Developing a Project Plan (Activity Networks)

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SE 4381, Software Project Planning and Management

Management Topics

1. Modern project management

PMBOK

2. Organization strategy and project selection

3. Organization: structure and culture

4. Defining the project

5. Estimating times and costs

6. Developing a project plan

7. Managing risk

8. Scheduling resources and cost

9. Reducing project duration

10. Leadership

11. Teams

12. Outsourcing

13. Monitoring progress

14. Project closure

15. International projects

16. Oversight

17. Agile PM

Critical chain project management

Project Networks

<u>The</u> tool used for planning, scheduling, and monitoring project progress

Depicts

- **project activities that must be completed**
- **logical sequences**
- **interdependencies of the activities**
- **times for activities to start and finish**
  - **along the longest path through the network – the critical path**

Basis for scheduling labor and equipment

Provides the estimate of project duration

Critical Path

How long will it take to do the project?

- **defines the schedule**

The longest path through the activity network is the minimum time to complete the project.

The path with no slack in its activities for getting the work done with delaying the project.

There may be more than one critical path of the same length…

When estimates are replaced with actuals, the critical path may shift (sensitivity).

Sensitivity

There may be more than one critical path through the activity network…

There may be paths that have very little slack…

Sensitivity indicates the likelihood that the critical path will change after the project starts.

- **effort <u>estimates</u> are used to identify the critical path**

Activities

An element in the project that consumes time

Built from work packages in the WBS

Integrating work packages and the activity network are more likely to fail when

- **different people define the work packages and activities**
- **the WBS is not deliverable / output oriented**

Networks identify the dependencies, sequencing, and timing of activities.

Terminology

Activity – an element of the project that requires time

Path – a sequence of connected, dependent activities

Critical path – the path with the longest duration through the network

- **if an activity on the critical path is delayed, the project is delayed the same amount of time**

Event – the point in time when an activity is started or completed

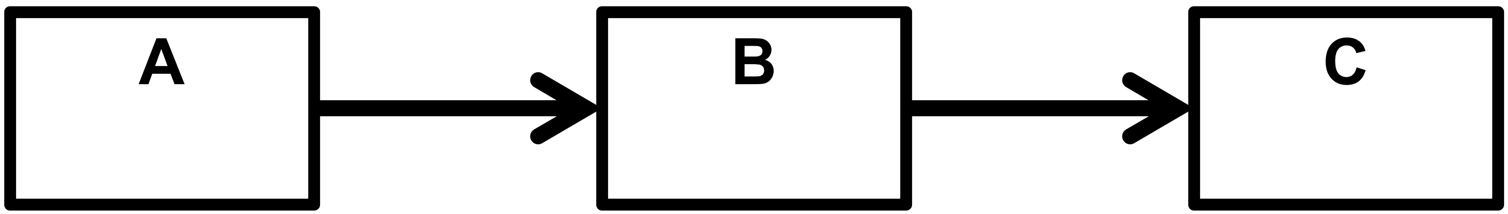
- **events do not consume time**

Merge activity – an activity that has more than one activity immediately preceding it

Burst activity – an activity with more than one activity immediately following it

Parallel activities – activities that can take place at the same time

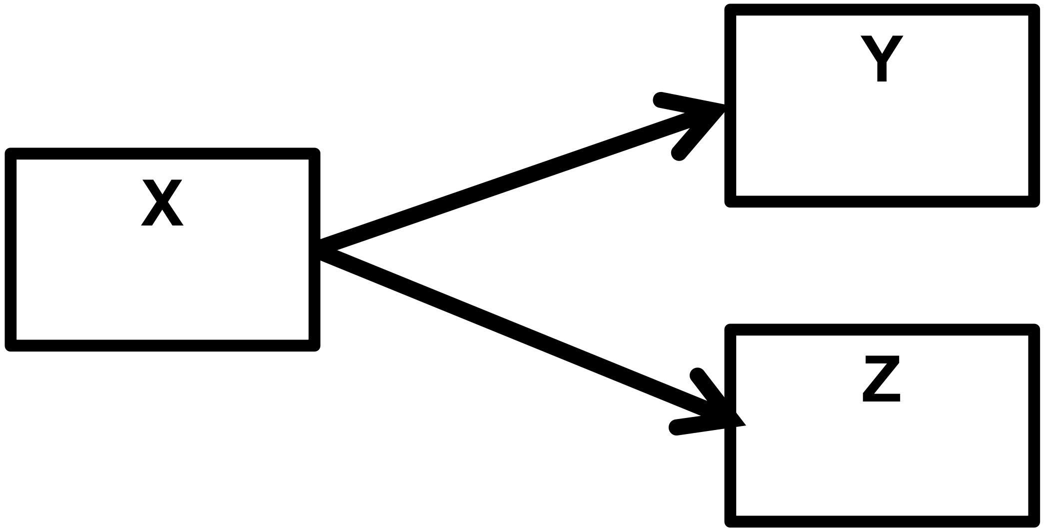
Larson and Gray, Figure 6.2



A is preceded by nothing.
A is succeeded by B.

B is preceded by A.
B is succeeded by C.

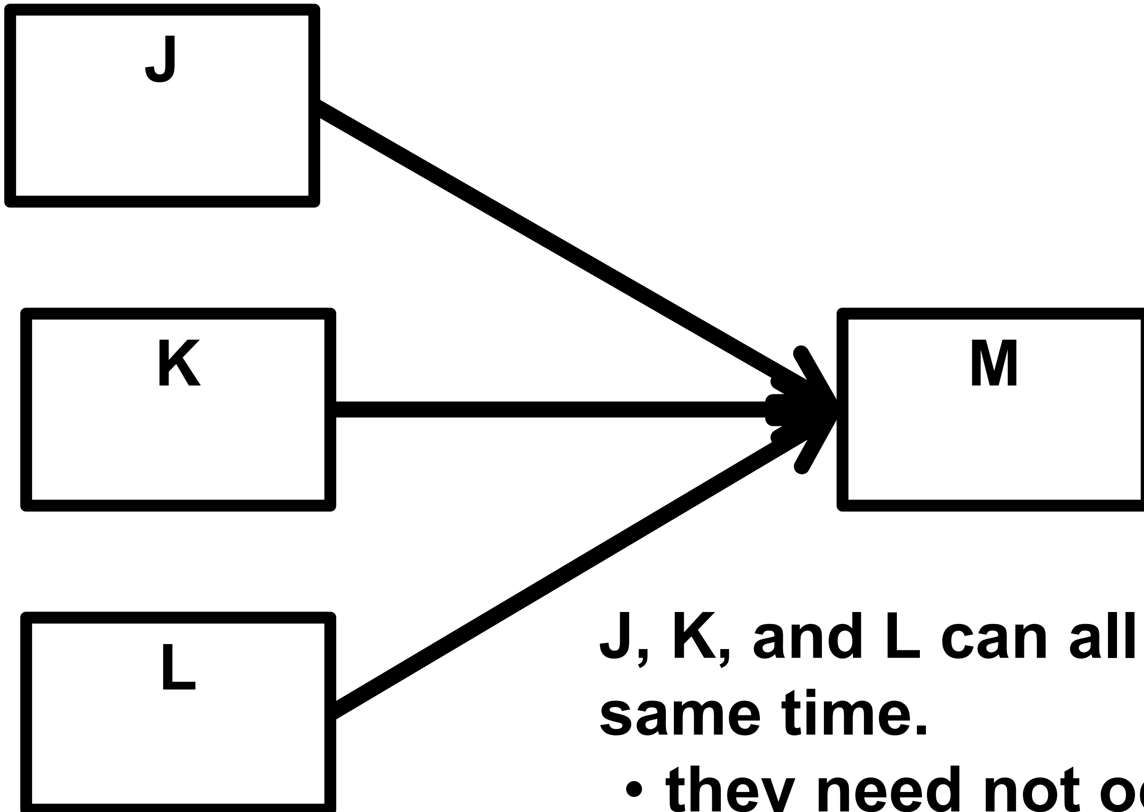
C is preceded by B.
C is succeeded by nothing.



Y and Z are preceded by X.

Y and Z <u>can</u> begin at the same time.

X is a burst activity.

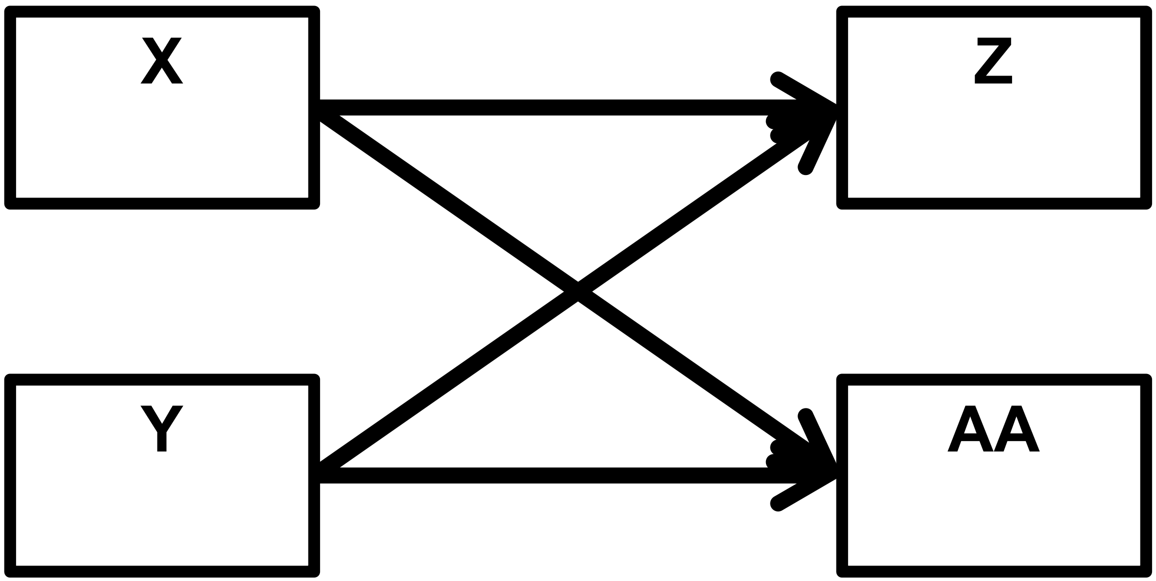


J, K, and L can all begin at the same time.

- **they need not occur simultaneously**

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

M is a merge activity.

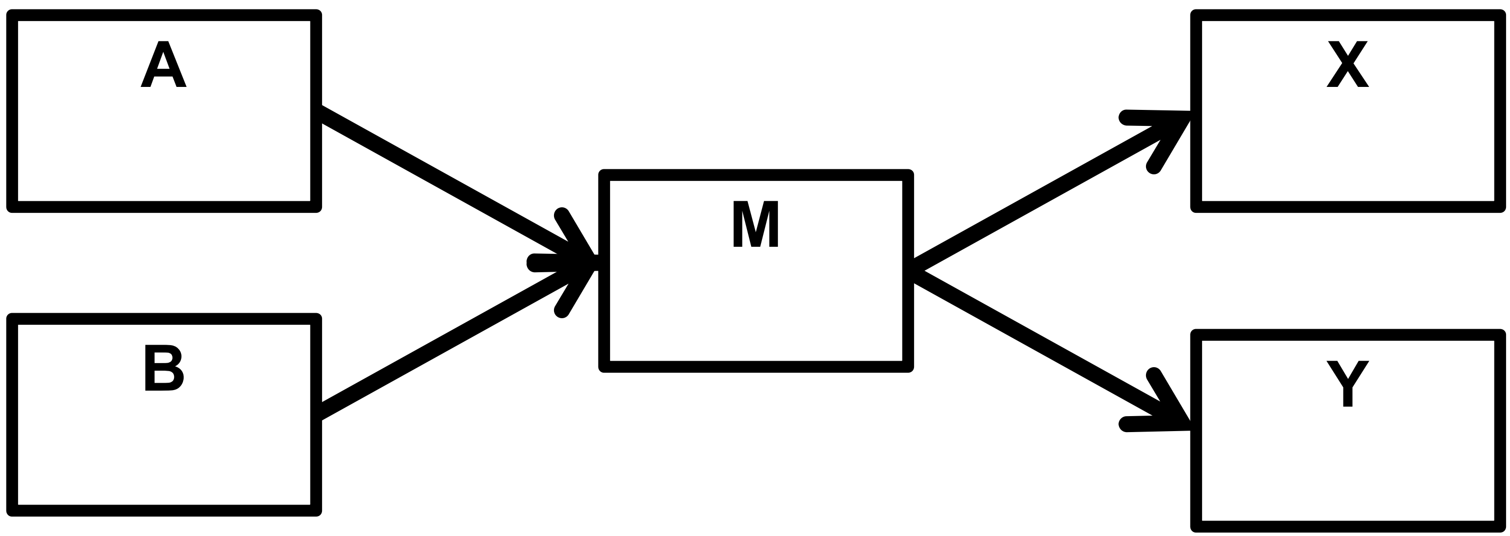


Z is preceded by X and Y. Z is a merge activity.

AA is preceded by X and Y. AA is a merge activity.

X is succeeded by Z and AA. X is a burst activity.

Y is succeeded by Z and AA. Y is a burst activity.



M is both a merge and burst activity.

Two Approaches to Building Activity Networks

Activity-on-node (AON)

- **the most popular style of documenting an activity network**

Activity-on-arrow (AOA)

The two approaches are equivalent.

The choice of AON vs AOA is a matter of preference.

AOA Method

Arrow in the network represents an activity that requires time

Node represents an event
- **do not consume time**

Each activity has a start and end node

“Dummy activities” are created when two are more activities are parallel and have the same start and finish nodes to ensure that each activity has a unique identification number.

AOA Advantages and Disadvantages

Advantages

- **Path tracing is simplified by activity/event numbering scheme.**
- **AOA is easier to draw if dependencies are intense.**
- **Key events or milestones can easily be flagged.**

Disadvantages

- **Use of dummy activities increases data requirements.**
- **Emphasis on events can detract from activities.**
  - **Activity delays cause events and projects to be late.**

AON Method (Precedence Diagram Method)

An activity is represented by a node (typically a rectangle).

Dependences are depicted by arrows between nodes.

Relations are found by answering:

- **Which <u>predecessor</u> activities must be completed immediately before this activity?**
- **Which <u>successor</u> activities must immediately follow this activity?**
- **Which <u>concurrent</u> (<u>parallel</u>) activities can occur while this activity is taking place?**

AON Advantages and Disadvantages

Advantages

- **No dummy activities are used.**
- **Events are not used.**
- **AON is easy to draw if dependencies are not intense.**
- **Activity emphasis is easily understood by first-level managers.**

Disadvantages

- **Network drawing and understanding are more difficult when dependencies are numerous.**

Basic Rules to Follow in Developing Project Networks

Networks typically flow from left to right.

An activity cannot begin until all preceding connected activities have been completed.

Arrows on networks indicate precedence and flow.

- **Arrows can cross over each other.**

Each activity should have a unique identification number.

- **An activity identification number should be larger than that of any activities that precede it.**

Looping is not allowed.

- **No recycling through a set of activities.**

Conditional statements are not allowed.

When there are (potentially) multiple "starts" to the project, use a common start node to indicate a clear project beginning on the network.

When there are (potentially) multiple "ends" to the project, use a single common end node to indicate a clear ending.

Forward and Backward Pass

Forward pass – earliest times

- **How soon can the activity start?**
  - **early start, ES**
- **How soon can the activity finish?**
  - **early finish, EF**
- **How soon can the project be finished?**
  - **expected time, TE**

Backward pass – latest times

- **How late can the activity start?**
  - late start, LS
- **How late can the activity finish?**
  - late finish, LF
- **Which activities represent the critical path?**
  - critical path, CP, is the longest path in the activity network – the minimum time to complete the project
- **How long can the activity be delayed?**
  - slack or float, SL

Legend for Forward and Backward Pass Nodes

ES	ID	EF
SL	Description	
LS	DUR	LF

ES – early start **ID – identifier** **EF – early finish**

SL – slack **Description**

LS – late start **DUR – duration** **LF – late finish**

Forward Pass Algorithm

Add activity times along each path in the network

- **EF = ES + DUR**

Carry the early finish (EF) to the next activity where it becomes its early start (ES)…

Unless the next activity is a merge activity

- **every activity will start at the instant when the last of its predecessors finish**
- **select the largest early finish time (EF) of all its immediate predecessor activities**

Backward Pass Algorithm

Subtract activity times along each path starting with the project end activity.

- **LS = LF – DUR**

Carry the LS to the next preceding activity to establish its LF…

Unless the next preceding activity is a burst activity

- **select the smallest LS of all its immediate successor activities to establish its LF**

Slack

The amount of time an activity can be delayed without delaying any immediately following (successor) activity.

The amount of time an activity can exceed its early finish date without affecting the early start date of any successor.

Determining Slack

Total slack is the amount of time an activity can exceed its early finish date without affecting the project end date (or an imposed completion date).

SL = LS – ES

SL = LF – EF

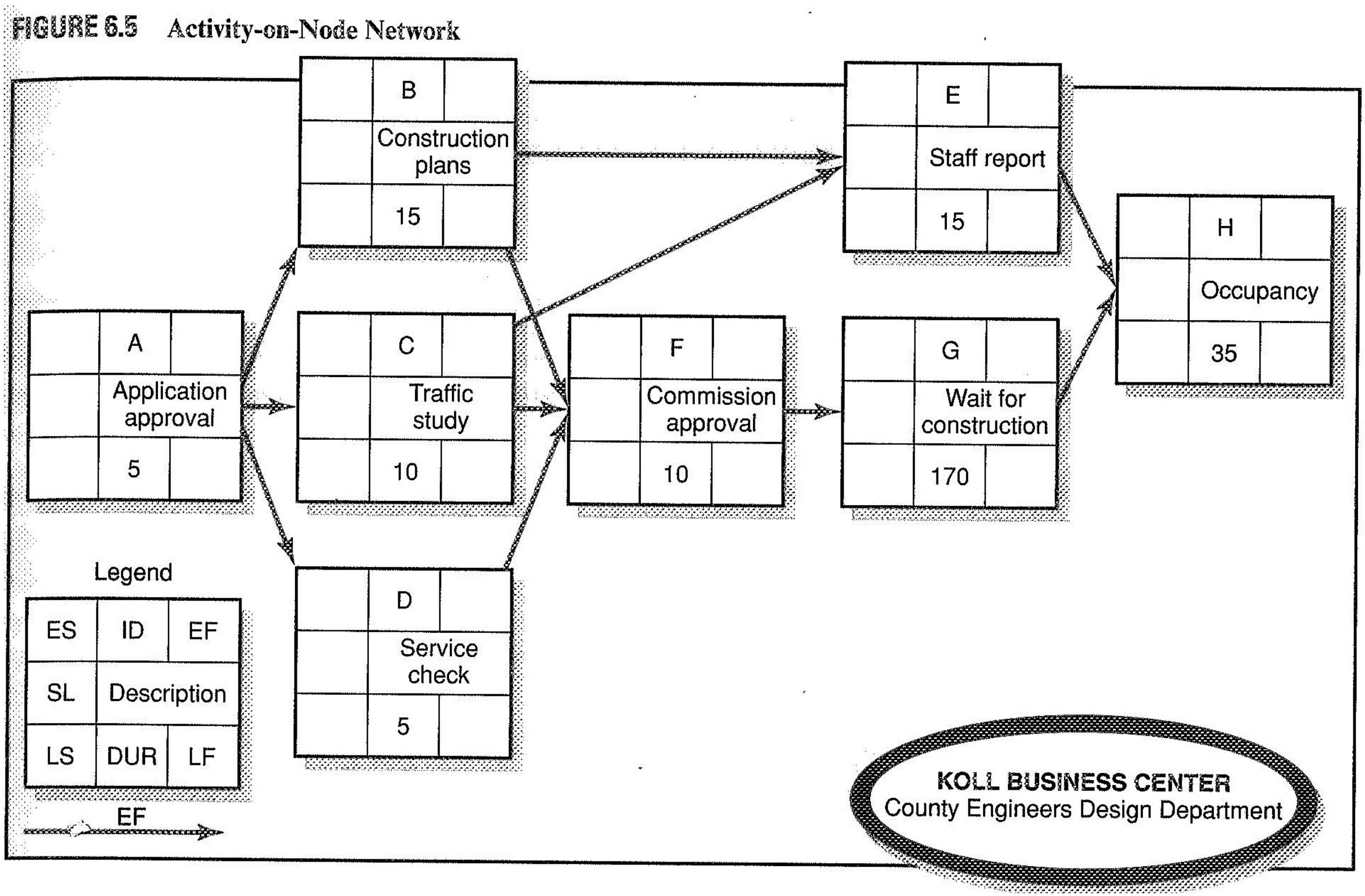
Critical path activities have a slack of 0.

Larson and Gray, Table 6.2

Koll Business Center
County Engineers Design Department

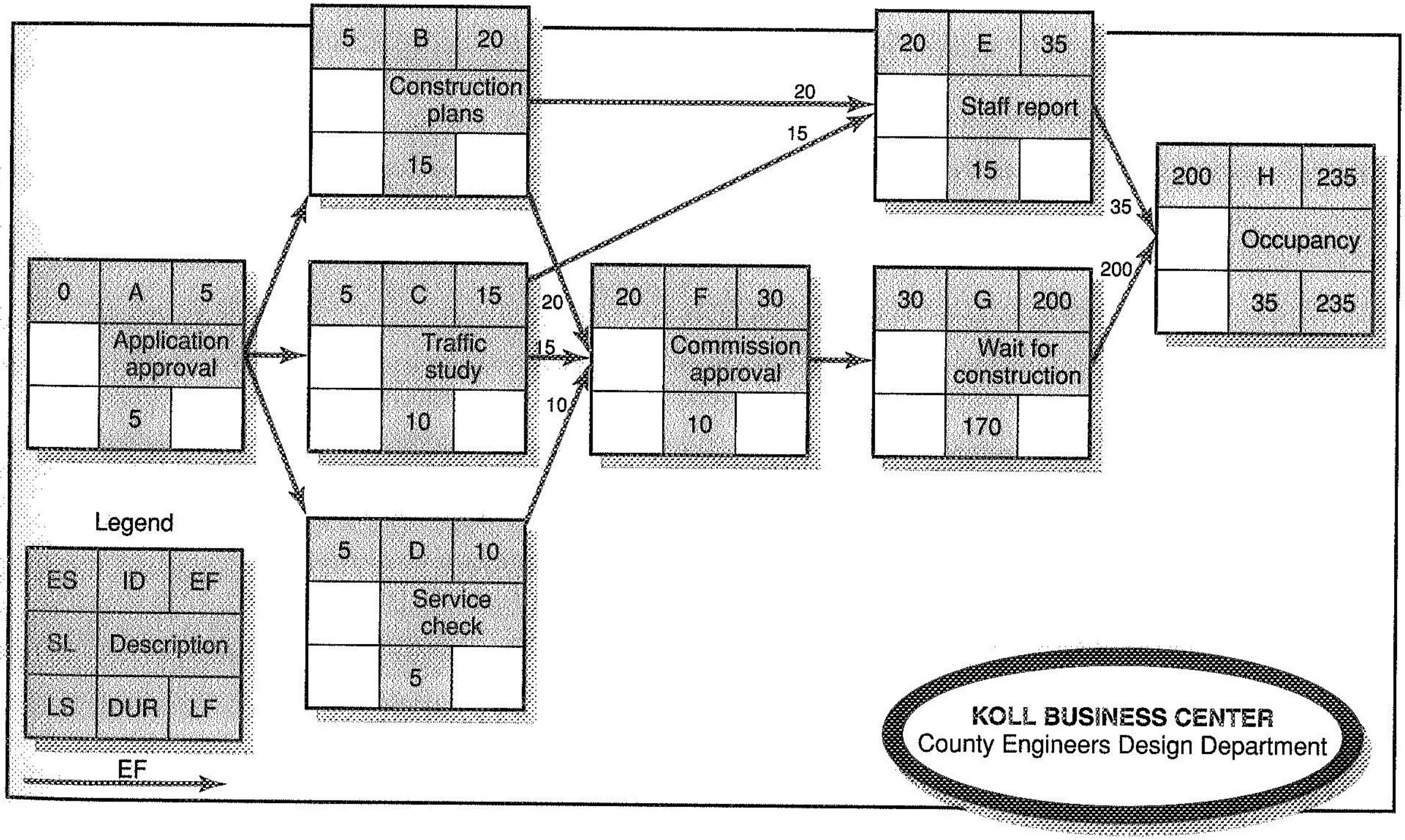
Activity	Description	Preceding Activity	Activity Time
A	Application approval	None	5
B	Construction plans	A	15
C	Traffic study	A	10
D	Service availability check	A	5
E	Staff report	B, C	15
F	Commission approval	B, C, D	10
G	Wait for construction	F	170
H	Occupancy	E, G	35

Larson and Gray, Figure 6.5



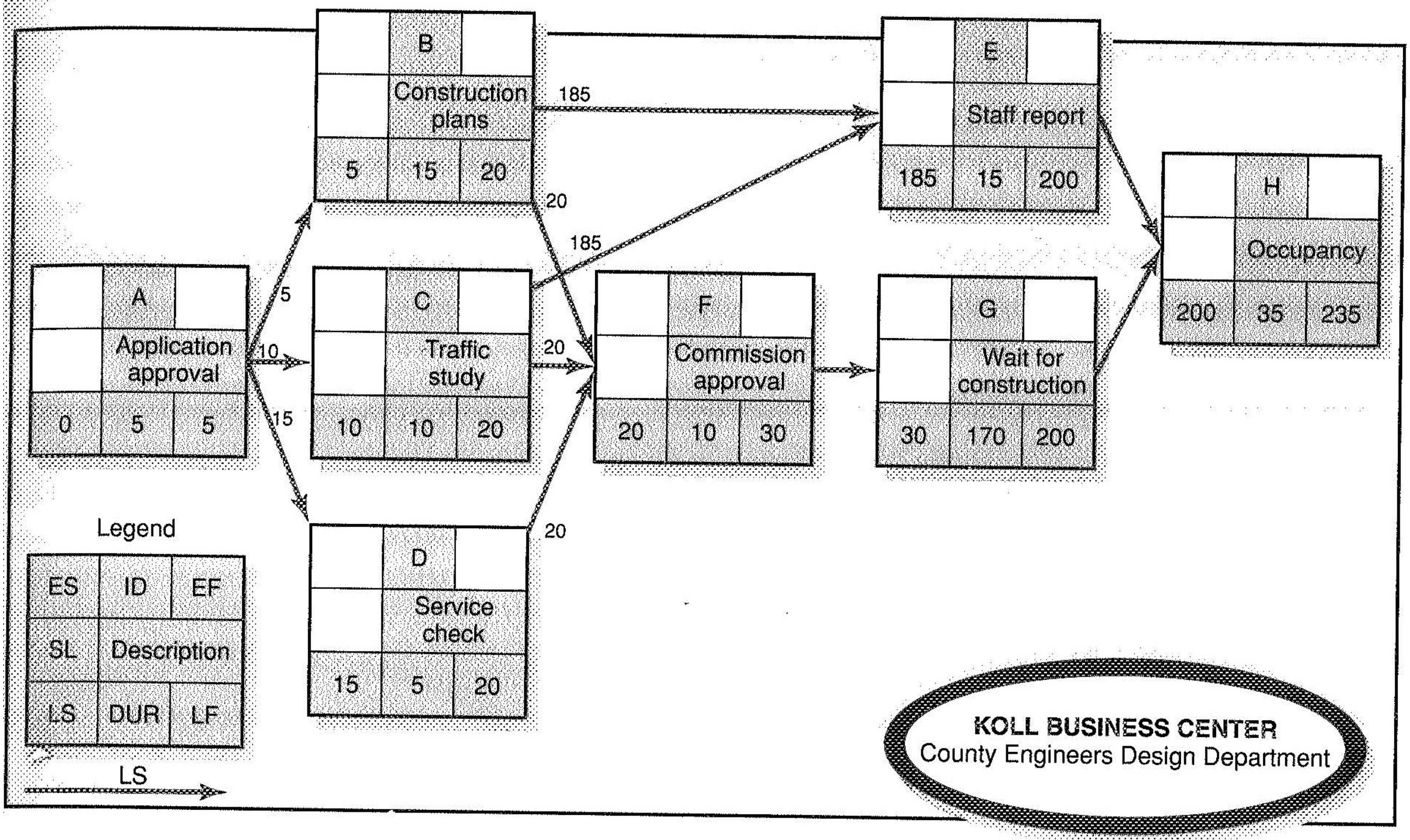
Larson and Gray, Figure 6.6

FIGURE 6.6 Activity-on-Node Network Forward Pass



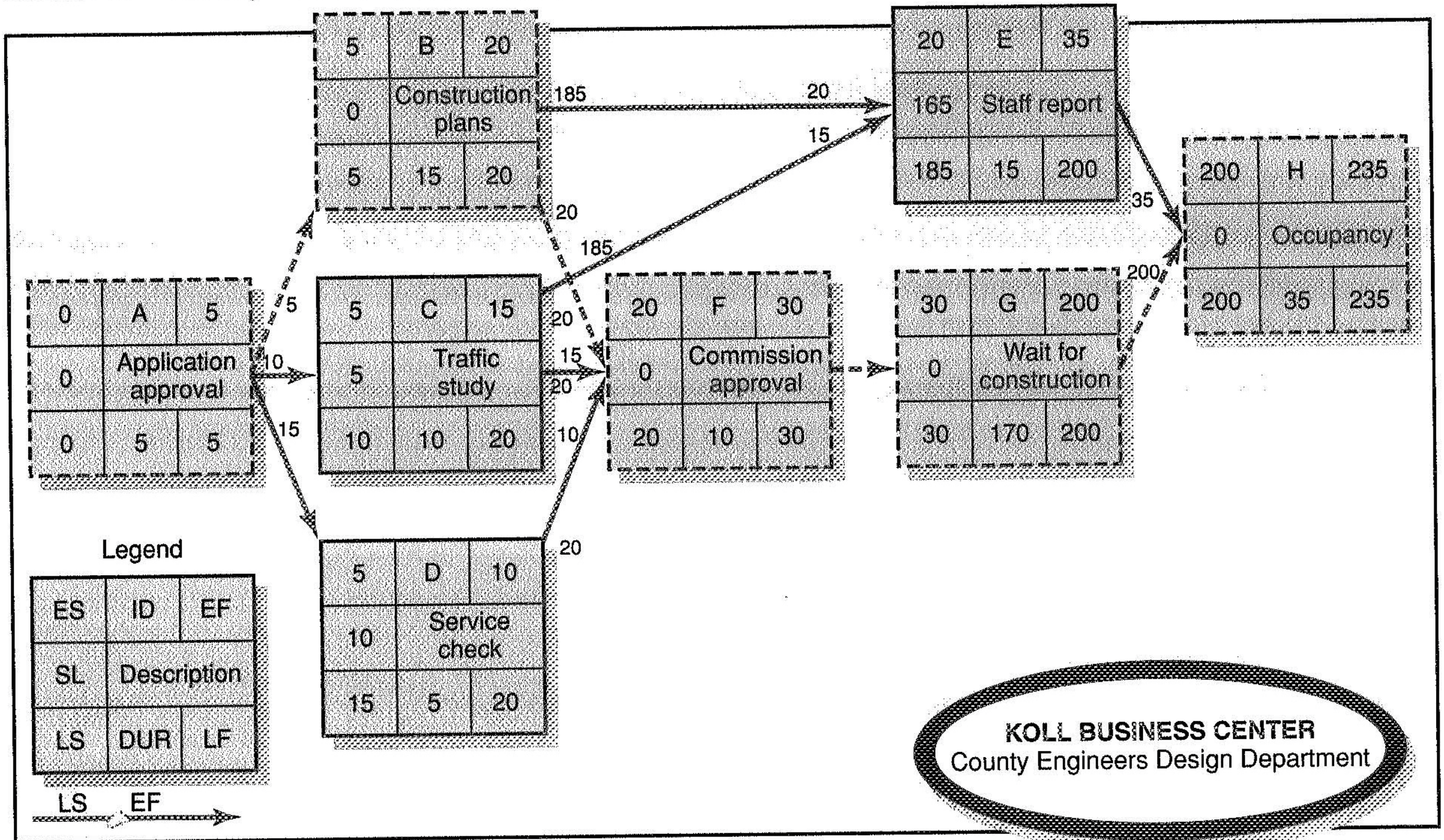
Larson and Gray, Figure 6.7

FIGURE 6.7 **Activity-on-Node Network Backward Pass**



Larson and Gray, Figure 6.8

FIGURE 6.8 Activity-on-Node Network with Slack



Using the Information

Early Start and Late Finish tell the time interval in which an activity should be completed.

Minimizing the level of detail in the activities may help prevent information overload.

- **activities represent one or more tasks from a work package**

Laddering

The assumption that all immediate preceding activities must be completed can be too restrictive.

Sometimes one activity can overlap another activity.

Breaking an activity into segments that can overlap is called laddering.

- **example: laying pipe**
  - **digging a trench**
  - **laying pipe**
  - **refilling the trench**

Lags

A lag is the minimum amount of time a dependent activity must be delayed to begin or end.

- **when activities of long duration delay the start or finish of successor activities, break the activity into smaller activities to avoid the long delay of the successor activity**
- **constrain the start and finish of an activity**

Types of Lags

Finish-to-Start

- **delay the start of the next activity**
  - **example: allowing concrete to cure after removing the forms**
  - **example: ordering materials**
- **be prepared to justify the legitimacy of the lag**

Start-to-Start

- **can be useful in concurrent engineering**
- **concurrency can lead to rework…**
- **useful in compressing the duration of the critical path**
  - **example: pipe laying (rather than laddering)**

Finish-to-Finish

- example: testing may begin before a release is complete but must finish up with the completed version of the release

Start-to-Finish

- finish depends on starting of another activity
  - example: documentation cannot end until after testing has started (presuming no changes after testing starts)

Hammock Activities

Identify the use of fixed resources or costs over a segment of a project

Derive their duration from the time span between other activities

- **from the start of the first activity using the resource to the finish of the last activity using it**

Can also be used to aggregate sections of a project (a subnetwork that preserves precedence).

Concurrent Engineering

Engineering design philosophy of cross-functional cooperation to create products that are better, cheaper, and more quickly brought to market.

- **increased role of manufacturing process design in product design decisions**
- **formation of cross-functional teams to accomplish the development process**
- **a focus on the customer during the development process**
- **the use of lead time as a source of competitive advantage**

R.P. Smith, "The Historical Roots of Concurrent Engineering Fundamentals," IEEE Transactions on Engineering Management, February 1997.

Activity Concurrency

Within-stage overlap of tasks

Across-stage overlap

- **concurrent activity across different stages of the development process**

Hardware/software overlap

- **occurs when software must be embedded into a larger system**

Across-project overlap

- **components designed for one product can be reused in current and future product releases**

J.D. Blackburn, G. Hoedemaker, and L.N. Van Wassenhove, "Concurrent Software Engineering: Prospects and Pitfalls," IEEE Transactions on Engineering Management, May 1996.

Information Concurrency

Front loading

- early involvement in upstream design activities of downstream functions or issues

Flying start

- preliminary information transfer flowing from upstream design activities to team members primarily concerned with downstream activities

Two-way high bandwidth information exchange

- intensive and rich communication among teams while performing concurrent activities

Defining "Project Plan"

A formal, approved document used to manage project execution.

- **PMBOK**

- **project charter**
- **description of project management approach**
- **scope statement**
- **WBS to the level at which control will be exercised**
- **cost estimates, schedule, responsibility assignments**
- **performance measurement baselines for technical scope, schedule, and cost**
- **major milestones**
- **key or required staff**
- **risk management plan**
- **subsidiary management plans**
- **open issues and pending decisions**

The Two Problems of Planning

"Plans are useless, planning is indispensable."

- **Dwight D. Eisenhower**

There is variation and uncertainty in everything (and we do not allow for uncertainty!).

People tend to underestimate a given task (even if they have done it many times before).

- **People tend to underestimate their own completion times.**
- **People tend to underestimate even more when others are present.**
- **People can deliberately underestimate to garner favor or win contracts.**

The Planning Fallacy

The Planning Fallacy describes plans and forecasts that

- **are unrealistically close to best-case scenarios**
- **could be improved by consulting the statistics of similar cases**

J. Benson, Why Plans Fail: Cognitive Bias, Decision Making, and Your Business, 2011.

Mitigating the Planning Fallacy

Reference class forecasting (Flyvbjerg)

Identify an appropriate reference class.

Obtain the statistics of the reference class.

Use the statistics to generate a baseline prediction.

Use specific information about the case to adjust the baseline prediction.

- **if there are particular reasons to expect the optimistic bias to be more or less pronounced in this project than for others of the same type**

Questions and Answers