the last project activity(ies) must be selected.
- In early planning stages, this time is usually set equal to the early finish (EF) of the last project activity (or in the case of multiple finish activities, the activity with the largest EF).



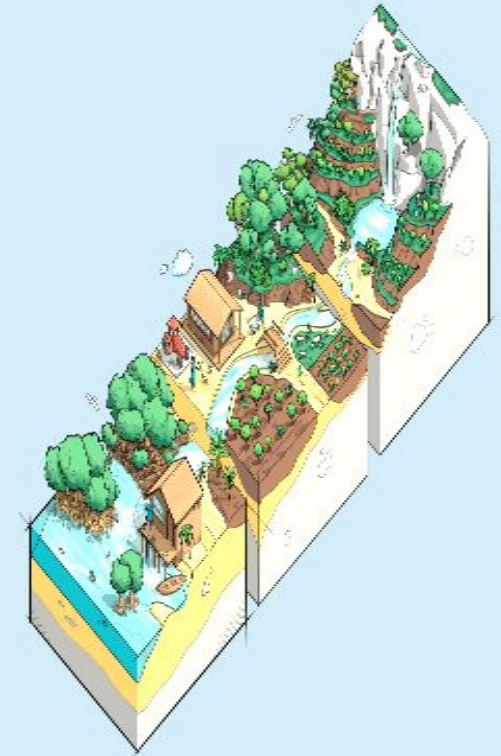
(2) Backward Pass – Latest Times – Cont..

- In some cases an imposed project duration deadline exists, and this date will be used.
- Let us assume for planning purposes we can accept the EF project duration (TE) equal to 100 workdays.
- The LF for activity H becomes 100 days (EF = LF).



4.6 Using the Forward and Backward Pass Information

- When the critical path is known, it is possible to tightly manage the resources of the activities on the critical path so no mistakes are made that will result in delays.
- In addition, if for some reason the project must be expedited to meet an earlier date, it is possible to select those activities, or combination of activities, that will cost the least to shorten the project.



Using the Forward and Backward Pass Information – Cont..

- Similarly, if the critical path is delayed and the time must be made up by shortening some activity or activities on the critical path to make up any negative slack, it is possible to identify the activities on the critical path that cost the least to shorten.
- If there are other paths with very little slack, it may be necessary to shorten activities on those paths also.



4.7 Level of Detail for Activities

- Time-phasing work and budgets of the project mandate careful definition of the activities that make up the project network.
- Typically an activity represents one or more tasks from a work package. How many tasks you include in each activity sets the level of detail.
- In some cases it is possible to end up with too much information to manage, and this can result in increased overhead costs.
- Managers of small projects have been able to minimize the level of detail by eliminating some of the preliminary steps to drawing networks.
- Larger firms also recognize the cost of information overload and are working to cut down the level of detail in networks and in most other dimensions of the project.

4.8 Practical Considerations

- Network Logic Errors Project network techniques have certain logic rules that must be followed.
- One rule is that conditional statements such as “if test successful build proto, if failure redesign” are not permitted.
- The network is not a decision tree; it is a project plan that we assume will materialize. If conditional statements were allowed, the forward and backward pass would make little sense.
- Although in reality a plan seldom materializes as we expect in every detail, it is a reasonable initial assumption.
- You shall see that once a network plan is developed, it is an easy step to make revisions to accommodate changes.



4.8 Practical Considerations – Cont..

- Another rule that defeats the project network and computation process is looping. Looping is an attempt by the planner to return to an earlier activity.
- Recall that the activity identification numbers should always be higher for the activities following an activity in question; this rule helps to avoid the illogical precedence relationships among the activities.
- An activity should only occur once; if it is to occur again, the activity should have a new name and identification number and should be placed in the right sequence on the network.
- If this loop were allowed to exist, this path would perpetually repeat itself. Many computer programs catch this type of logic error



(1) Activity Numbering

- Each activity needs a unique identification code—a letter or a number. In practice very elegant schemes exist.
- Most schemes number activities in ascending order, that is, each succeeding activity has a larger number so that the flow of the project activities is toward project completion.
- It is customary to leave gaps between numbers (1, 5, 10, 15 . . .). Gaps are desirable so you can add missing or new activities later.
- Because it is nearly impossible to draw a project network perfectly, numbering networks is frequently not done until after the network is complete.



Use of Computer to Develop Networks

- All of the tools and techniques discussed in this chapter can be used with computer software currently available.
- Two examples are shown in Figures 6.10 and 6.11. Figure 6.10 presents a generic AON computer output for the Automated Warehouse Picking System project.
- Observe that these computer outputs use numbers to identify activities. The critical path is identified by the nodes (activities) 2, 4, 6, and 9.
- The activity description is shown on the top line of the activity node.
- The activity start time and identification are on the second line

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Calendar Dates

- Ultimately you will want to assign calendar dates to your project activities.
- If a computer program is not used, dates are assigned manually.
- Lay out a calendar of workdays (exclude non-workdays), and number them.
- Then relate the calendar workdays to the workdays on your project network.
- Most computer programs will assign calendar dates automatically after you identify start dates, time units, non-workdays, and other information.

Multiple Starts and Multiple Projects

- Some computer programs require a common start and finish event in the form of a node—usually a circle or rectangle—for a project network.
- Even if this is not a requirement, it is a good idea because it avoids “dangler” paths.
- Dangler paths give the impression that the project does not have a clear beginning or ending.
- If a project has more than one activity that can begin when the project is to start, each path is a dangler path.
- The same is true if a project network ends with more than one activity; these unconnected paths are also called danglers.
- Danglers can be avoided by tying dangler activities to a common project start or finish node.

4.9 Extended Network Techniques to Come Closer to Reality

- The method for showing relationships among activities in the last section is called the finish-to-start relationship because it assumes all immediate preceding connected activities must be completed before the next activity can begin.
- In an effort to come closer to the realities of projects, some useful extensions have been added. The use of laddering was the first obvious extension practitioners found very useful.



Thank You