SWE 4803

Lec - 5

PLANNING PROCESS GROUP

PLANNING PROCESS GROUP

Planning Process Group

Planning Process Group

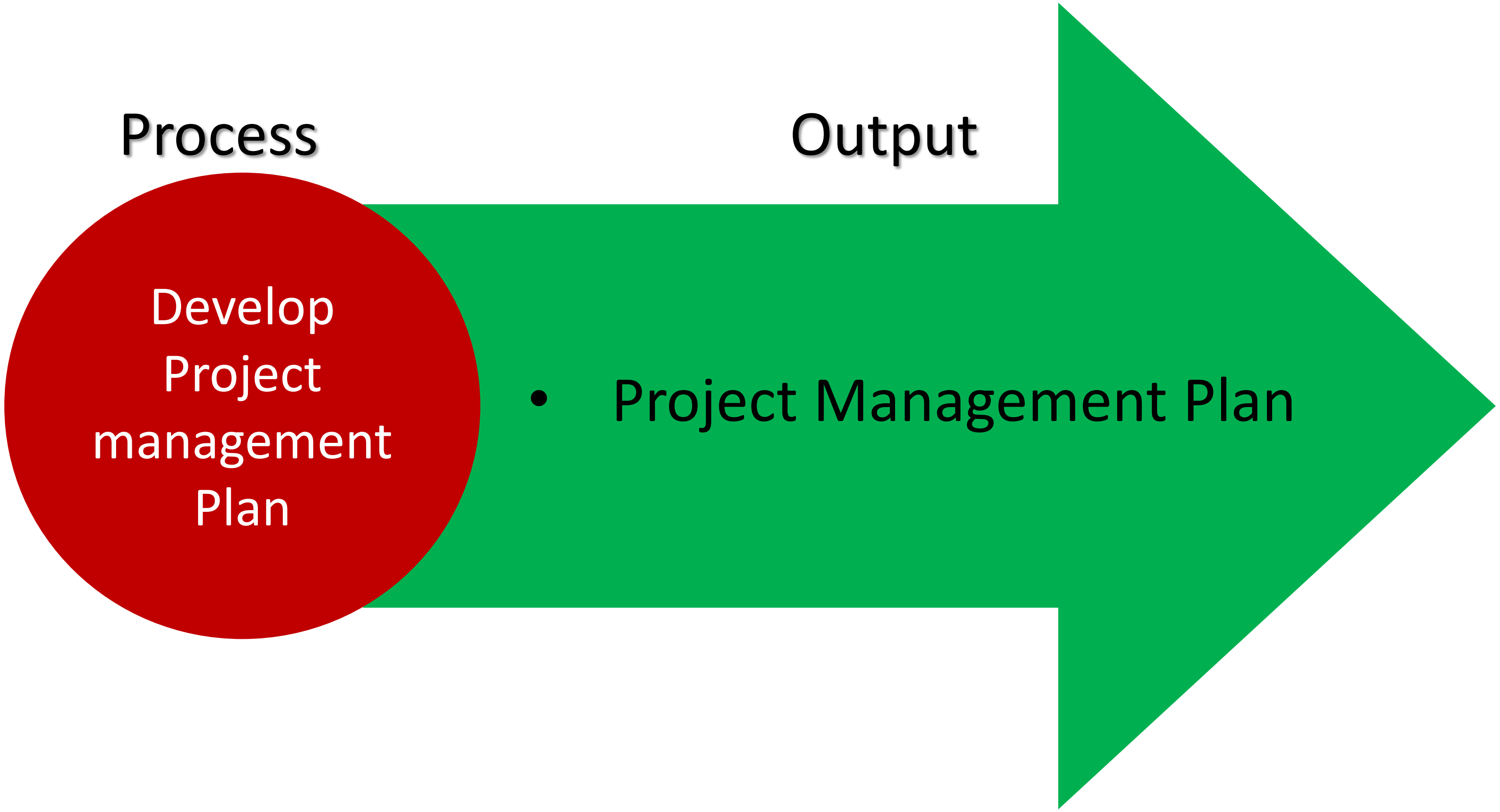
1. Develop Project Management Plan ⇒ Project Integration Management
2. Plan Scope Management ⇒ Project Scope Management
3. Collect Requirements ⇒ Project Scope Management
4. Define Scope ⇒ Project Scope Management
5. Create WBS ⇒ Project Scope Management
6. Plan Schedule Management ⇒ Project Schedule Management
7. Define Activities ⇒ Project Schedule Management
8. Sequence Activities ⇒ Project Schedule Management
9. Estimate Activity Durations ⇒ Project Schedule Management
10. Develop Schedule ⇒ Project Schedule Management
11. Plan Cost Management ⇒ Project Cost Management
12. Estimate Costs ⇒ Project Cost Management

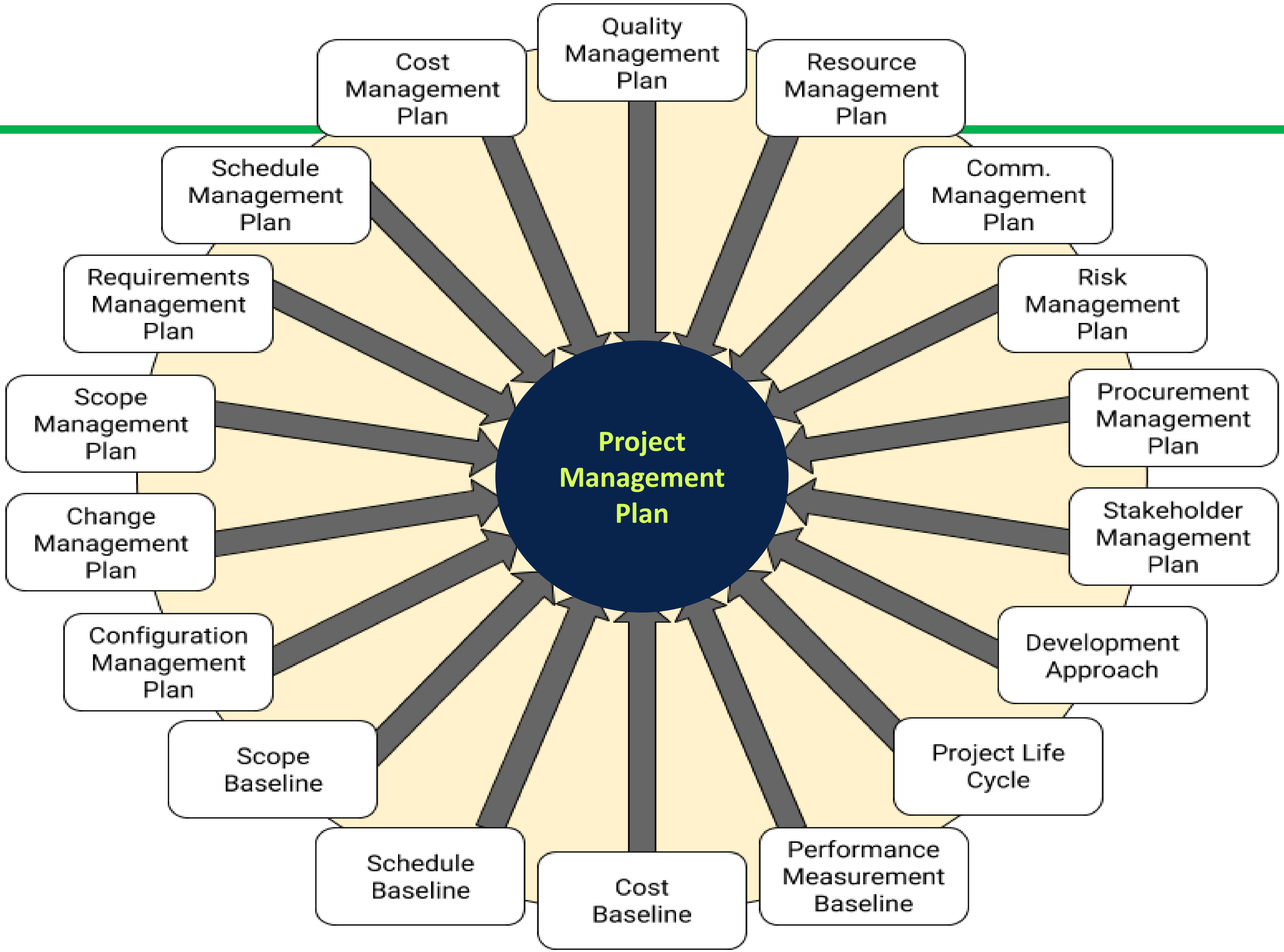
PLANNING PROCESS GROUP

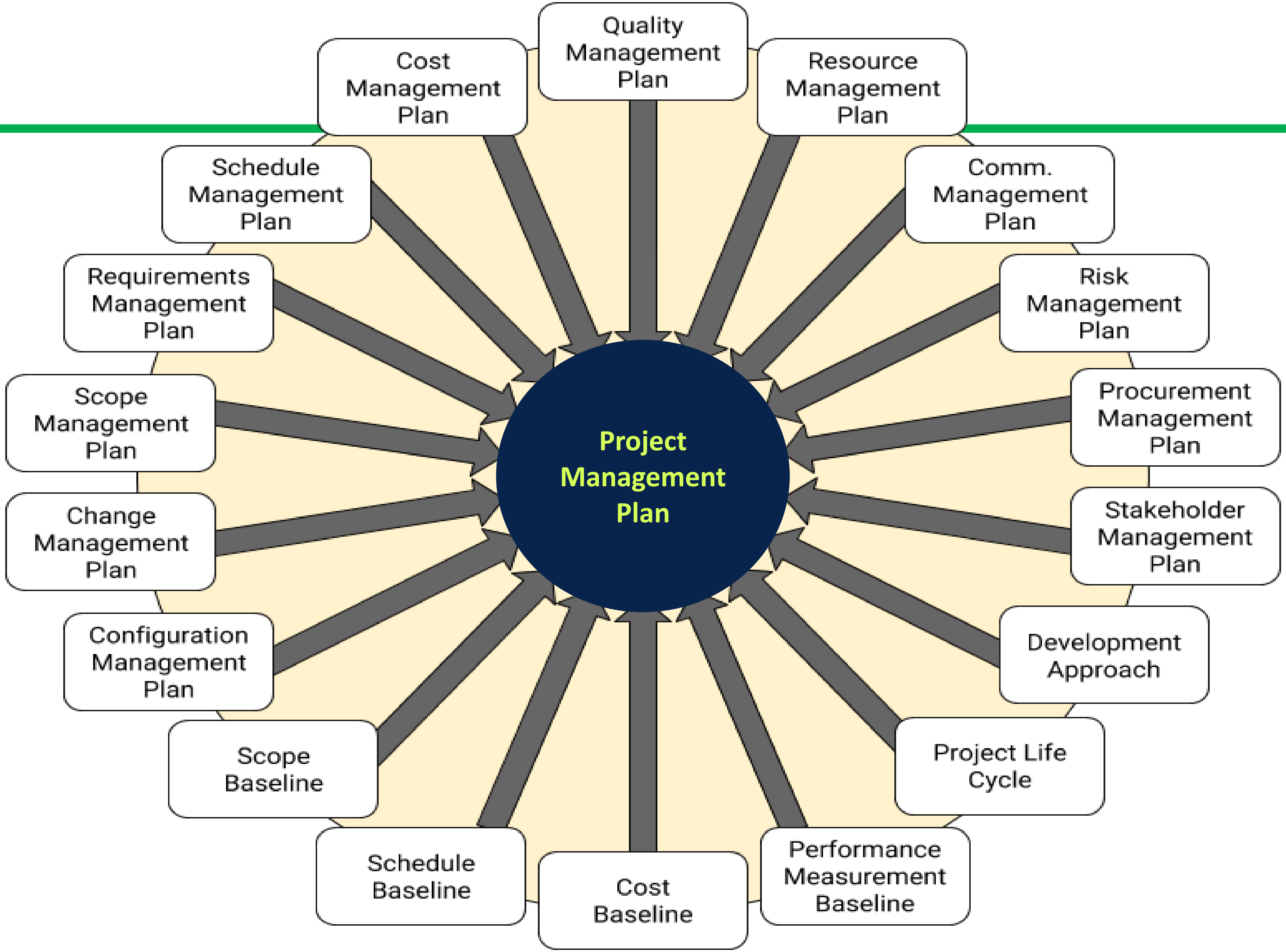
PLANNING PROCESS GROUP

13. Determine Budget ⇒ Project Cost Management
14. Plan Quality Management ⇒ Project Quality Management
15. Plan Resource Management ⇒ Project Resource Management
16. Estimate Activity Resources⇒ Project Resource Management
17. Plan Communications Management ⇒ Project Communication Management
18. Plan Risk Management ⇒ Project Risk Management
19. Identify Risks ⇒ Project Risk Management
20. Perform Qualitative Risk Analysis ⇒ Project Risk Management
21. Perform Quantitative Risk Analysis ⇒ Project Risk Management
22. Plan Risk Responses ⇒ Project Risk Management
23. Plan Procurement Management ⇒ Project Procurement Management
24. Plan Stakeholder Engagement ⇒ Project Stakeholder Management

1. Develop Project Management Plan



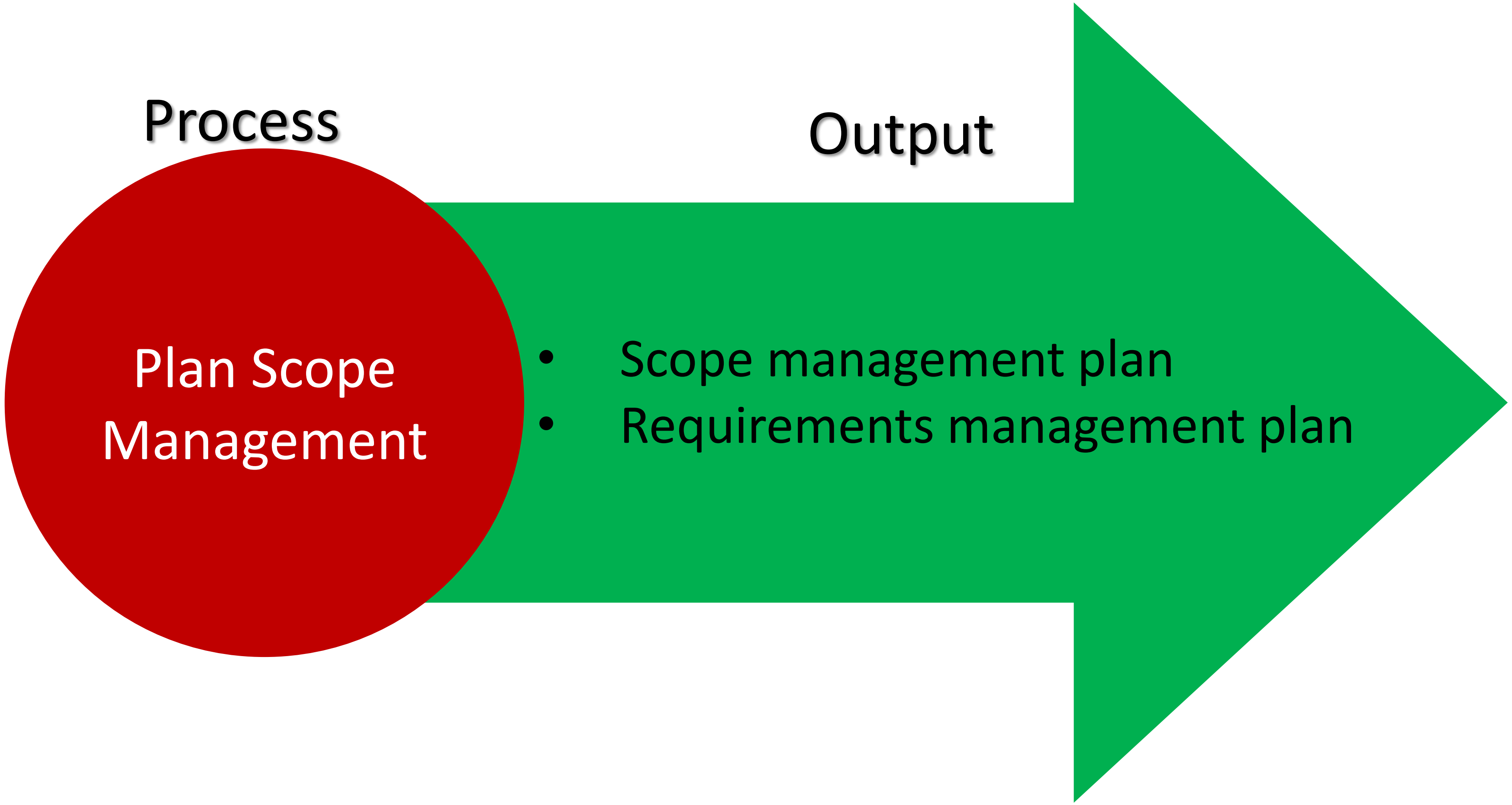

Project Management Plan
Quality Management Plan
Resource Management Plan
Comm. Management Plan
Risk Management Plan
Procurement Management Plan
Stakeholder Management Plan
Development Approach
Project Life Cycle
Performance Measurement Baseline
Cost Baseline
Schedule Baseline
Scope Baseline
Configuration Management Plan
Change Management Plan
Scope Management Plan
Requirements Management Plan
Schedule Management Plan
Cost Management Plan



We will be back here after completing related processes

PLAN SCOPE MANAGEMENT

Plan Scope Management is the process of creating a scope management plan that documents how the project and product scope will be **defined, validated, and controlled**..



Plan Scope Management

Plan Scope Management

KEY CONCEPTS FOR PROJECT SCOPE MANAGEMENT

In the project context, the term "scope" can refer to:

Product scope - The features and functions that characterize a product, service, or result.

Project scope - The work performed to deliver a product, service, or result with the specified features and functions. The term "project scope" is sometimes viewed as including product scope.

Plan Scope Management

Plan Scope Management

Inputs

.1 Project charter
.2 Project management plan
- Quality management plan
- Project life cycle description
- Development approach

.3 Enterprise environmental factors
.4 Organizational process assets

Tools & Techniques

.1 Expert judgment
.2 Data analysis
- Alternatives analysis

.3 Meetings

Outputs

.1 Scope management plan
.2 Requirements management plan

Plan Scope Management

Input:

Project charter	• From project charter, we get project purpose, high-level project description, assumptions, constraints, and high-level requirements that the project is intended to satisfy.
Project Mgt plan	• Quality management plan, Project life cycle description, Development approach
EEF & OPA	• EEF - Organizations culture, infrastructure, personnel administration and marketplace condition • OPA - Policy, procedure, historical information, lesson learned

Plan Scope Management

Tools & Techniques:

Expert judgment	• From knowledgeable and experienced parties
Data Analysis	• Various ways of collecting requirements, elaborating the project and product scope, creating the product, validating the scope, and controlling the scope are evaluated.
Meetings	• Attendees at these meeting my include project manager, project sponsor, selected team members etc.

Plan Scope Management

Output:

Scope management plan

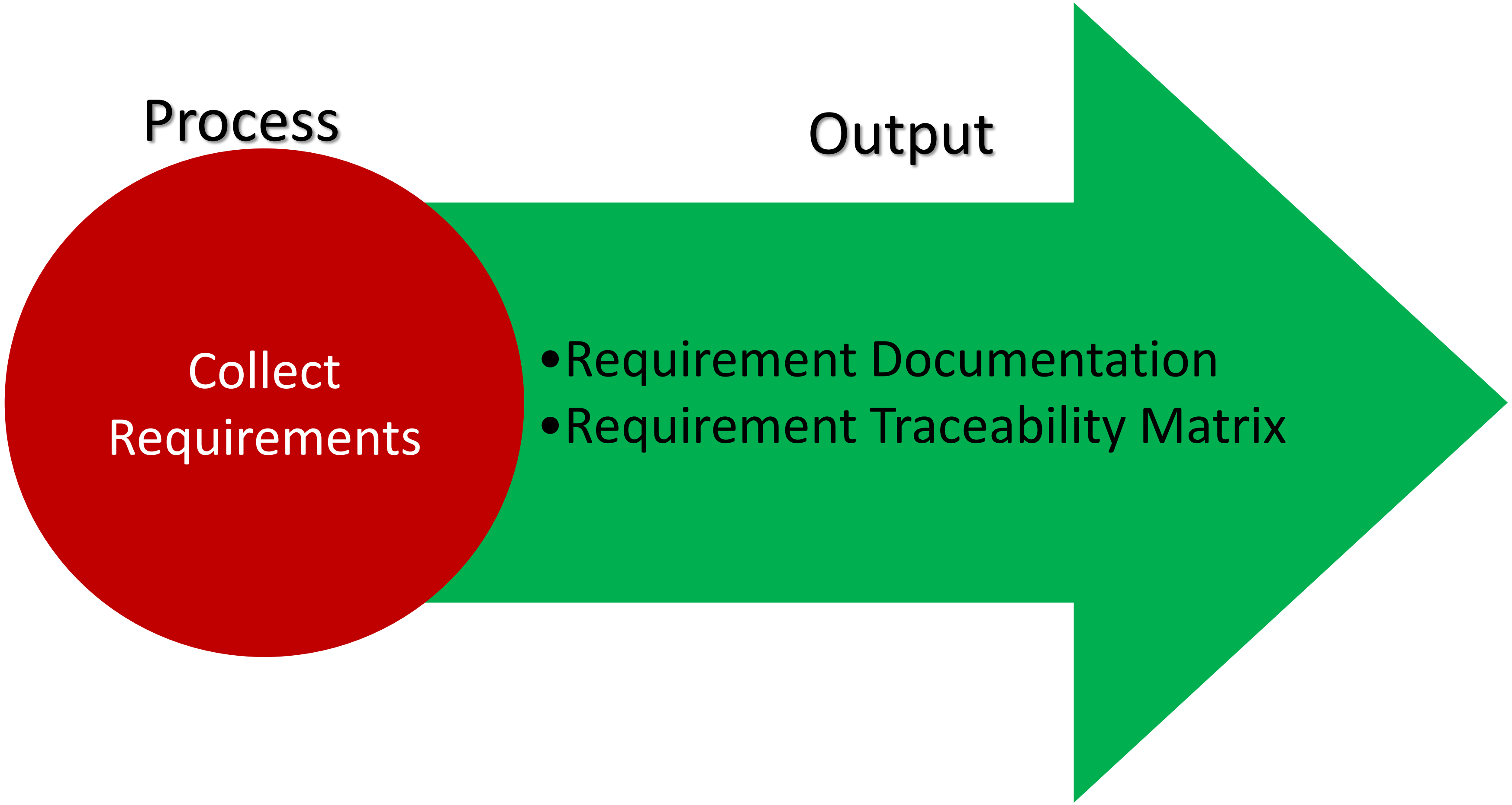
- is a component of the project management plan that describes how the scope will be defined, developed, monitored, controlled, and validated. It includes:
  - Process for preparing a project scope statement;
  - Process that enables the creation of the WBS from the detailed project scope statement;
  - Process that establishes how the scope baseline will be approved and maintained; and
  - Process that specifies how formal acceptance of the completed project deliverables will be obtained.

Requirement management plan

- How requirements activities will be planned, tracked, and reported;
- Configuration management activities such as: how changes will be initiated; how impacts will be analyzed; how they will be traced, tracked, and reported; as well as the authorization levels required to approve these changes;
- Requirements prioritization process;
- Metrics that will be used and the rationale for using them; and
- Traceability structure that reflects the requirement attributes captured on the traceability matrix.

Collect Requirement

Collect Requirements is the process of determining, documenting, and managing stakeholder needs and requirements to meet objectives.



Collect Requirement

Collect Requirements

Inputs

.1 Project charter
.2 Project management plan
- Scope management plan
- Requirements management plan
- Stakeholder engagement plan

.3 Project documents
- Assumption log
- Lessons learned register
- Stakeholder register

.4 Business documents
- Business case

.5 Agreements
.6 Enterprise environmental factors
.7 Organizational process assets

Tools & Techniques

.1 Expert judgment
.2 Data gathering
- Brainstorming
- Interviews
- Focus groups
- Questionnaires and surveys
- Benchmarking

.3 Data analysis
- Document analysis

.4 Decision making
- Voting
- Multicriteria decision analysis

.5 Data representation
- Affinity diagrams
- Mind mapping

.6 Interpersonal and team skills
- Nominal group technique
- Observation/conversation
- Facilitation

.7 Context diagram
.8 Prototypes

Outputs

.1 Requirements documentation
.2 Requirements traceability matrix

Collect Requirement

Input:

Project charter	• The project charter documents the high-level project description and high-level requirements that will be used to develop detailed requirements.
Project Mgt plan	• Scope management plan. • Requirement management plan • Stakeholder management plan
Project Documents	• Assumption log • Lesson learned register • Stakeholder register

Collect Requirement

Input:

Business Documents	• A business document that can influence the Collect Requirements process is the business case, which can describe required, desired, and optional criteria for meeting the business needs.
Agreements	• Agreements can contain project and product requirements.
EEF & OPA	• EEF - Organization’s culture, Infrastructure, Personnel administration, and Marketplace conditions. • OPA - Policies and procedures, and Historical information and lessons learned repository with information from previous projects.

COLLECT REQUIREMENT

Tools & Techniques: Expert judgment

Expertise should be considered from individuals or groups with specialized knowledge or training in the following topics:

- Business analysis
- Requirements elicitation
- Requirements analysis
- Requirements documentation
- Project requirements in previous similar projects
- Diagramming techniques
- Facilitation, and
- Conflict management.

Collect Requirement

Tools & Techniques: Data Gathering

includes:

- Brainstorming
- Interviews
- Focus groups
- Questionnaires
- surveys
- Benchmarking

Collect Requirement

Tools & Techniques: Data Analysis

There is a wide range of documents that may be analyzed to help elicit relevant requirements.

1. Agreements;
2. Business plans;
3. Business process or interface documentation;
4. Business rules repositories;
5. Current process flows;
6. Marketing literature;
7. Problem/issue logs;
8. Policies and procedures;
9. Regulatory documentation such as laws, codes, or ordinances, etc.;
10. Requests for proposal; and
11. Use cases.

Collect Requirement

Tools & Techniques: Decision-making

- ✓ Voting
  - Unanimity: 100% agreement
  - Majority: 50% +
  - Plurality: largest block
- ✓ Autocratic Decision Making
- ✓ Multicriteria decision analysis

Collect Requirement

Tools & Techniques: Decision-making

Multicriteria decision analysis

1. Define your objective
2. Define your criteria (*non-beneficial & beneficial)*
3. Determine the weight of each criterion
4. List your choices
5. Determine your performance values
6. Rate your choices
7. Normalize the performance values (*non-beneficial & beneficial)* ***for non-beneficial criteria, you should take the lowest value of these criteria and divide it by each performance value****. For* ***beneficial criteria, you divide each by the maximum value.***
8. Multiply values by weight
9. Calculate the performance scores

Collect Requirement

Tools & Techniques: Decision-making

Multicriteria decision analysis

To finish the 360-degree image viewer development for your ongoing software project, you need to incorporate an image stitching library. Due to your company's lack of expertise in image stitching, you have decided to outsource the image stitching library and have gathered data on four different image stitching libraries from four different companies. Your job is to assess and select the most suitable image stitching library from four available options with proper justification by considering the criteria provided in Table below. To decide based on the given criteria, you need to consider that the *Resolution Limit* holds the highest weightage of 40%, while all other criteria are considered equally important. Furthermore, price is the only **non-beneficial** factor.

	Criteria			
	Price	**Library Size**	**Resolution Limit**	**Performance**
Image Stitching Lib 1	$2500	16 MB	12 MP	Excellent (5)
Image Stitching Lib 2	$2000	16 MB	8 MP	Average (3)
Image Stitching Lib 3	$3000	32 MB	16 MP	Good (4)
Image Stitching Lib 4	$2750	32 MB	8 MP	Good (4)

COLLECT REQUIREMENT

Tools & Techniques: Decision-making: **Multicriteria decision analysis**

	Criteria			
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Collect Requirement

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Normalizing

	Criteria			
	Price	**Library Size**	**Resolution Limit**	**Performance**
Image Stitching Lib 1	(2000/2500)	16/32	12 /16	5/5
Image Stitching Lib 2	(2000/2000)	16 /32	8 /16	3/5
Image Stitching Lib 3	(2000/3000)	32 /32	16 /16	4/5
Image Stitching Lib 4	(2000/2750)	32 /32	8 /16	4/5

Collect Requirement

Tools & Techniques: Decision-making: **Multicriteria decision analysis**

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Image Stitching Lib 4	$2750	32 MB	8 MP	Good (4)

Multiply by weights

	Criteria			
	Price	**Library Size**	**Resolution Limit**	**Performance**
Image Stitching Lib 1	.8*.2	.5*.2	.75*.4	1*.2
Image Stitching Lib 2	1*.2	.5*.2	.5*.4	.6*.2
Image Stitching Lib 3	.667*.2	1*.2	1*.4	.8*.2
Image Stitching Lib 4	.727*.2	1*.2	.5*.4	.8*.2

Collect Requirement

Tools & Techniques: Decision-making: **Multicriteria decision analysis**

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	Criteria			
	Price	**Library Size**	**Resolution Limit**	**Performance**
Image Stitching Lib 1	.16	.1	.3	.2
Image Stitching Lib 2	.2	.1	.2	.12
Image Stitching Lib 3	.1334	.2	.4	.16
Image Stitching Lib 4	.1454	.2	.2	.16

Collect Requirement

Tools & Techniques: Decision-making: **Multicriteria decision analysis**

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	Criteria				
	Price	**Library Size**	**Resolution Limit**	**Performance**	
Image Stitching Lib 1	.16	.1	.3	.2	**0.76**
Image Stitching Lib 2	.2	.1	.2	.12	**0.62**
Image Stitching Lib 3	.1334	.2	.4	.16	**0.8934**
Image Stitching Lib 4	.1454	.2	.2	.16	**0.7054**

Collect Requirement

Tools & Techniques: Decision-making: **Multicriteria decision analysis**

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Image Stitching Lib 4	.1454	.2	.2	.16	**0.7054**

Collect Requirement

Tools & Techniques: Data representation

- ✓ **Affinity diagrams.** Affinity diagrams allow large numbers of ideas to be classified into groups for review and analysis.
- ✓ **Mind mapping.** Mind mapping consolidates ideas created through individual brainstorming sessions into a single map to reflect commonality and differences in understanding and to generate new ideas.

COLLECT REQUIREMENT

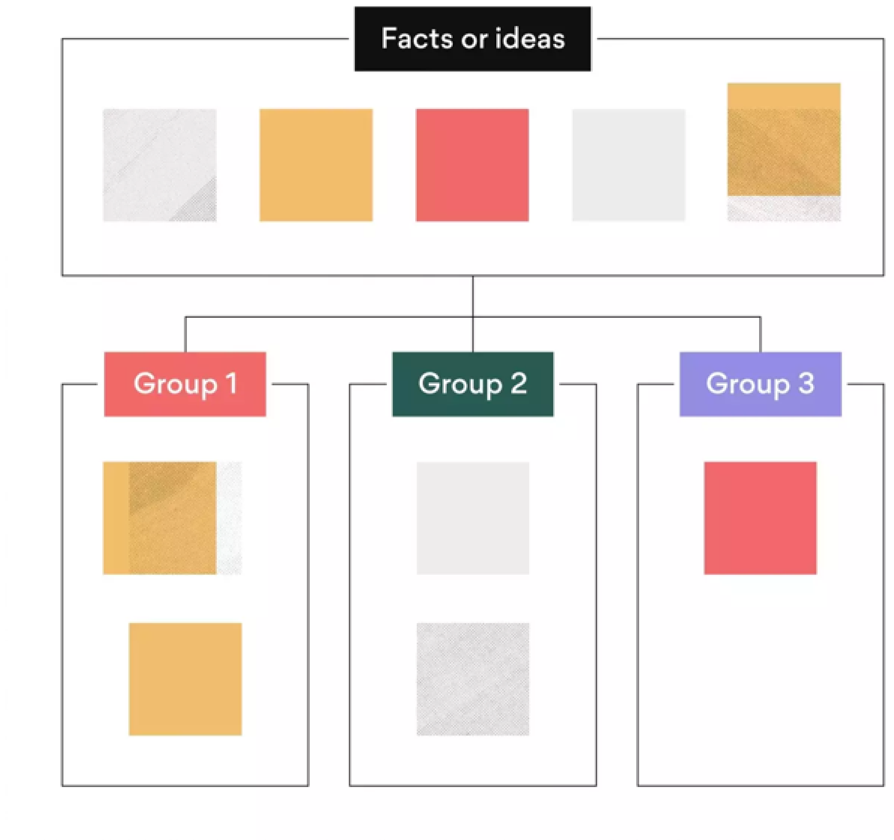
Tools & Techniques: Data representation

✓ **Affinity diagrams.**

COLLECT REQUIREMENT

Tools & Techniques: Data representation

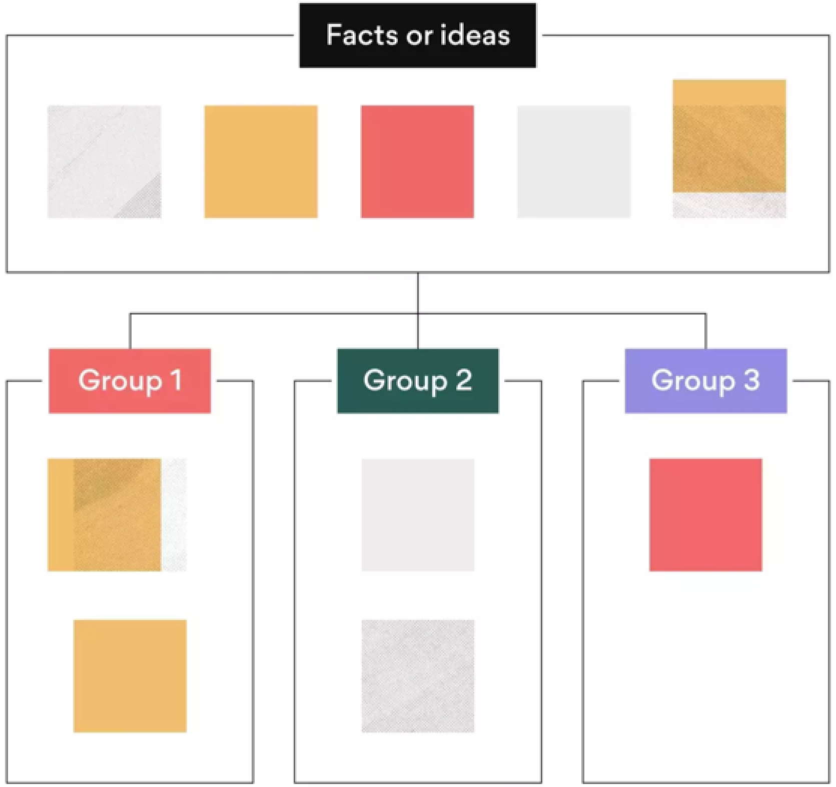
✓ **Affinity diagrams.**



Collect Requirement

Tools & Techniques: Data representation

✓ **Affinity diagrams.**



Challenges in Production

Staff	Distribution	Quality	Capacity
Lack of Staff training	Not enugh trucks.	Varialble ingredients quality	Insufficient ovens
Difficulties recruiting	Cooling systems in trucks unreliable.	Packaging not strong Enough	Limited storage space
High Overtime	Project damaged in transit		Seasonal demand

COLLECT REQUIREMENT

Tools & Techniques: Data representation

- ✓ **Mind mapping.**

Collect Requirement

Tools & Techniques: Data representation

✓ **Mind mapping.**

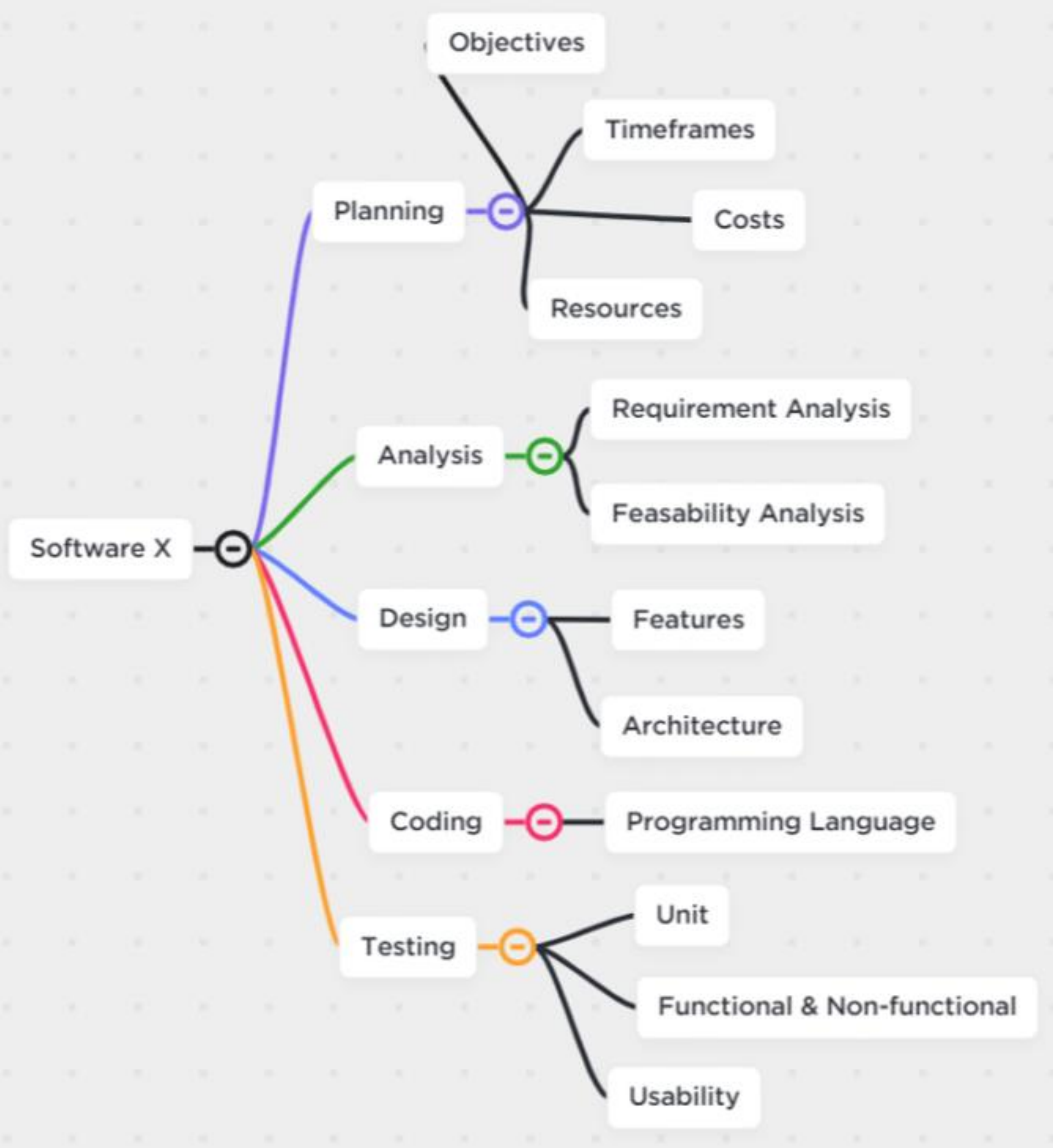
To build a mind map diagram, you first choose a **central idea** or main topic. The main topic will have branches that connect it to other linked **subtopics**, and you repeat the process until you have a literal map of your mind!

COLLECT REQUIREMENT

Tools & Techniques: Data representation

✓ **Mind mapping.**

To build a mind map diagram, you first choose a **central idea** or main topic. The main topic will have branches that connect it to other linked **subtopics**, and you repeat the process until you have a literal map of your mind!



COLLECT REQUIREMENT

Tools & Techniques: Data representation

✓ **Mind mapping.**

Collect Requirement

Tools & Techniques: Data representation

- ✓ **Mind mapping.**

Prepare a mind map for **Arranging a Meeting**

Collect Requirement

Tools & Techniques: Interpersonal and Team skills

- ✓ Nominal group technique
- ✓ Observation and conversation
- ✓ facilitation

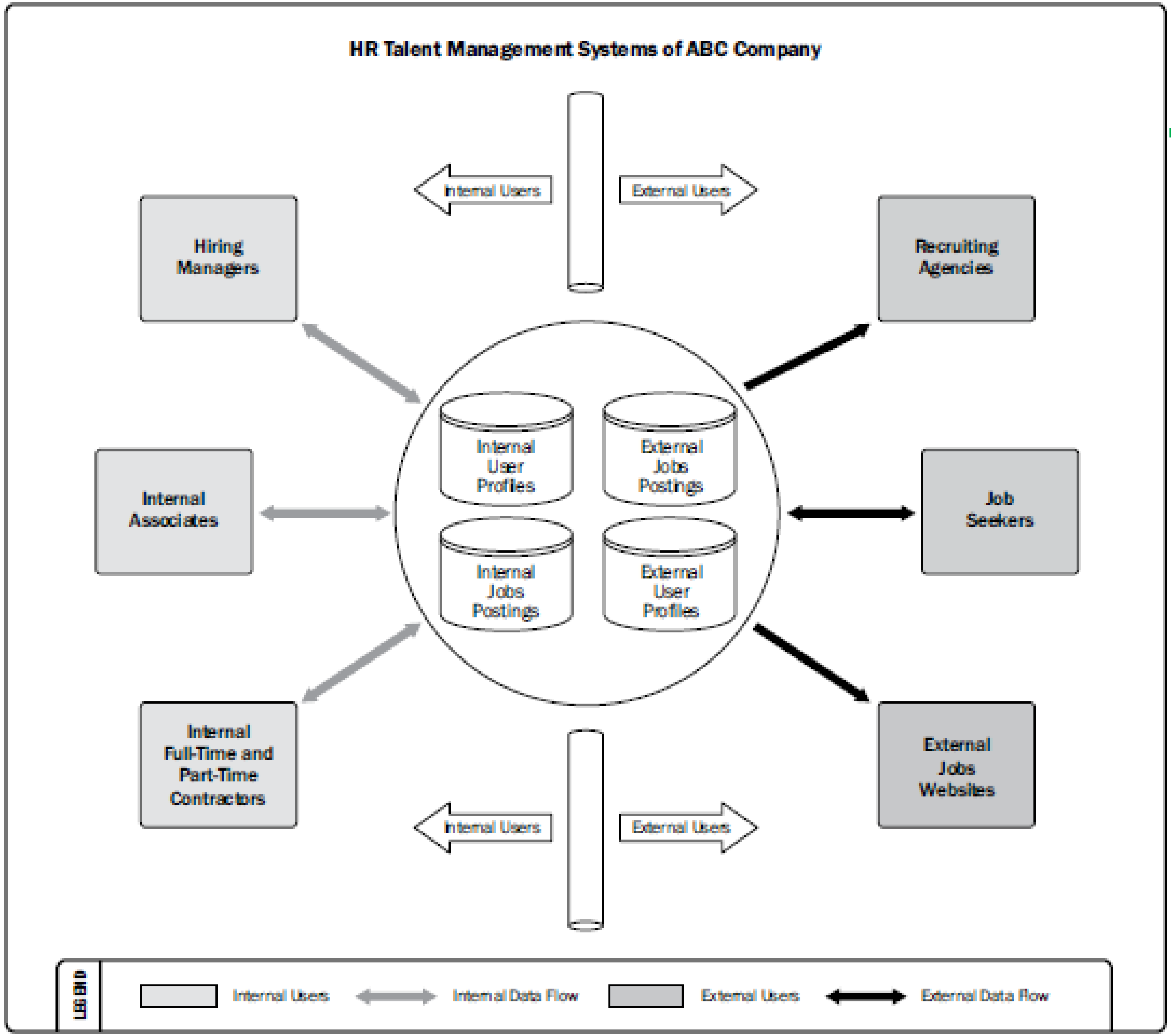
COLLECT REQUIREMENT

Tools & Techniques: Context diagram

- ✓ Example of a scope model
- ✓ Visually depict the product scope by showing business system and how people and other system interact with it.

Tools & Techniques: Prototype

- ✓ Prototyping is a method of obtaining early feedback on requirements by providing a model of the expected product before actually building it.


HR Talent Management Systems of ABC Company
Internal Users
External Users
Hiring Managers
Recruiting Agencies
Internal User Profiles
External Jobs Postings
Internal Jobs Postings
External User Profiles
Internal Associates
Job Seekers
Internal Full-Time and Part-Time Contractors
External Jobs Websites
Internal Users
External Users
LEGEND
Internal Users
Internal Data Flow
External Users
External Data Flow

Collect Requirement

Output:

Requirement Documentation

- Business requirement
- Stakeholders requirements
- Solution requirements
- Functional & non functional requirements
- Transition and readiness requirements
- Project requirement
- Quality requirement

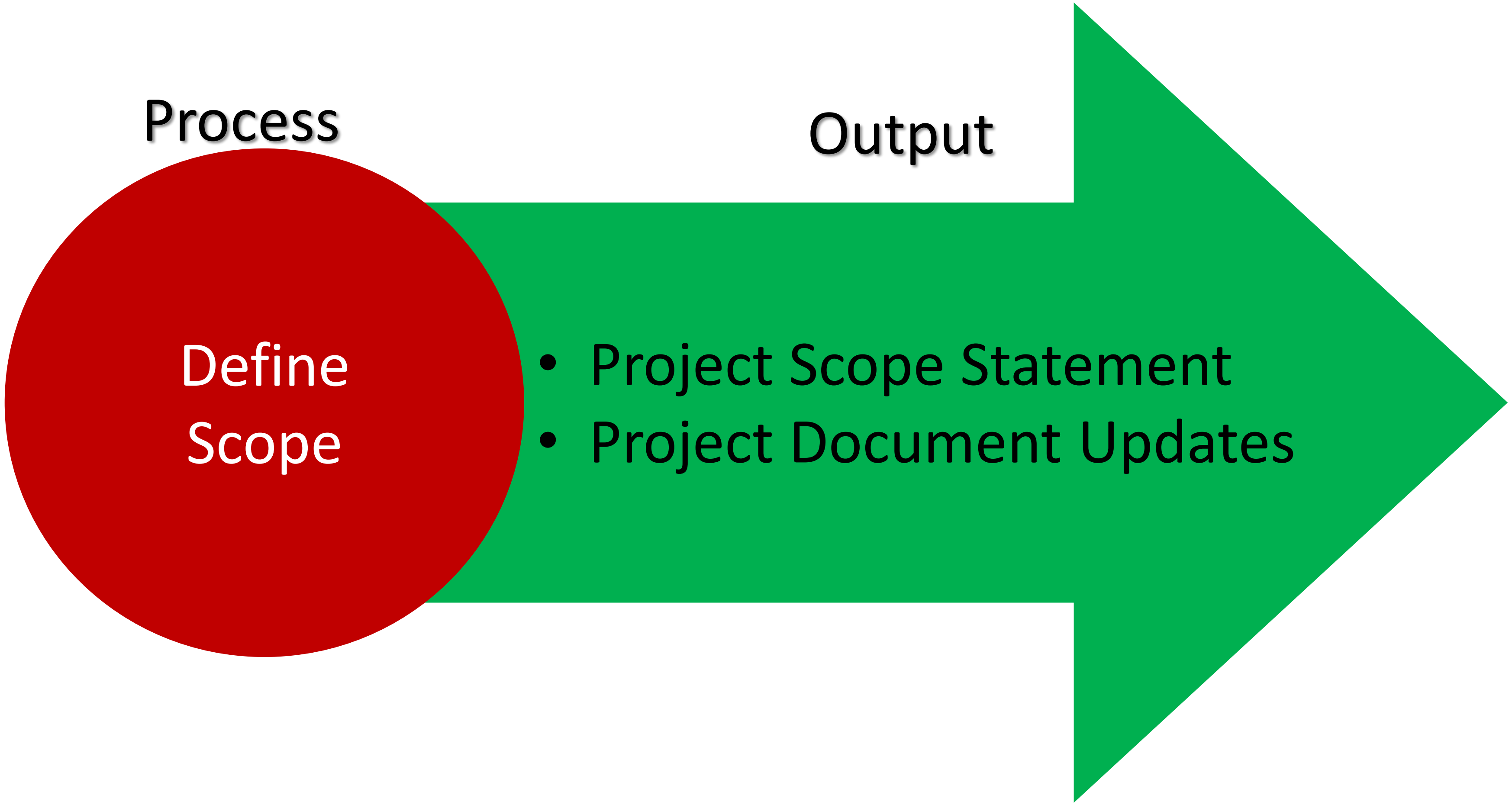
Requirement traceability matrix

- business need, opportunity, goal
- Project objectives
- WBS deliverables
- Product design and development
- Test scenario
- High level to detail level

REQUIREMENTS TRACEABILITY MATRIX					
Project Name: Online Flight Booking Application					
Business Requirements Document BRD		Functional Requirements Document FSD			Test Case Document
Business Requirement ID#	Business Requirement / Business Use case	Functional Requirement ID#	Functional Requirement / Use Case	Priority	Test Case ID#
BR_1	Reservation Module	FR_1	One Way Ticket booking	High	TC#001 TC#002
		FR_2	Round Way Ticket		TC#003 TC#004
		FR_3	Multicity Ticket booking	High	TC#005 TC#006
BR_2	Payment Module	FR_4	By Credit Card	High	TC#007 TC#008
		FR_5	By Debit Card	High	TC#009
		FR_6	By Reward Points	Medium	TC#010 TC#011

DEFINE SCOPE

The process of developing a detailed description of the project and product



DEFINE SCOPE

Define Scope

Inputs

.1 Project charter
.2 Project management plan
- Scope management plan

.3 Project documents
- Assumption log
- Requirements documentation
- Risk register

.4 Enterprise environmental factors
.5 Organizational process assets

Tools & Techniques

.1 Expert judgment
.2 Data analysis
- Alternatives analysis

.3 Decision making
- Multicriteria decision analysis

.4 Interpersonal and team skills
- Facilitation

.5 Product analysis

Outputs

.1 Project scope statement
.2 Project documents updates
- Assumption log
- Requirements documentation
- Requirements traceability matrix
- Stakeholder register

Define Scope

Tools & Techniques: Product Analysis

✓ product analysis techniques include but are not limited to:

- Product Features and Functionality,
- Requirements analysis,
- Systems analysis,
- Lifecycle Analysis,
- Value analysis, and
- Value engineering.

DEFINE SCOPE

Output:

Project Scope Statement

- Product scope description.
- Deliverables
- Acceptance criteria
- Project exclusion

Project Document Updates

- Assumption log
- Requirement documentation
- Requirement tractability matrix
- Stakeholder register

DEFINE SCOPE

Output:

Project Scope Statement

- Product scope description.
- Deliverables
- Acceptance criteria
- Project exclusion

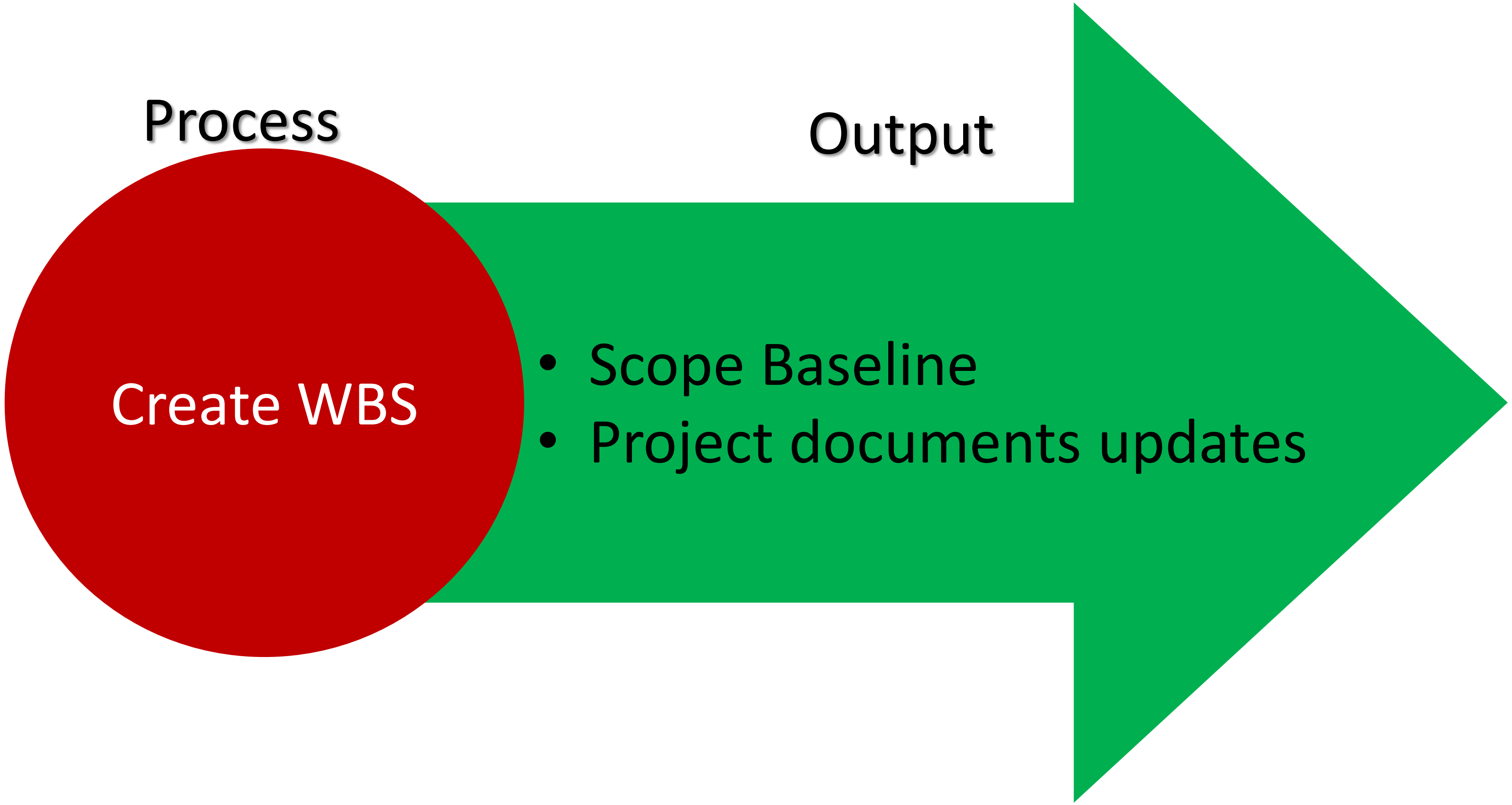
The project charter contains high-level information, while the project scope statement contains a detailed description of the scope components.

Project Document Updates

- Assumption log
- Requirement documentation
- Requirement tractability matrix
- Stakeholder register

CREATE WBS

- ✓ **Work Breakdown Structure (WBS)**
- ✓ The process of developing a detailed description of the project and product



Create WBS

The process of subdividing project deliverables and project work into smaller, more manageable components.

Create WBS

The process of subdividing project deliverables and project work into smaller, more manageable components.

Create WBS

Inputs

.1 Project management plan
- Scope management plan

.2 Project documents
- Project scope statement
- Requirements documentation

.3 Enterprise environmental factors

.4 Organizational process assets

Tools & Techniques

.1 Expert judgment

.2 Decomposition

Outputs

.1 Scope baseline

.2 Project documents updates
- Assumption log
- Requirements documentation

WORK BREAKDOWN STRUCTURE (WBS)

- ✓ The WBS represents a logical decomposition of the work to be performed and focuses on how the product, service, or result is naturally subdivided. It is an outline of what work is to be performed.

LEVEL	ELEMENT DESCRIPTION
1	Project
2	Category
3	Subcategory
4	Sub-Subcategory
5	Work Package

Create WBS

Input:

PROJECT MANAGEMENT PLAN	• A project management plan component includes but is not limited to the scope management plan.
PROJECT DOCUMENTS	• Scope management plan. • Requirement documentation • Stakeholder management plan
EEF & OPA	• EEF - industry-specific WBS standards • OPA - Policies, procedures, and templates for the WBS, Project files from previous projects, Lessons learned from previous projects.

CREATE WBS

Tools & Techniques:

1. Expert Judgement
2. Decomposition

CREATE WBS

Tools & Techniques:

1. Expert Judgement
2. Decomposition

Decomposition activities:

- Identifying and analyzing the deliverables and related work
- Structuring and organizing the WBS
- Decomposing the upper WBS levels into lower-level detailed components
- Developing and assigning identification codes to the WBS components
- Verifying that the degree of decomposition of the deliverables is appropriate.

CREATE WBS

Tools & Techniques:

1. Expert Judgement
2. Decomposition

Decomposition activities:

- Identifying and analyzing the deliverables and related work
- Structuring and organizing the WBS
- Decomposing the upper WBS levels into lower-level detailed components
- Developing and assigning identification codes to the WBS components
- Verifying that the degree of decomposition of the deliverables is appropriate.

Rolling wave planning and **100% rule** applies in case of decomposition

CREATE WBS

Output:

Project Scope Baseline

- The scope baseline is the approved version of a scope statement, WBS, and its associated WBS dictionary, which can be changed only through formal change control procedures and is used as a basis for comparison
- scope Statement
- WBS
- Work Package
- Planning Package
- WBS Dictionary
  - ✓ Code of account identifier
  - ✓ Description of work
  - ✓ Responsible organization
  - ✓ Schedule milestones, associated activities
  - ✓ Resource required, cost estimation,
  - ✓ acceptance criteria

Project Document Updates

- Assumption log
- Requirement documentation

MORE ON WBS

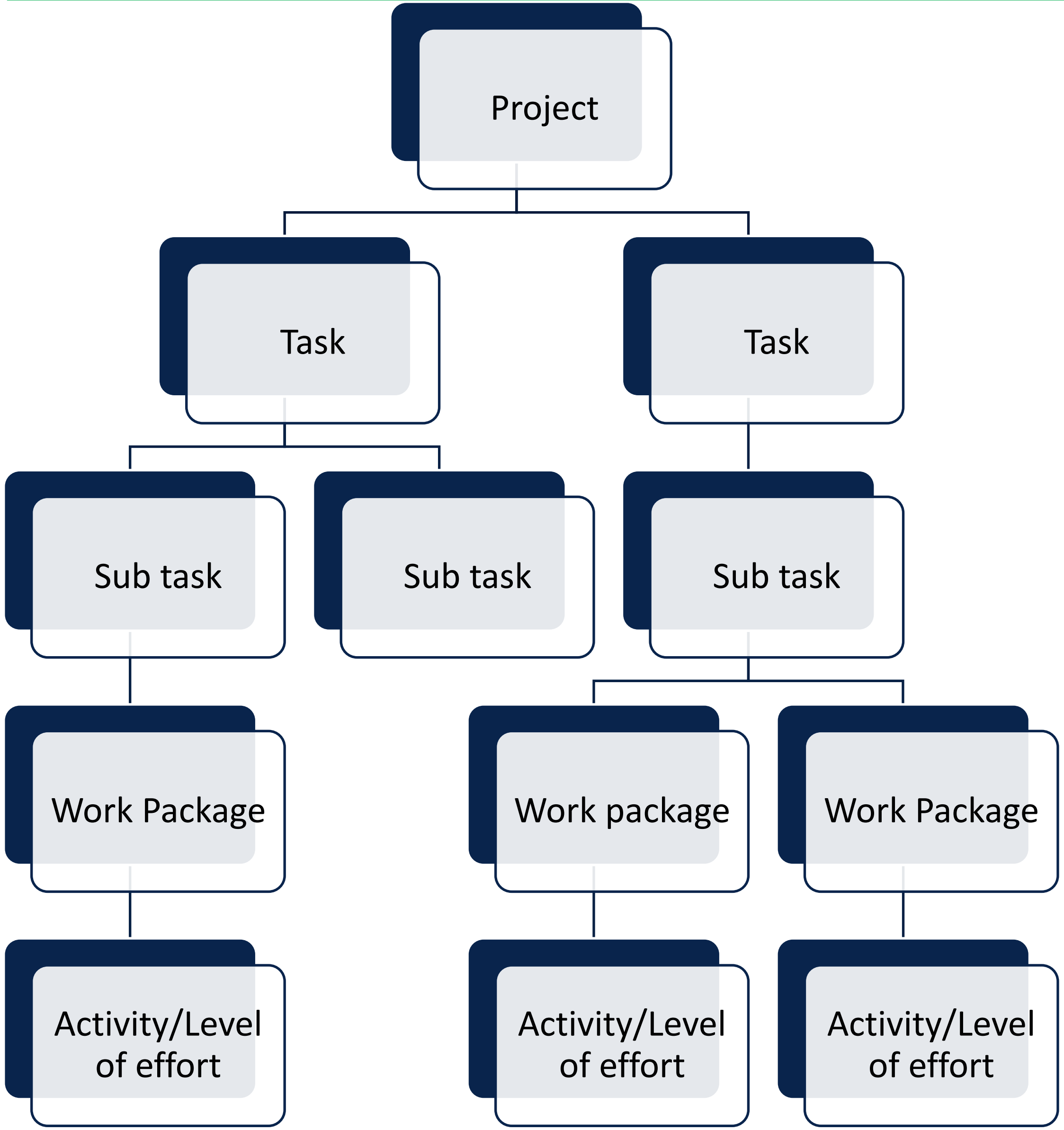
- ✓ WBS is used for every project
- ✓ WBS does not show the sequence of the execution. That will be determined when a schedule is developed.

More on WBS

- ✓ WBS is used for every project
- ✓ WBS does not show the sequence of the execution. That will be determined when a schedule is developed.
- ✓ The concept behind the WBS is very simple.
- ✓ **It requires you to break down complex tasks into smaller tasks until you reach a point where you can no longer subdivide the tasks.**

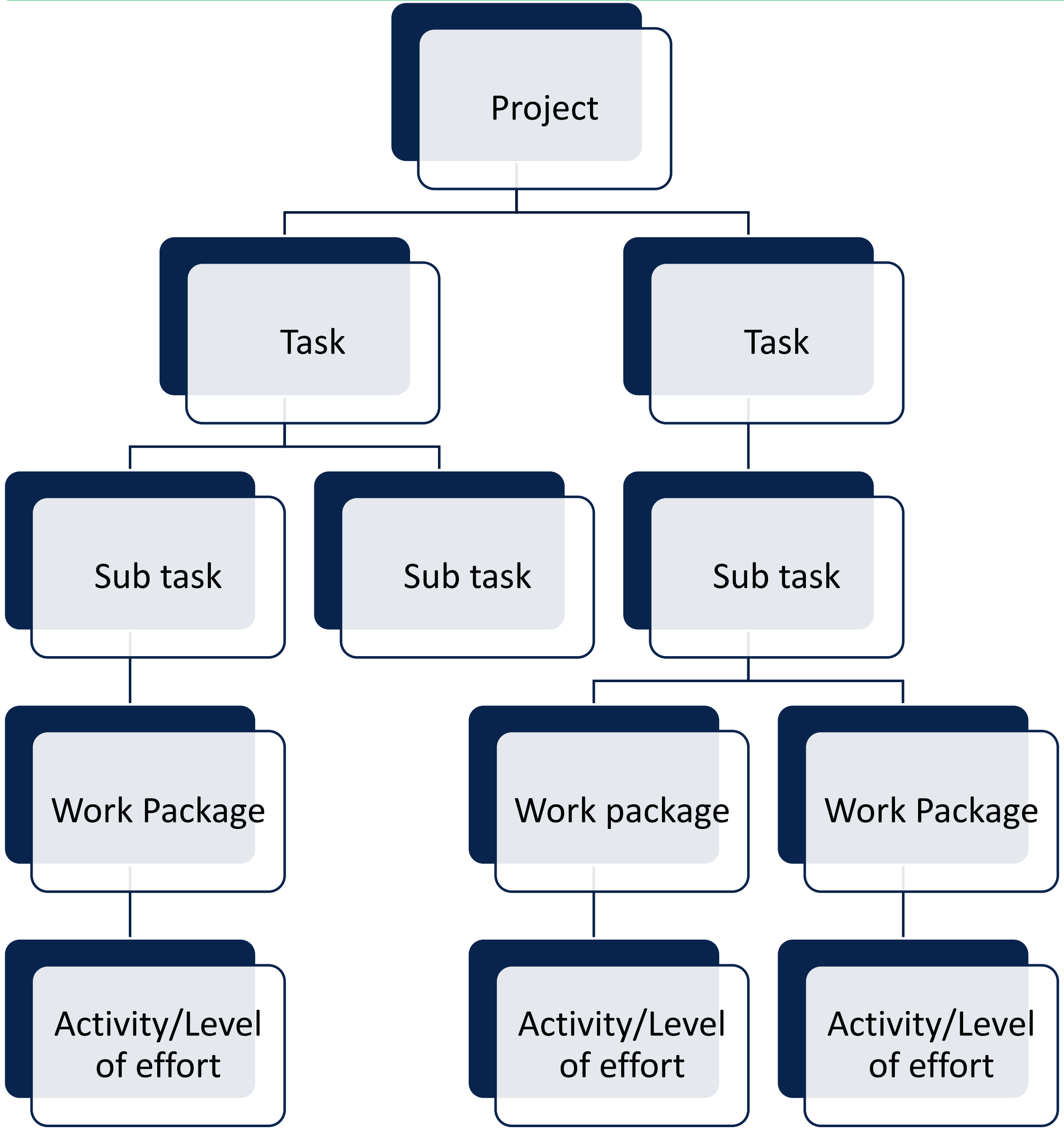
More on WBS

More on WBS



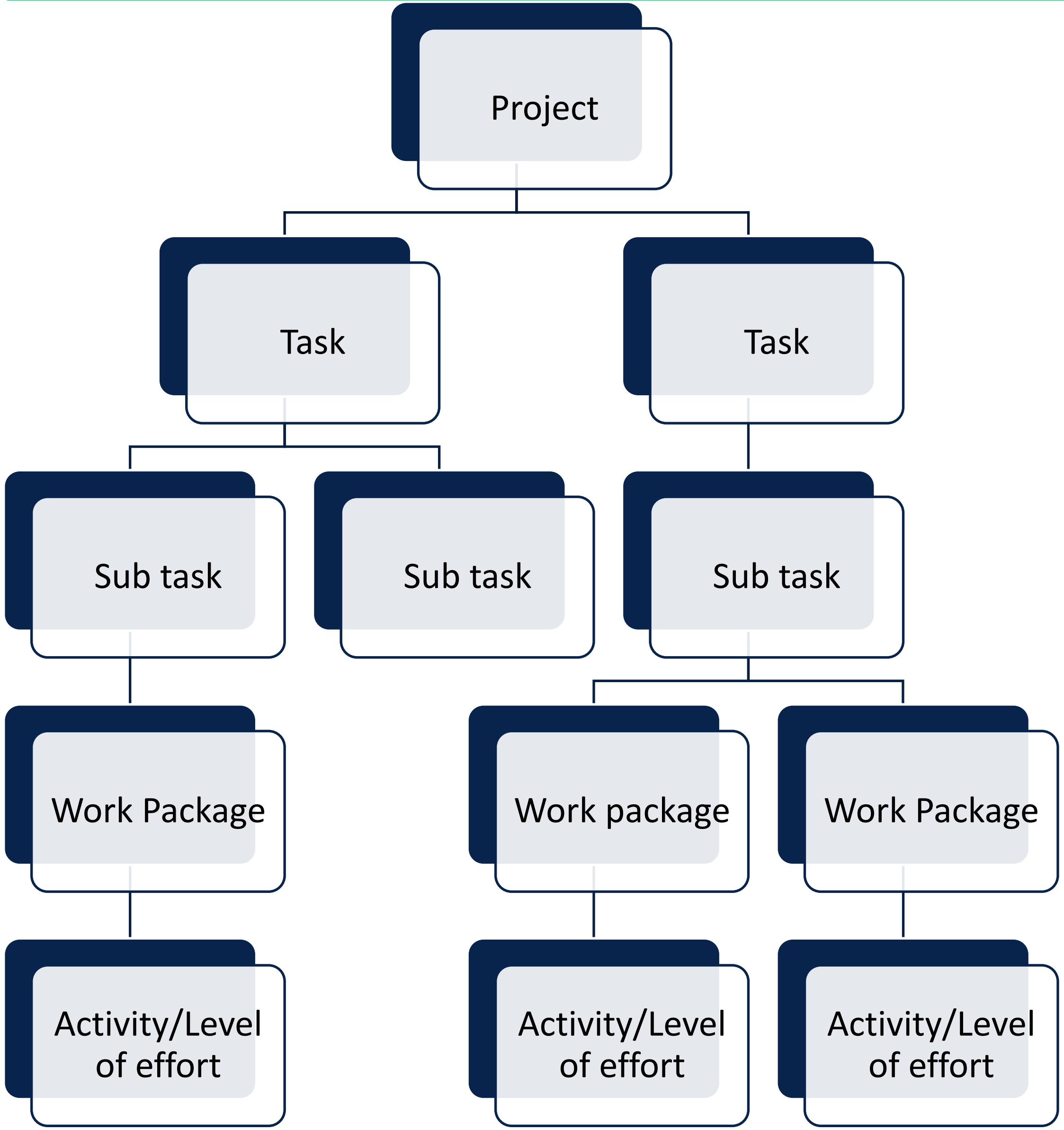
Project
Task
Task
Sub task
Sub task
Sub task
Work Package
Work package
Work Package
Activity/Level of effort
Activity/Level of effort
Activity/Level of effort

More on WBS



- ✓ Tasks should be broken down until you are able to:
  - ✓ Manage the task
  - ✓ **Estimate** the time required to complete the task
  - ✓ Estimate the cost involved with the task

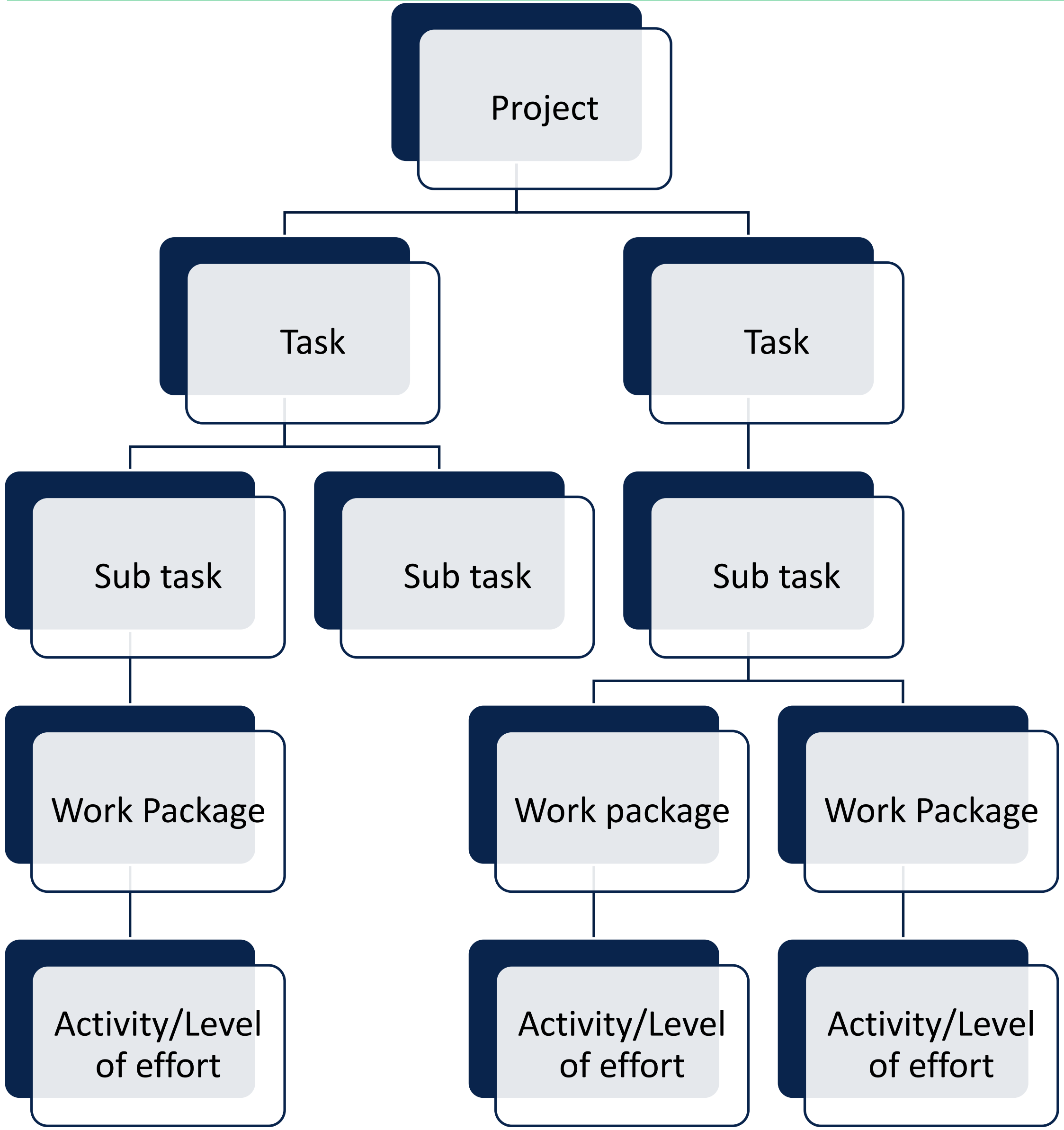
MORE ON WBS



- ✓ Tasks should be broken down until you are able to:
  - ✓ Manage the task
  - ✓ **Estimate** the time required to complete the task
  - ✓ Estimate the cost involved with the task

- ✓ **Rule 1** "80-hour rule" which means that no single activity or group of activities at the lowest level of detail of the WBS to produce a single deliverable should be more than 80 hours of effort.

More on WBS



- ✓ Tasks should be broken down until you are able to:
  - ✓ Manage the task
  - ✓ **Estimate** the time required to complete the task
  - ✓ Estimate the cost involved with the task

- ✓ **Rule 2** The second rule of thumb is that no activity or group of activities at the lowest level of detail of the WBS should be longer than a single reporting period. Thus if the project team is reporting progress monthly, then no single activity or series of activities should be longer than one month long.

More on Create WBS

- ✓ WBS Development Guidelines:
  - ✓ Stop breaking down work when you reach a low enough level to do tan estimate of desired accuracy
  - ✓ Involve those people who must do the work in the planning process
  - ✓ WBS should be completed before the schedule
  - ✓ WBS does not have to be symmetrical

More on Create WBS

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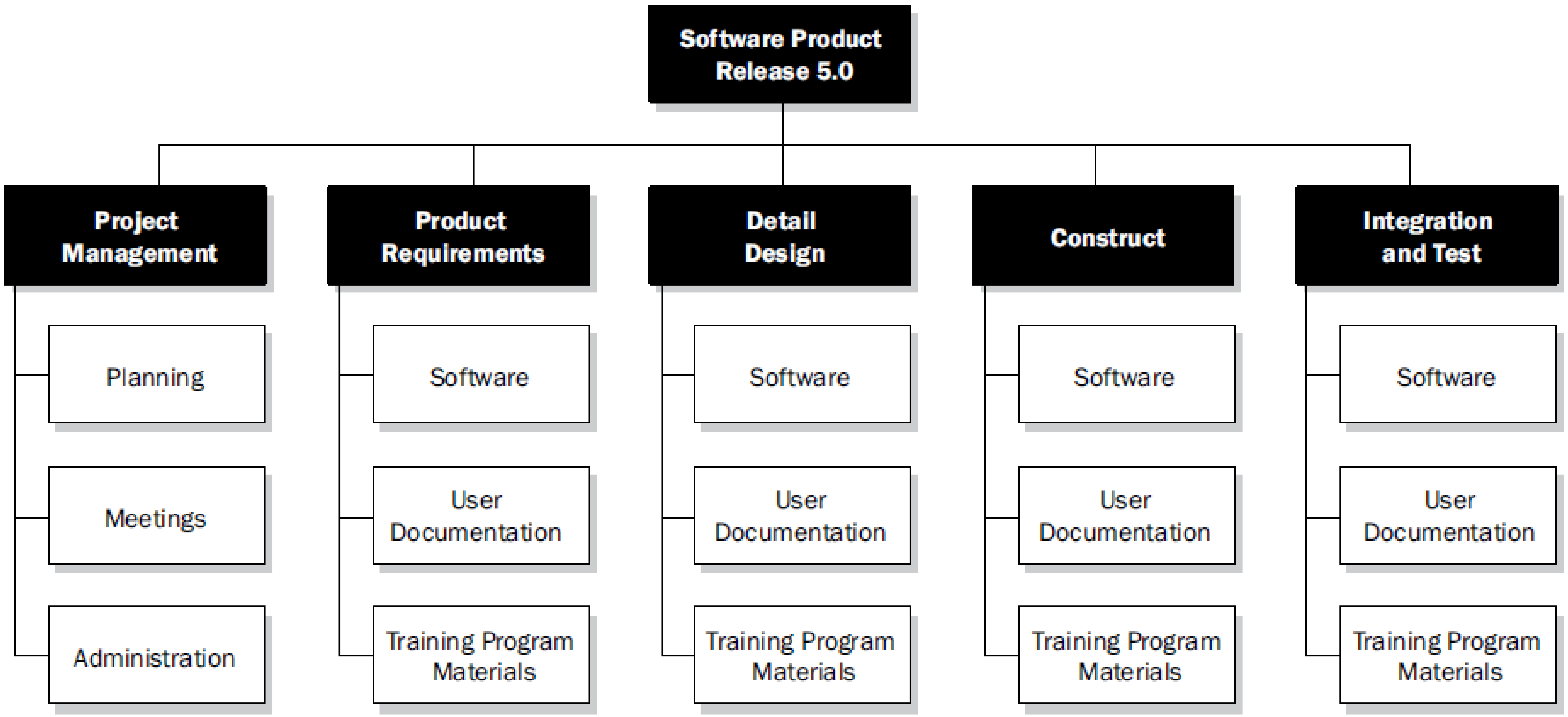
  - ✓ Involve those people who must do the work in the planning process
  - ✓ WBS should be completed before the schedule
  - ✓ WBS does not have to be symmetrical

- ✓ There are two types of WBS:
  - Deliverable-Based
  - Phase-Based.


Software Product Release 5.0
Project Management
Product Requirements
Detail Design
Construct
Integration and Test
Planning
Meetings
Administration
Software
User Documentation
Training Program Materials
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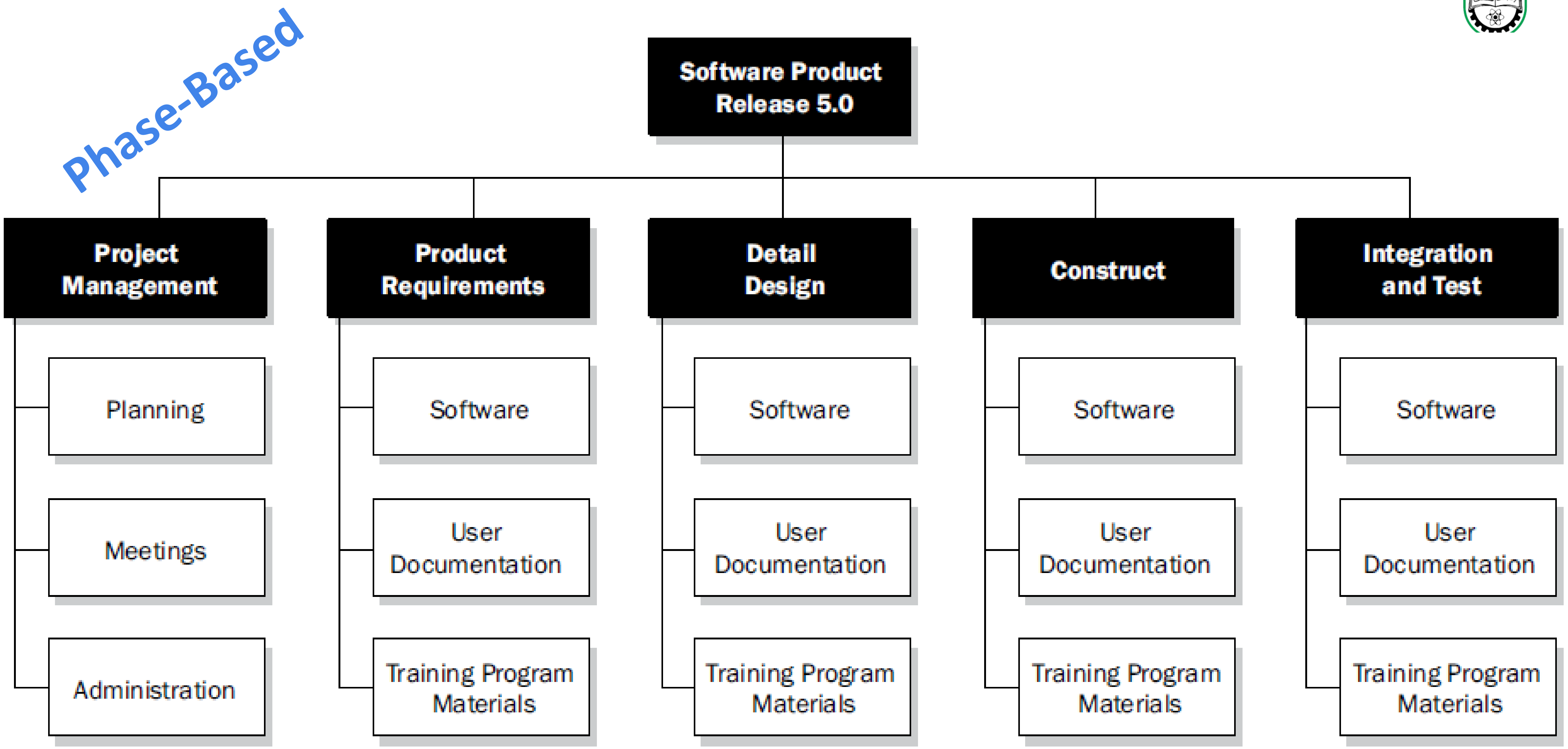
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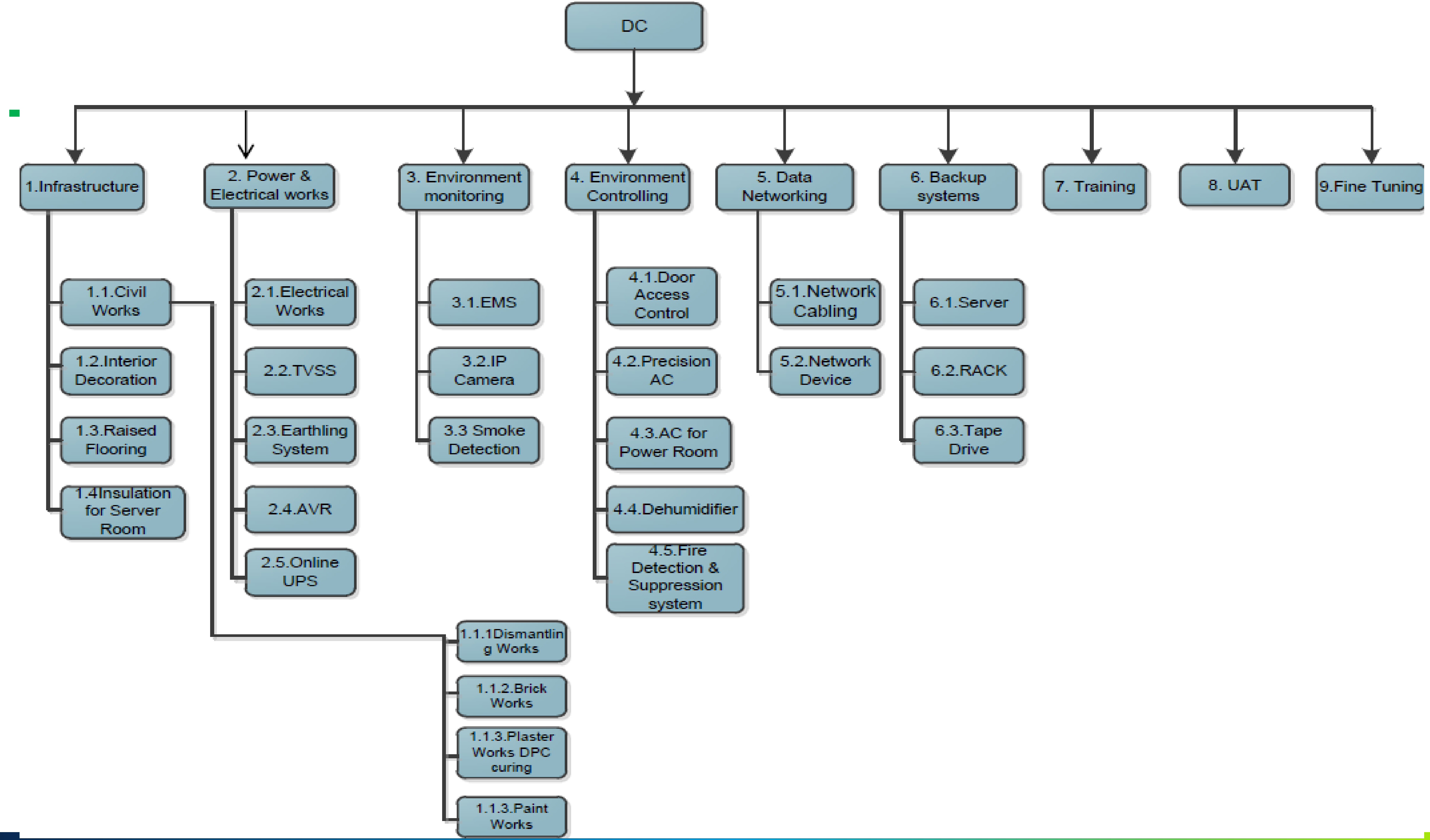
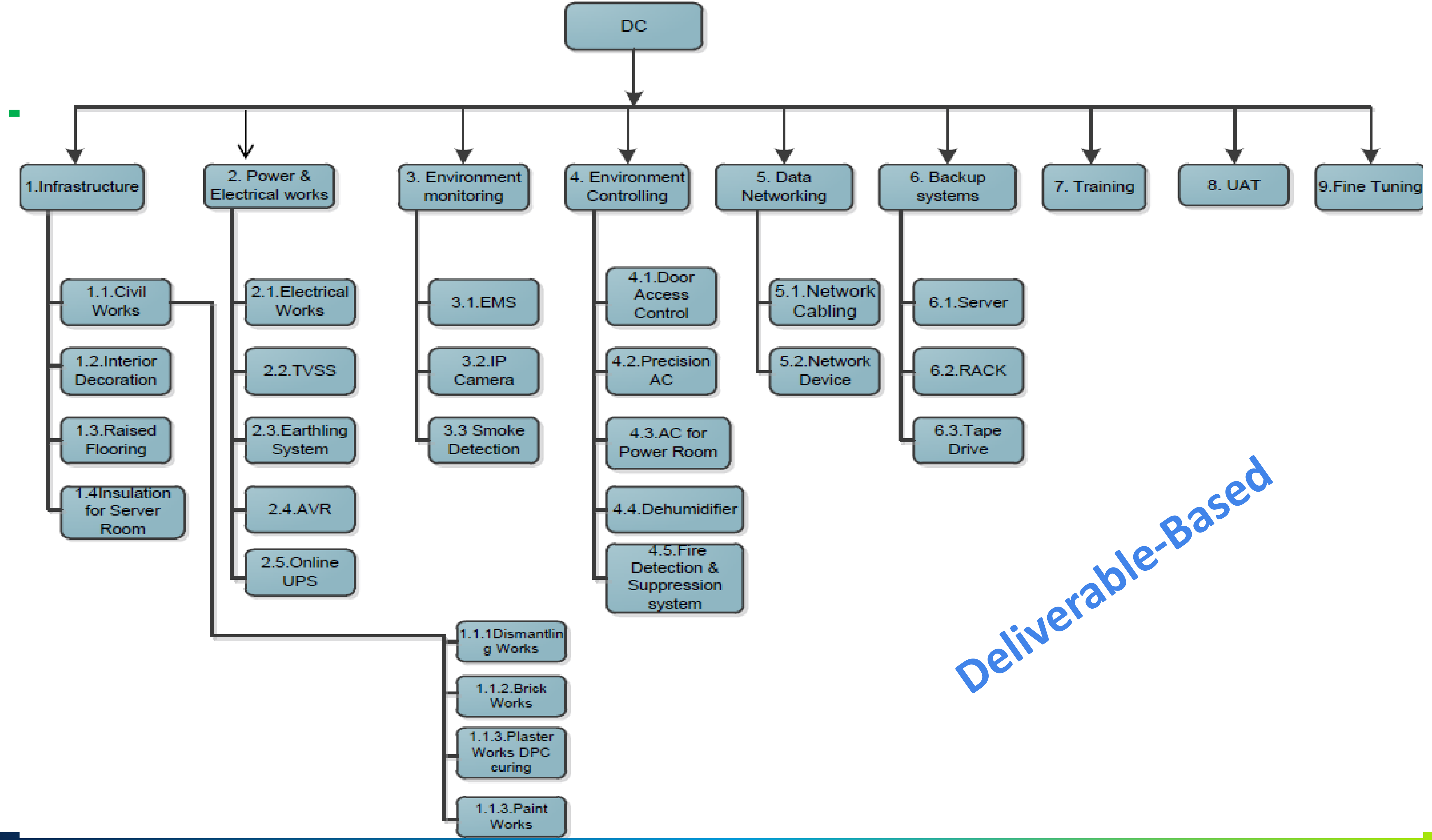

DC
1.Infrastructure
2. Power & Electrical works
3. Environment monitoring
4. Environment Controlling
5. Data Networking
6. Backup systems
7. Training
8. UAT
9.Fine Tuning
1.1.Civil Works
1.2.Interior Decoration
1.3.Raised Flooring
1.4Insulation for Server Room
2.1.Electrical Works
2.2.TVSS
2.3.Earthling System
2.4.AVR
2.5.Online UPS
3.1.EMS
3.2.IP Camera
3.3 Smoke Detection
4.1.Door Access Control
4.2.Precision AC
4.3.AC for Power Room
4.4.Dehumidifier
4.5.Fire Detection & Suppression system
5.1.Network Cabling
5.2.Network Device
6.1.Server
6.2.RACK
6.3.Tape Drive
1.1.1Dismantling Works
1.1.2.Brick Works
1.1.3.Plaster Works DPC curing
1.1.3.Paint Works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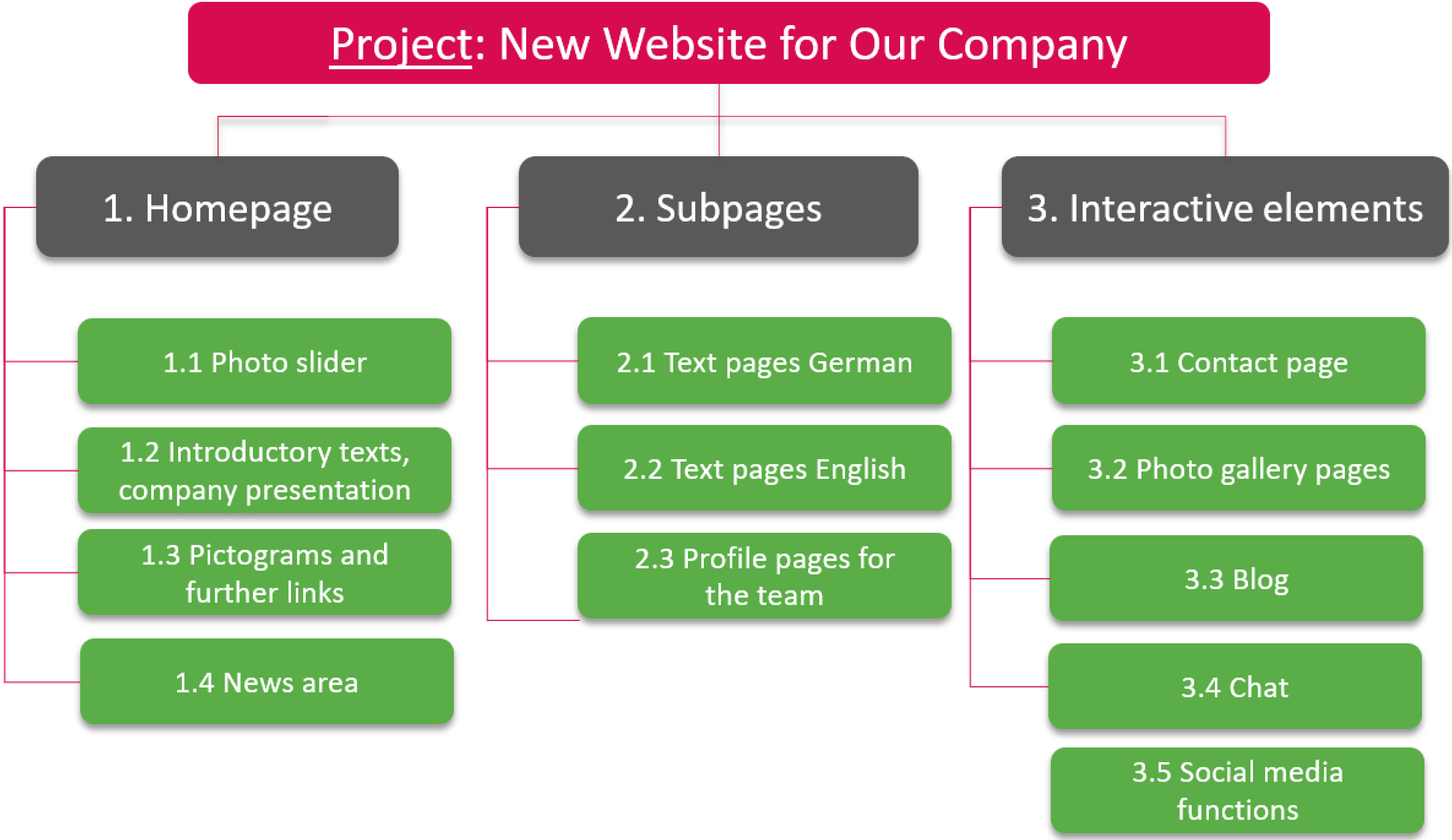
1.1.1Dismantling Works
1.1.2.Brick Works
1.1.3.Plaster Works DPC curing
1.1.3.Paint Works
Deliverable-Based

Project: New Website for Our Company

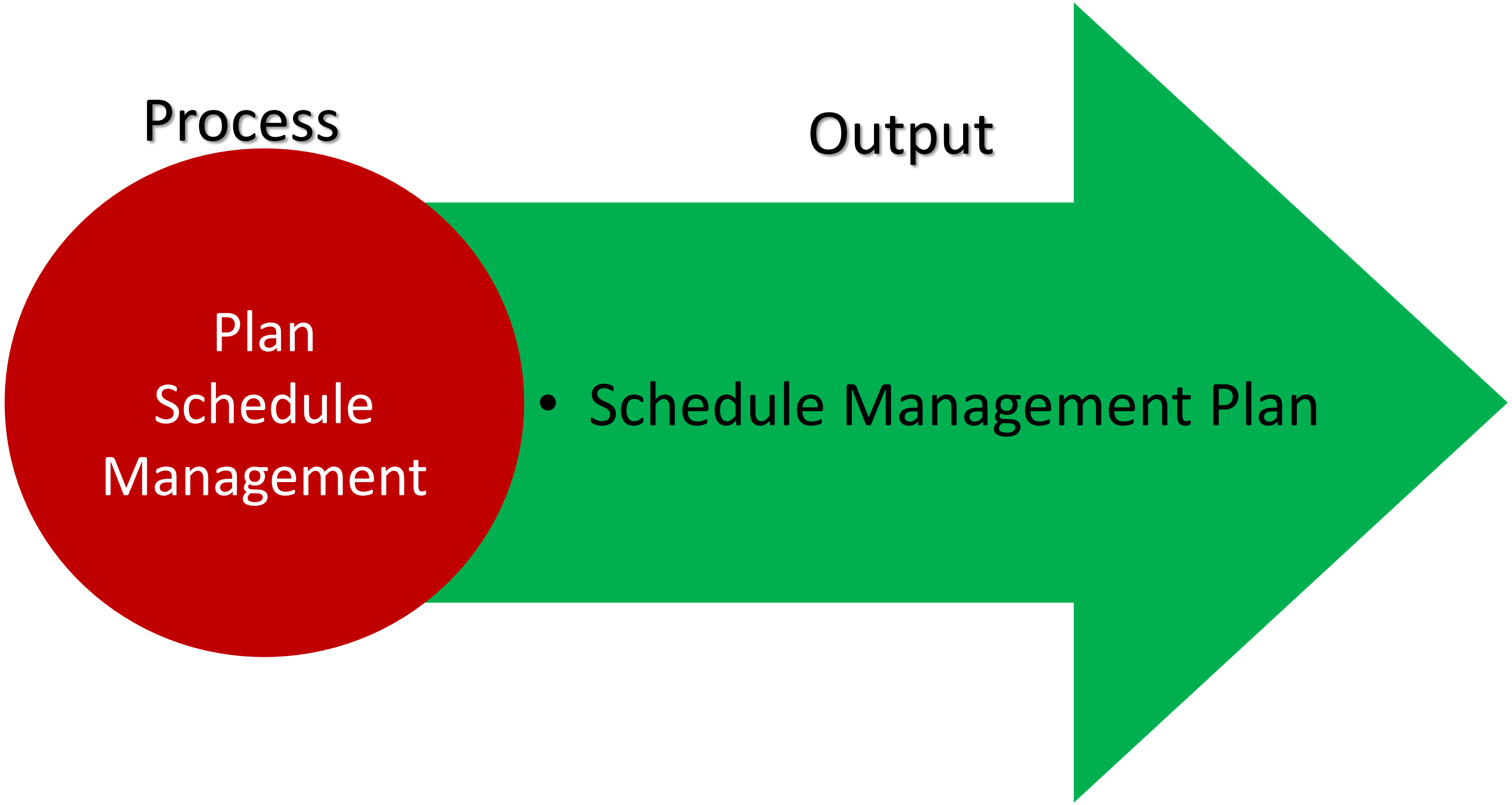
- 1. Design
  - 1.1 Site structure
  - 1.2 Navigation
  - 1.3 Color scheme / Layout
  - ...
- 2. Development
  - 2.1 Homepage
  - 2.2 Content pages
  - 2.3 Contact form
  - 2.4 Gallery
  - ...
- 3. Test
  - 3.1 Navigation
  - 3.2 Links
  - 3.3 Contact form
  - 3.4 Gallery
  - ...
- 4. Go-Live
  - 4.1 Beta test with selected users
  - 4.2 Global rollout

Work packages


Project: New Website for Our Company
1. Homepage
1.1 Photo slider
1.2 Introductory texts, company presentation
1.3 Pictograms and further links
1.4 News area
2. Subpages
2.1 Text pages German
2.2 Text pages English
2.3 Profile pages for the team
3. Interactive elements
3.1 Contact page
3.2 Photo gallery pages
3.3 Blog
3.4 Chat
3.5 Social media functions

Plan Schedule Management

The process of establishing the policies, procedures, and documentation for planning, developing, managing, executing, and controlling the project schedule.



Plan Schedule Management

It provides guidance and direction on how the project schedule will be managed throughout the project

Plan Schedule Management

Inputs

.1 Project charter
.2 Project management plan
- Scope management plan
- Development approach

.3 Enterprise environmental factors
.4 Organizational process assets

Tools & Techniques

.1 Expert judgment
.2 Data analysis
.3 Meetings

Outputs

.1 Schedule management plan

Plan Schedule Management

Input:

PROJECT CHARTER	• defines the summary milestone schedule that will influence the management of the project schedule.
PROJECT MANAGEMENT PLAN	• Scope management plan - how the scope will be defined and developed • Development approach - help to define the scheduling approach, estimating techniques, scheduling tools, and techniques for controlling the schedule.
EEF & OPA	• EEF - Organizational culture and structure, physical resource availability, Scheduling software, Commercial databases, such as standardized estimating data • OPA - Historical information and lessons learned repositories, Existing formal and informal schedule development, management- and control-related policies, procedures, and guidelines, Templates and forms, Monitoring and reporting tools.

Plan Schedule Management

Tools & Techniques:

Expert judgment	• Expertise should be considered from individuals or groups with specialized knowledge or training in previous, similar projects: ✓ Schedule development, management, and control; ✓ Scheduling methodologies (e.g., predictive or adaptive life cycle); ✓ Scheduling software; and ✓ The specific industry for which the project is developed.
Data Analysis	• Alternatives analysis can include determining which schedule methodology to use, or how to combine various methods on the project.
Meetings	• may hold planning meetings to develop the schedule management plan.

PLAN SCHEDULE MANAGEMENT

Output: Schedule management plan

Plan Schedule Management

Output: Schedule management plan

1. **Schedule Model**: Scheduling methodologies and scheduling tools

Plan Schedule Management

Output: Schedule management plan

1. **Schedule Model**: Scheduling methodologies and scheduling tools
2. **Release and iteration length**. When using an adaptive life cycle, the time-boxed periods for releases, waves, and iterations are specified.

Plan Schedule Management

Output: Schedule management plan

1. **Schedule Model**: Scheduling methodologies and scheduling tools
2. **Release and iteration length**. When using an adaptive life cycle, the time-boxed periods for releases, waves, and iterations are specified.
3. **Prescribed level of details** necessary to manage the work

Plan Schedule Management

Output: Schedule management plan

1. **Schedule Model**: Scheduling methodologies and scheduling tools
2. **Release and iteration length**. When using an adaptive life cycle, the time-boxed periods for releases, waves, and iterations are specified.
3. **Prescribed level of details** necessary to manage the work
4. **Level of accuracy** acceptable range used to determine activity duration

Plan Schedule Management

Output: Schedule management plan

1. **Schedule Model**: Scheduling methodologies and scheduling tools
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5. **Unit of measure**: staff hour, meter, liters, tons, kilometers etc.

PLAN SCHEDULE MANAGEMENT

Output: Schedule management plan

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6. **Control threshold**: variance threshold

Plan Schedule Management

Output: Schedule management plan

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7. **Rule of performance measurement**: Earned value measurement technique (baseline, fixed formula) schedule performance measurement

Plan Schedule Management

Output: Schedule management plan

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8. **Reporting formats**: format and frequency

Plan Schedule Management

Output: Schedule management plan

1. **Schedule Model**: Scheduling methodologies and scheduling tools
2. **Release and iteration length**. When using an adaptive life cycle, the time-boxed periods for releases, waves, and iterations are specified.
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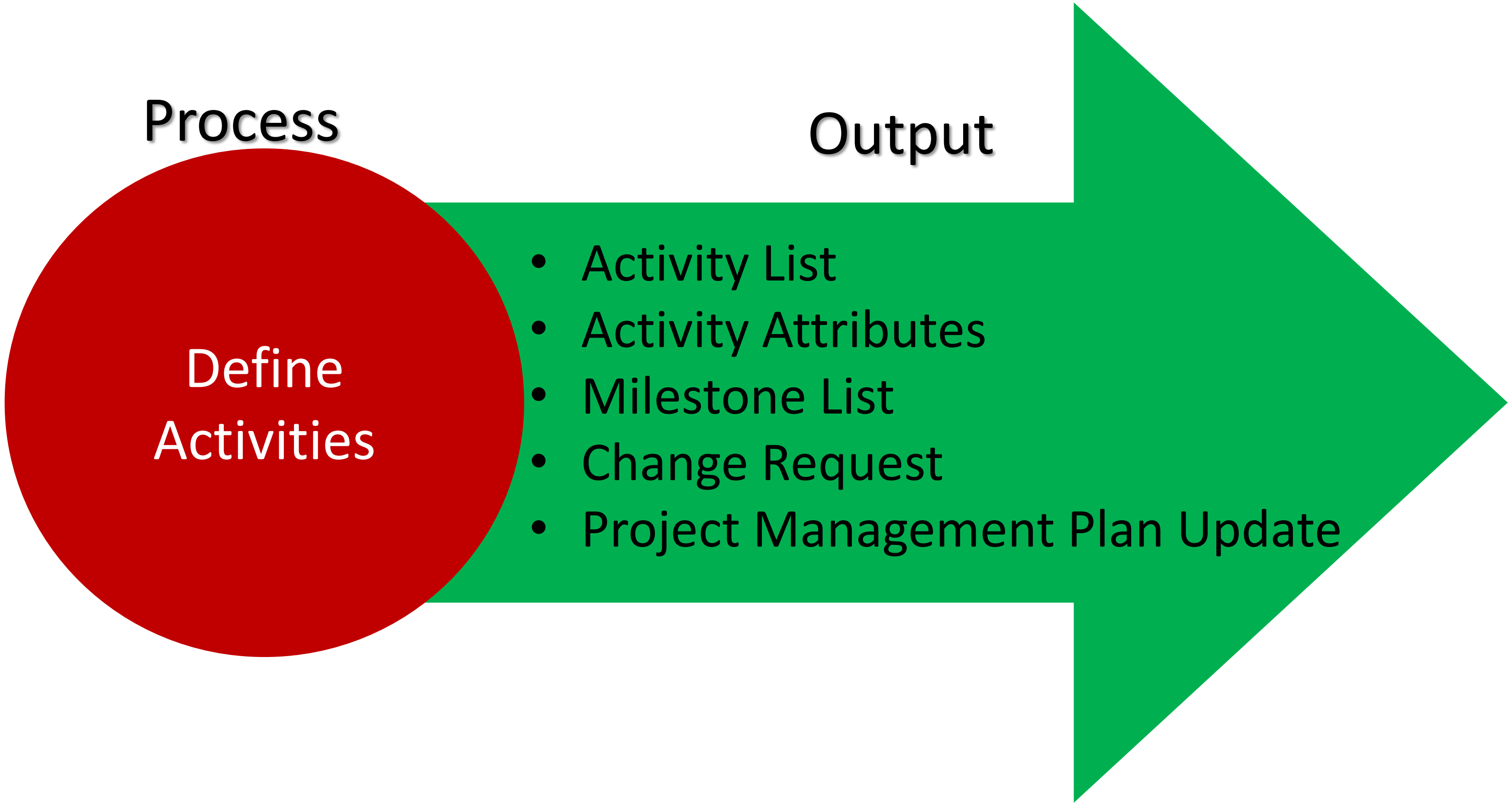
6. **Control threshold**: variance threshold
7. **Rule of performance measurement**: Earned value measurement technique (baseline, fixed formula) schedule performance measurement
8. **Reporting formats**: format and frequency
9. **Process descriptions**: schedule management processes are documented.

DEFINE ACTIVITIES

The process of identifying and documenting the specific actions to be performed to produce the project deliverables.



DEFINE ACTIVITIES

it decomposes work packages into schedule activities that provide a basis for estimating, scheduling, executing, monitoring, and controlling the project work.

Define Activities

Inputs

.1 Project management plan
- Schedule management plan
- Scope baseline

.2 Enterprise environmental factors

.3 Organizational process assets

Tools & Techniques

.1 Expert judgment

.2 Decomposition

.3 Rolling wave planning

.4 Meetings

Outputs

.1 Activity list

.2 Activity attributes

.3 Milestone list

.4 Change requests

.5 Project management plan updates
- Schedule baseline
- Cost baseline

Define Activities

Input:

PROJECT MANAGEMENT PLAN	• Scope management plan - defines the schedule methodology, the duration of waves for rolling wave planning, and the level of detail necessary to manage the work • Scope baseline- The project WBS, deliverables, constraints, and assumptions documented in the scope baseline are considered explicitly while defining activities.
EEF & OPA	• EEF - Organizational culture and structure, Project management information system (PMIS), Commercial databases • OPA - Historical information and lessons learned repositories, Standardized processes, Templates that contain a standard activity list, Existing formal and informal activity planning-related policies, procedures, and guidelines,

Define Activities

Tools & Techniques:

- ✓ Expert Judgement
- ✓ Decomposition
- ✓ Rolling Wave planning
- ✓ Meeting

Define Activities

Output:

Activity List	• Comprehensive list including all schedule activities • Included activity identifies and scope of work description
Activity Attributes	• the activity identifier, activity codes, activity description, predecessor activities, successor activities, logical relationships, leads and lags, resource requirements, imposed dates, constraints and assumptions
Milestone List	• Identifies all the milestones and indicates whether the milestone is mandatory (required by the contract) or optional (based on project requirements)

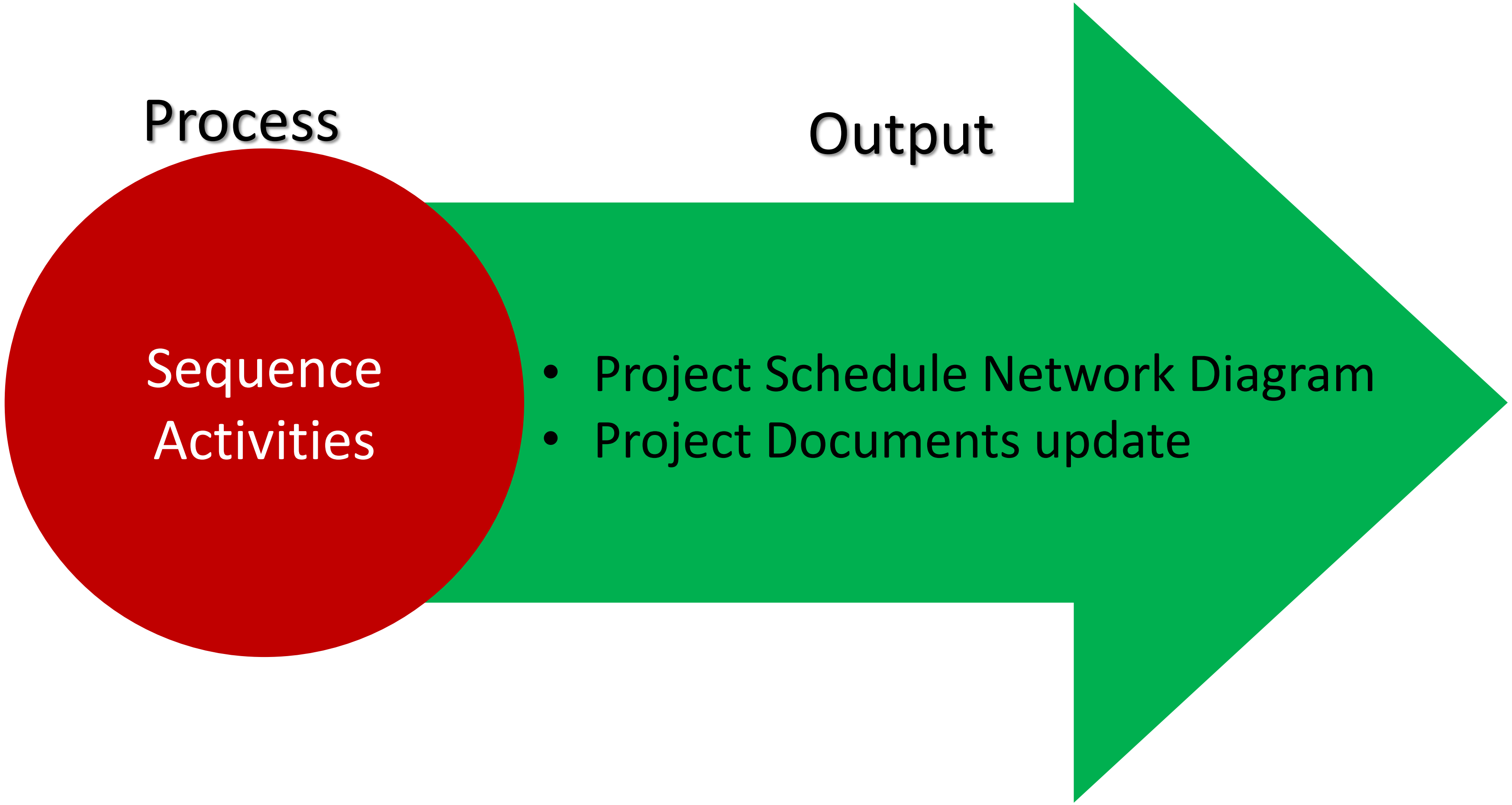
Define Activities

Output:

Output	Description
Change Request	• Once the project has been baselined, the progressive elaboration of deliverables into activities may reveal work that was not initially part of the project baselines.
Project Management Plan Update	• Schedule baseline • Cost baseline

Sequence Activities

- ✓ process of identifying and documenting relationships among the project activities.
- ✓ it defines the logical sequence of work to obtain the greatest efficiency given all project constraints.



SEQUENCE ACTIVITIES

The Sequence Activities process concentrates on converting the project activities from a list to a diagram to act as a first step to publish the schedule baseline.

Sequence Activities

Inputs

.1 Project management plan
- Schedule management plan
- Scope baseline

.2 Project documents
- Activity attributes
- Activity list
- Assumption log
- Milestone list

.3 Enterprise environmental factors

.4 Organizational process assets

Tools & Techniques

.1 Precedence diagramming method

.2 Dependency determination and integration

.3 Leads and lags

.4 Project management information system

Outputs

.1 Project schedule network diagrams

.2 Project documents updates
- Activity attributes
- Activity list
- Assumption log
- Milestone list

Sequence Activities

Input:

PROJECT MANAGEMENT PLAN	• Schedule Management Plan • Scope Baseline
PROJECT DOCUMENTS	• Activity List, Activity Attribute, Milestone list • Assumption log
EEF & OPA	• EEF - Government or industry standards, Project management information system (PMIS), Scheduling tools, and Organization work authorization systems. • OPA - Standard, PMIS, tools, work authorization system, Scheduling methodology, LL knowledge base

Sequence Activities

Tools & Techniques:

- ✓ precedence diagramming method (PDM)
- ✓ Dependency Determination
- ✓ Leads and Lags
- ✓ Project management information system (PMIS)

SEQUENCE ACTIVITIES

Tools & Techniques: precedence diagramming method (PDM)

- ✓ is a technique used for constructing a schedule model in which activities are represented by nodes and are graphically linked by one or more logical relationships to show the sequence in which the activities are to be performed.

Sequence Activities

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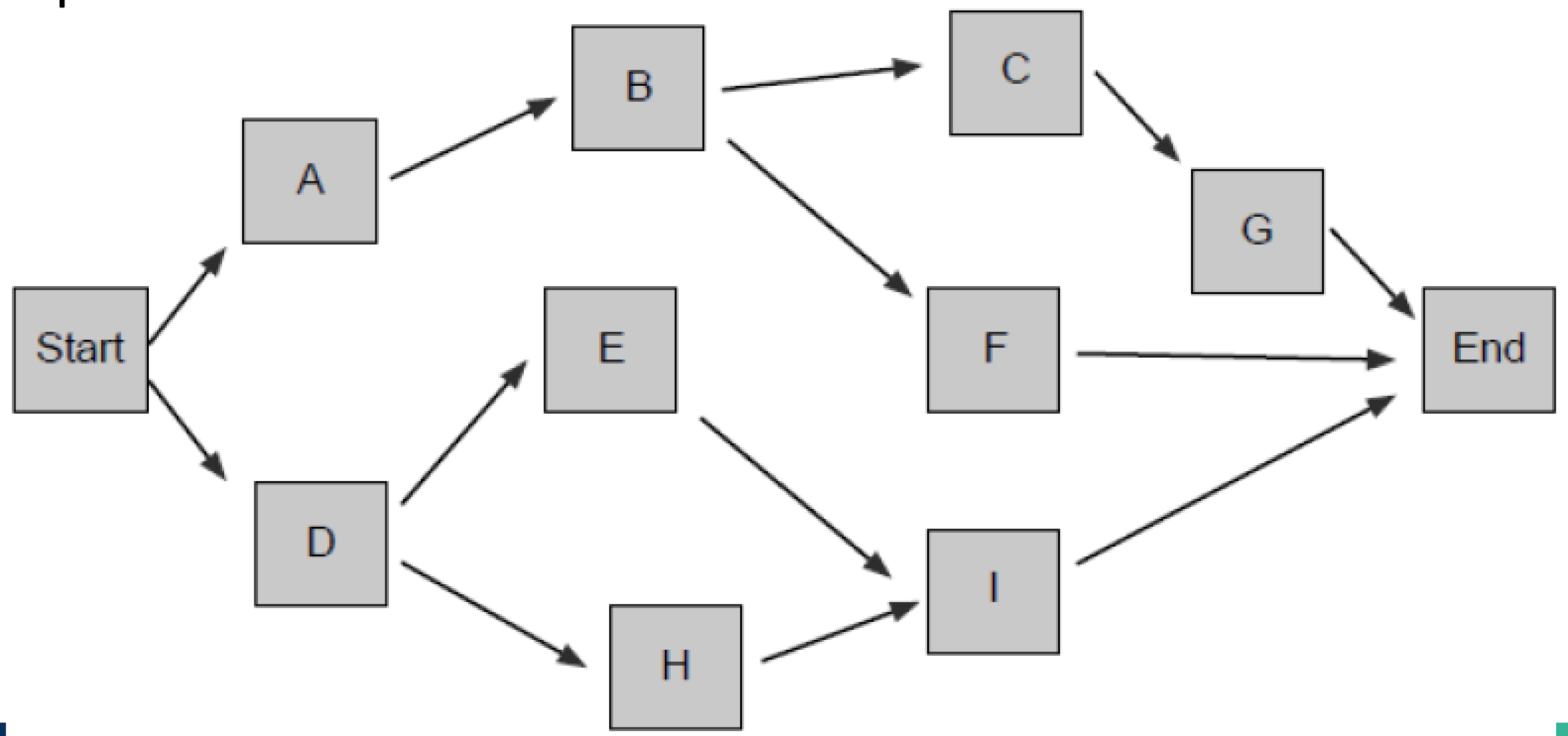

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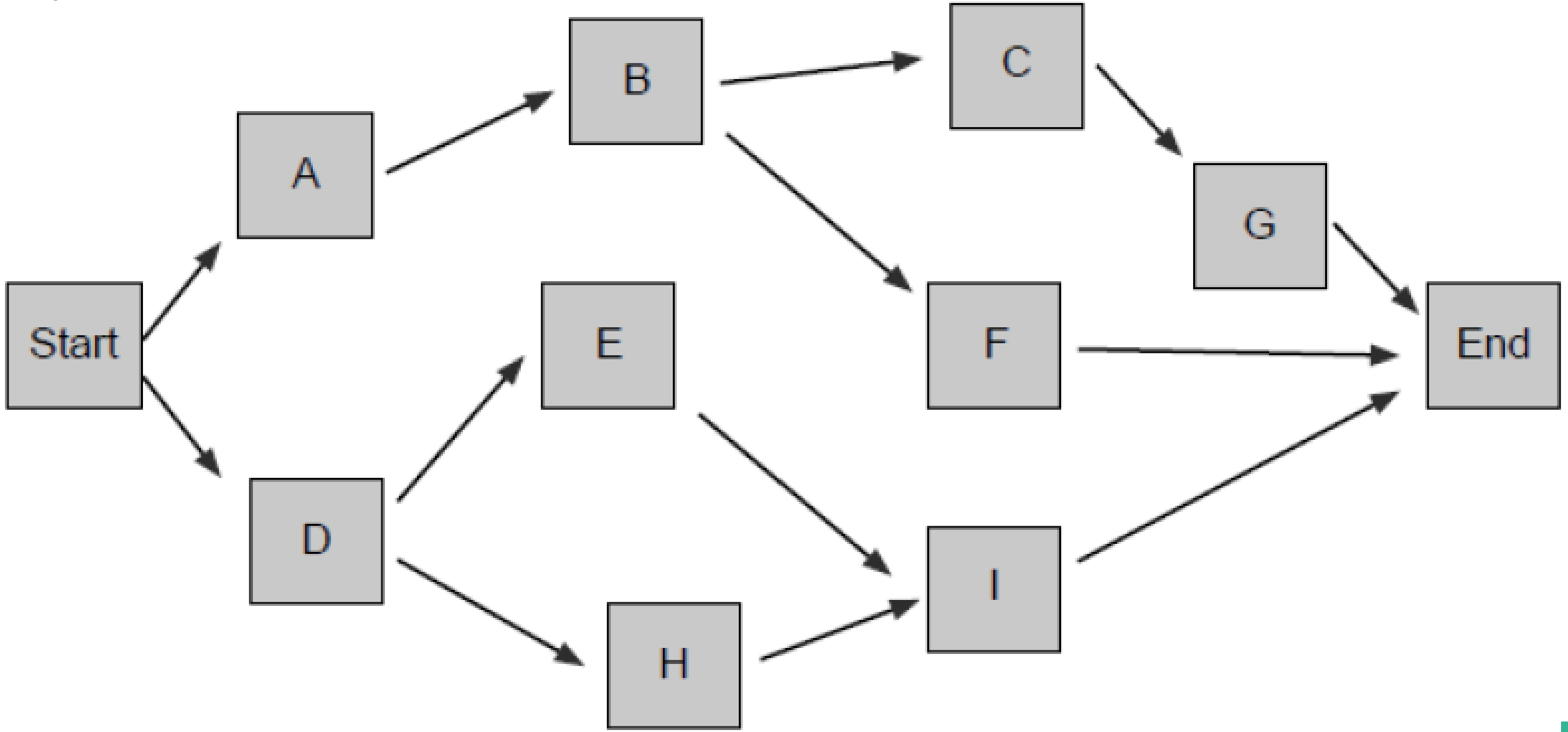


Name	Predecessor
Start	-
A	Start
B	A
C	B
D	Start
E	D
F	B
G	C
H	D
I	E,H
End	F,G,H

Sequence Activities

Tools & Techniques: precedence diagramming method (PDM)

Types of Dependency

Finish to Start (F-S)

The initiation of the successor activity depends upon the completion of the predecessor activity

you cannot start testing a method before the test cases are developed

Start-to-start (S-S)

The initiation of the successor activity depends upon the initiation of the predecessor activity

Data collection can begin at the same time as the literature review.

Finish-to-finish (F-F)

The completion of the successor activity depends upon the completion of the predecessor activity

The research report is finalized when data analysis is complete.

Start-to-finish (S-F)

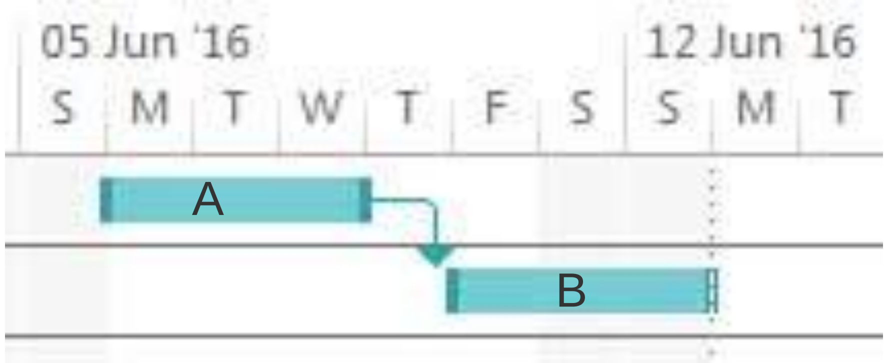
The completion of the successor activity depends upon the initiation of the predecessor activity

Database Migration- to stop the old system you must start the new system

SEQUENCE ACTIVITIES

Tools & Techniques: precedence diagramming method (PDM)

Finish to Start (F-S)



Task B cannot start until task A finishes.

A – Write User Manual

B – Print User Manual

SEQUENCE ACTIVITIES

Tools & Techniques: precedence diagramming method (PDM)

Start to Start (S-S)

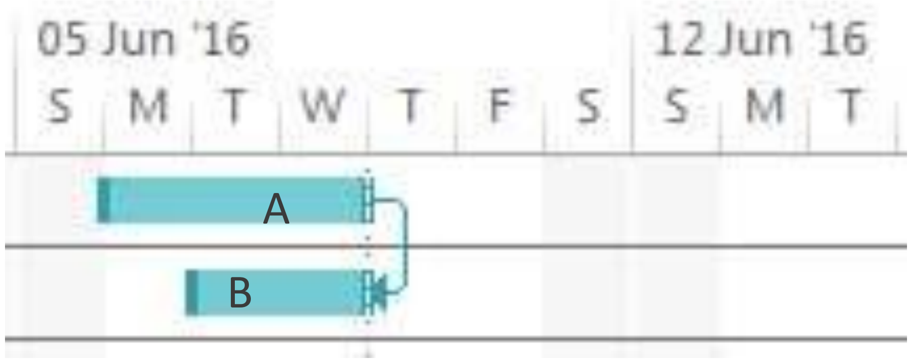
task B can only start when task A has started

A – Write Code for S/W Module X
B – Write DB Scripts for S/W Module X

SEQUENCE ACTIVITIES

Tools & Techniques: precedence diagramming method (PDM)

Finish to Finish (F-F)



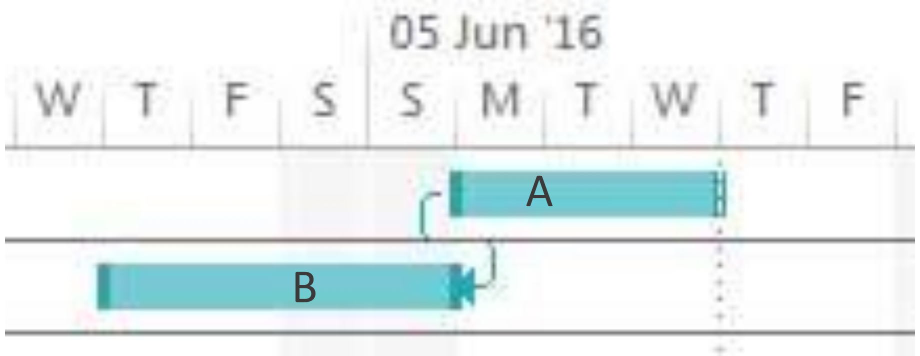
task B cannot finish until task A finishes

A – Write Code for S/W Module X
B – Unit Test S/W Module X

SEQUENCE ACTIVITIES

Tools & Techniques: precedence diagramming method (PDM)

Start to Finish (S-F)



task B cannot finish until task A starts.

A – Start using New Software System
B – Phase out Old Software System

SEQUENCE ACTIVITIES

Tools & Techniques: precedence diagramming method (PDM)

SEQUENCE ACTIVITIES

Tools & Techniques: precedence diagramming method (PDM)

- ✓ FS is the most commonly used type of precedence relationship. The SF relationship is very rarely used
- ✓ Two activities can have two logical relationships at the same time (for example, SS and FF).
- ✓ Multiple relationships between the same activities are not recommended, so a decision has to be made to select the relationship with the highest impact.
- ✓ Closed loops are also not recommended in logical relationships.

SEQUENCE ACTIVITIES

Tools & Techniques: precedence diagramming method (PDM)

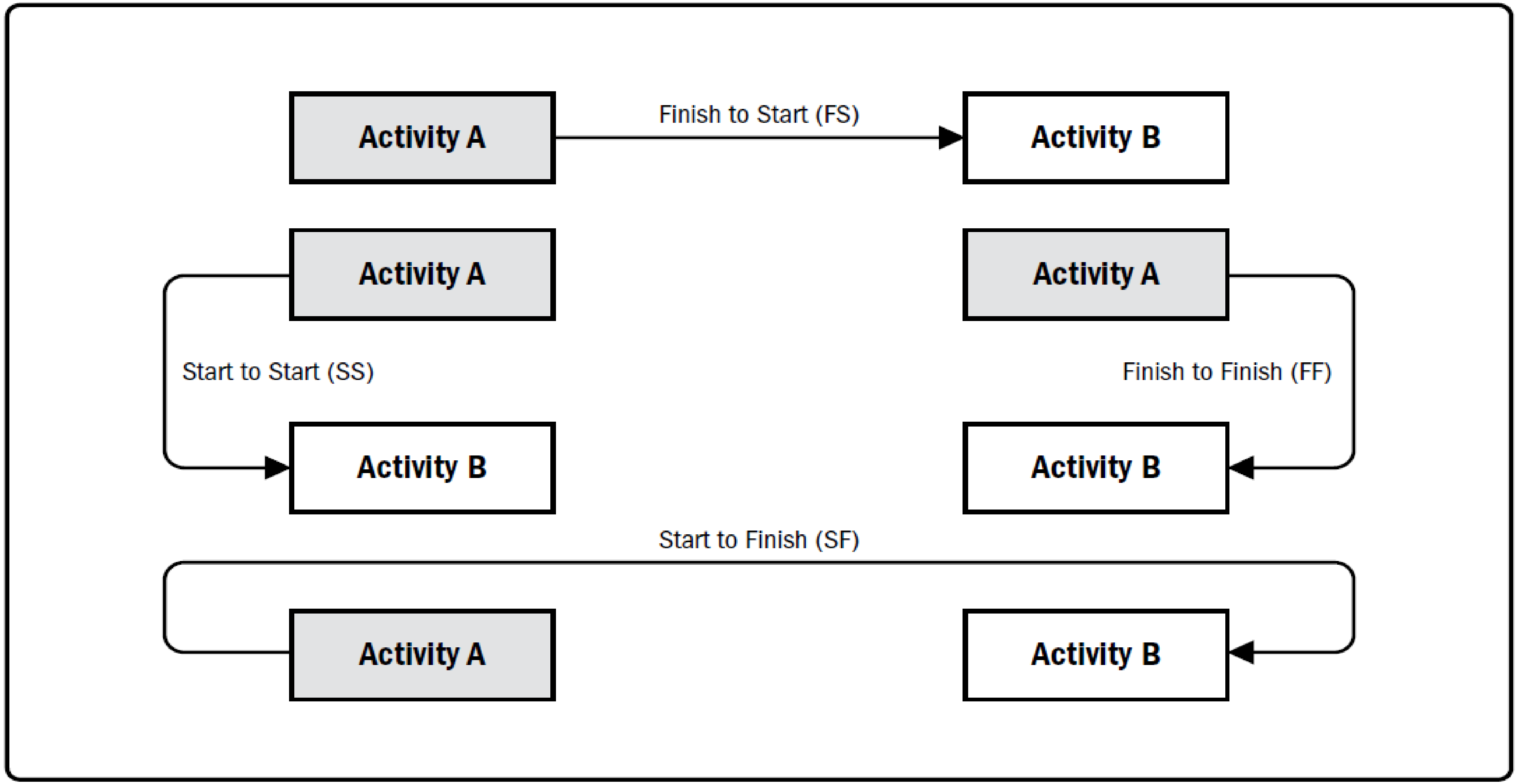


Figure 6-9. Precedence Diagramming Method (PDM) Relationship Types

EXAMPLE OF PRECEDENCE DIAGRAMMING METHOD

Example of Precedence Diagramming Method

For one of your project followings are the task list:

1. technical design of module A (duration: 10 days),
2. technical design of module B (duration: 5 days),
3. development of module A (duration: 15 days),
4. development of module B (duration: 20 days), and
5. development of feature F in module B (duration: 1 day).

Example of Precedence Diagramming Method

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1. technical design of module A (duration: 10 days),
2. technical design of module B (duration: 5 days),
3. development of module A (duration: 15 days),
4. development of module B (duration: 20 days), and
5. development of feature F in module B (duration: 1 day).

The technical dependencies are:

1. The technical design of module B cannot finish until the technical design of module A has been completed.
2. The technical designs of module A must be completed before the module A development can start.
3. The technical designs of module B must be completed before the module B development can start.
4. The development of module B can only be started when the development of module A has been started.
5. The development of feature F cannot be finished before the development of module B has started (although it can be developed independently, it needs to be integrated into module B)

EXAMPLE OF PRECEDENCE DIAGRAMMING METHOD

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1. technical design of module A (duration: 10 days),
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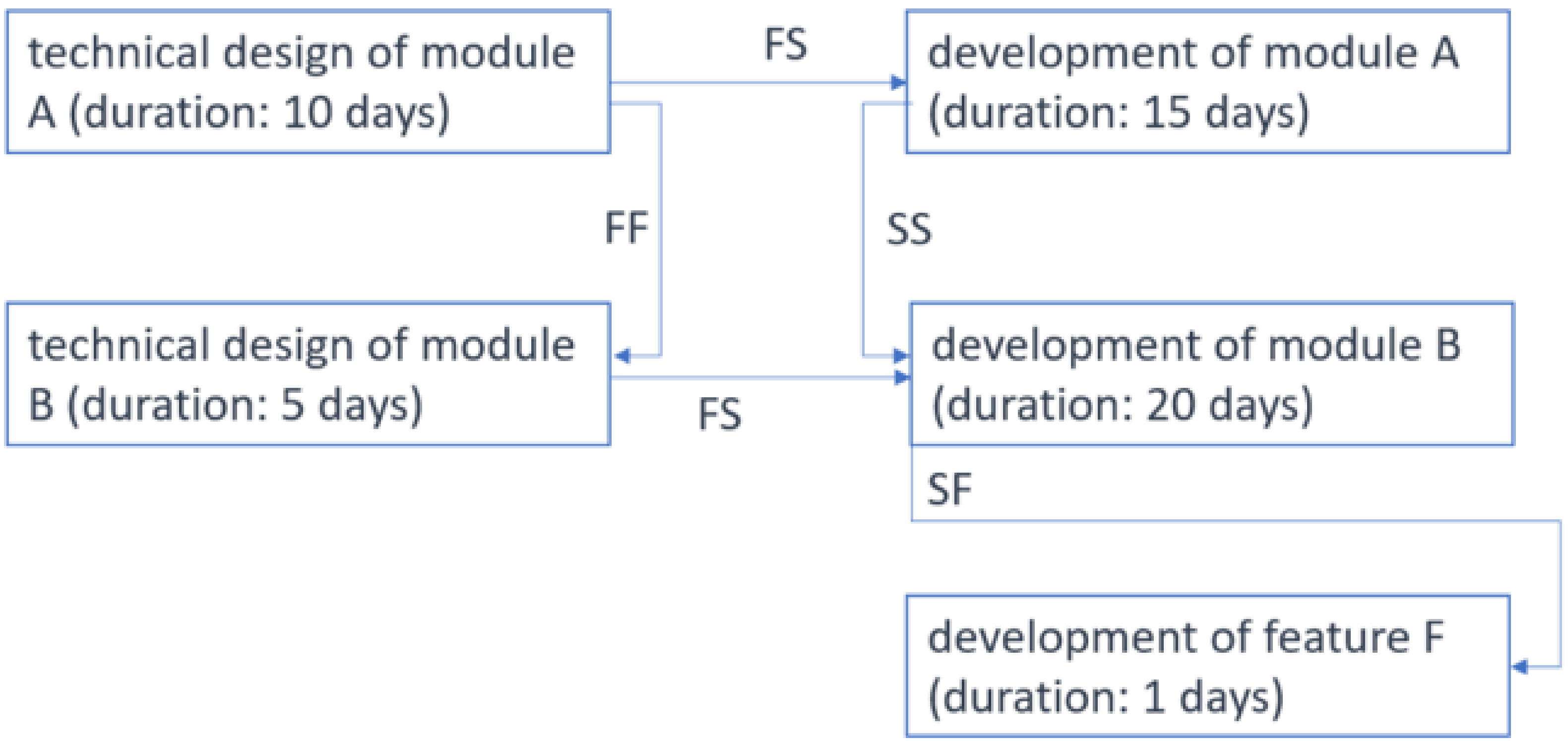
4. The development of module B can only be started when the development of module A has been started.
5. The development of feature F cannot be finished before the development of module B has started (although it can be developed independently, it needs to be integrated into module B)

Logical Relationship:

1. Activity (1) is predecessor of activity (2) in a finish-to-finish (FF) dependency *(There could also be a start-to-start (SS) dependency between (1) and (2) but the FF relationship is prioritized as its impact is higher)*
2. Activity (1) is predecessor of activity (3) in a finish-to-start (FS) relationship
3. Activity (2) is predecessor of activity (4) in a finish-to-start (FS) relationship
4. **Activity (3) is predecessor of activity (4) in a start-to-start (SS) relationship**
5. Activity (5) is a successor of activity (4) and in a start-to-finish (SF) relationship

EXAMPLE OF PRECEDENCE DIAGRAMMING METHOD



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4. **Activity (3) is predecessor of activity (4) in a start-to-start (SS) relationship**
5. Activity (5) is a successor of activity (4) and in a start-to-finish (SF) relationship

SEQUENCE ACTIVITIES

Tools & Techniques: Dependency Determination

Dependency Determination

Mandatory dependencies

Contractually required or inherent in the nature of the work (called hard logic)

A floor of a building cannot be constructed until foundation is laid.

Discretionary dependencies

defined by project management team. Known as "softlogic", "preferential logic" or "preferred logic"

Until UAT documents are finalized, team will not start implementation

External dependencies

involve a relationship between project activities and non project activities.

The testing activity of software may be dependent on the delivery of hardware from an external source

Internal dependencies

Internal dependencies involve a precedence relationship between project activities and are generally inside the project team's control.

team cannot test a machine until they assemble it, there is an internal mandatory dependency.

Sequence Activities

Tools & Techniques: Leads and Lags

- ✓ *The amount of time whereby a successor activity can be advanced with respect to a predecessor activity.*
- ✓ A Lead provides acceleration to the Successor Activity.

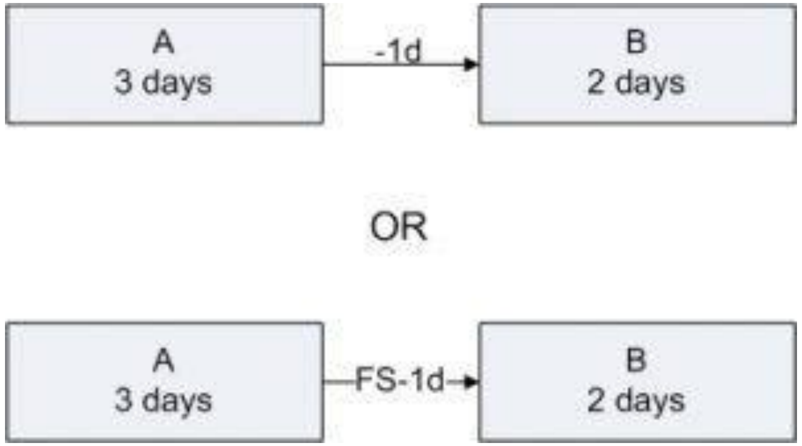
Consider two activities A and B.

Duration of A – 3 days

Duration of B – 2 days

B has a **Finish to Start** Relationship with A with a Lead of 1 day.

The scheduled start of B is 1 day before the scheduled Finish of A.



Project Team would need 4 days to complete these activities. If the said FS relationship was without any Lead, the Project Team would have needed 5 days.

SEQUENCE ACTIVITIES

Tools & Techniques: Leads and Lags

- ✓ *The amount of time whereby a successor activity is required to be delayed with respect to a predecessor activity.*
- ✓ A Lag provides mandatory delay to the Successor Activity.

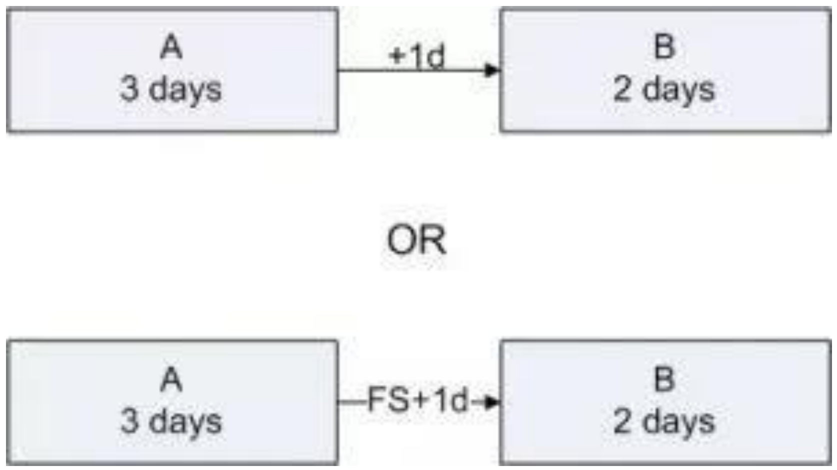
Consider two activities A and B.

Duration of A – 3 days

Duration of B – 2 days

B has a Finish to Start Relationship with A with a Lag of 1 day.

The scheduled Start of B is 1 day after the scheduled Finish of A.



Project Team would need 6 days to complete these activities. If the said FS relationship was without any Lag, the Project Team would have needed 5 days.

Example of Leads and Lags

Example of Leads and Lags

In a project, the durations are estimated as follows:

1. technical design of module A: 10 days
2. technical design of module B: 5 days
3. development of module A: 15 days
4. development of module B: 20 days

Example of Leads and Lags

In a project, the durations are estimated as follows:

1. technical design of module A: 10 days
2. technical design of module B: 5 days
3. development of module A: 15 days
4. development of module B: 20 days

The dependencies are:

1. the technical designs of module A and B, respectively, must be completed before the respective module can be developed,
2. the technical design of module B makes reference to that of module A,
3. thus, the module A design needs to be 50% completed before the module B design can be started, and
4. the development of module A depends on module B, which needs to be 25% completed before the team can start the development of module A.

Example of Leads and Lags

In a project, the durations are estimated as follows:

1. technical design of module A: 10 days
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3. development of module A: 15 days
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The dependencies are:

1. the technical designs of module A and B, respectively, must be completed before the respective module can be developed,
2. the technical design of module B makes reference to that of module A,
3. thus, the module A design needs to be 50% completed before the module B design can be started, and
4. the development of module A depends on module B, which needs to be 25% completed before the team can start the development of module A.

Logical Relationship:

1. Activity 1 and activity 2 (SS with lag 5d)
2. Activity 1 and activity 3 (FS)
3. Activity 2and activity 4 (FS)
4. Activity 3 and activity 4 (SS with lag 5d)

1. technical design of module A: 10 days
2. technical design of module B: 5 days
3. development of module A: 15 days
4. development of module B: 20 days

	days									
Activity	5	10	15	20	25	30	35	40	45	50
Design module A	■	■								
Design module B			■							
Develop module B				■	■	■	■			
Develop module A								■	■	■

Schedule of the project based on finish-to-start relationships.

Activity	Dependencies and durations	Lag time	Lead time
Design module A	takes 10 days	first activity	first activity
Design module B	can start 5 days after the design of module A started and takes 5 days	5 days (after start of A)	5 days (before finishing A)
Develop module B	can start when the design of module B is completed and takes 20 days	no lag	no lead
Develop module A	can start when module B is 25% completed and takes 15 days	5 days (after start of B)	15 days (before completion of B)

Activity	Dependencies and durations	Lag time	Lead time
Design module A	takes 10 days	first activity	first activity
Design module B	can start 5 days after the design of module A started and takes 5 days	5 days (after start of A)	5 days (before finishing A)
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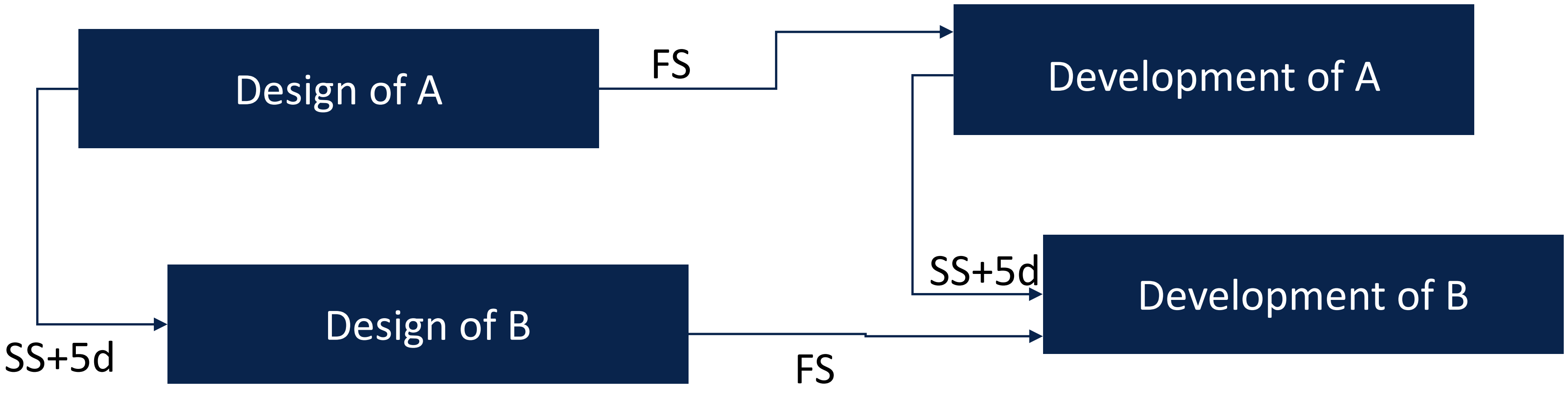

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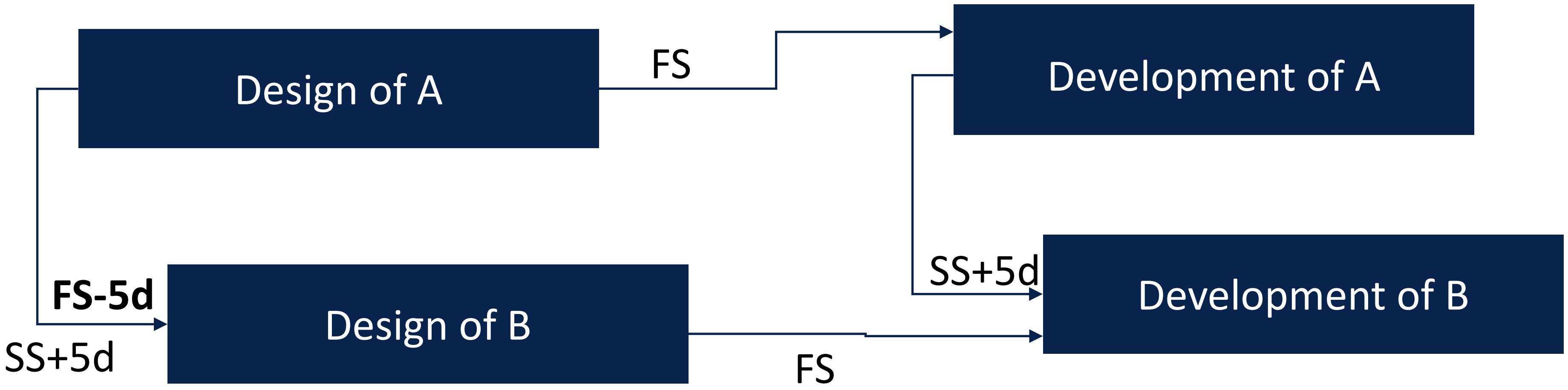

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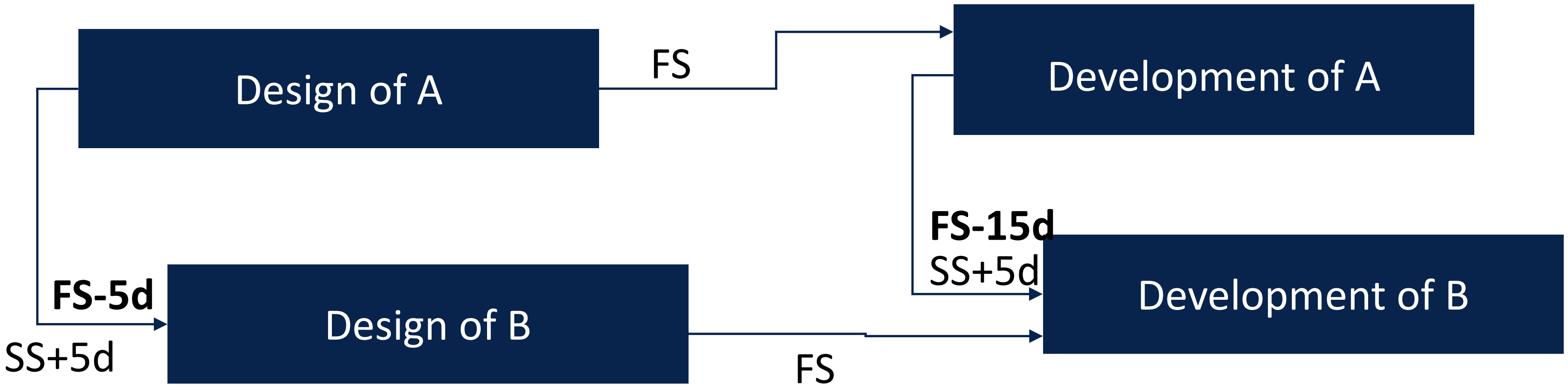

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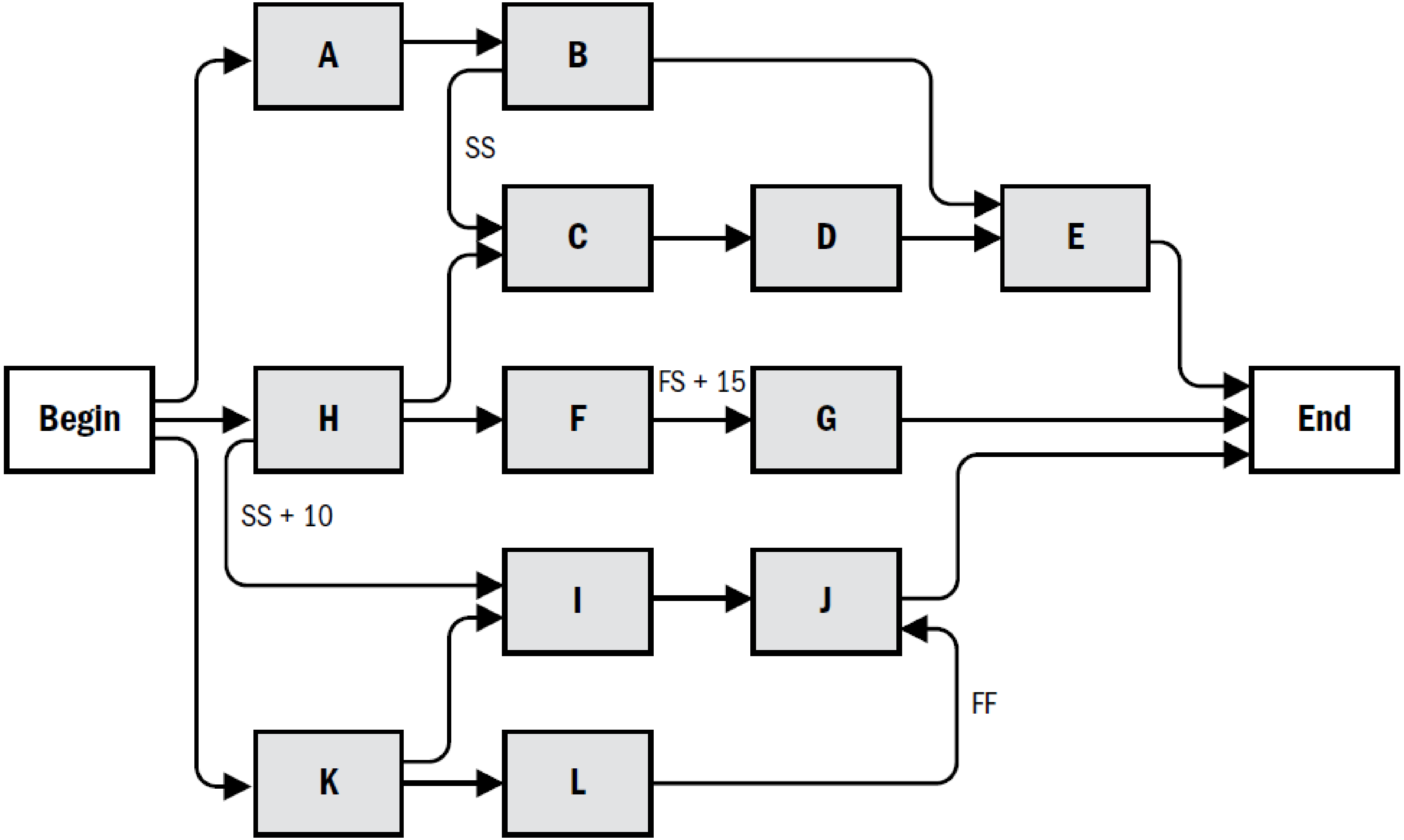
	days									
Activity	5	10	15	20	25	30	35	40	45	50
Design module A										
Design module B										
Develop module B										
Develop module A										

EXAMPLE OF LEADS AND LAGS

	days									
Activity	5	10	15	20	25	30	35	40	45	50
Design module A										
Design module B										
Develop module B										
Develop module A										

Sequence Activities



Project Schedule Network Diagram

Sequence Activities

Tools & Techniques: Project management information systems

- ✓ provides access to information technology (IT) software tools, such as scheduling software tools, work authorization systems, configuration management systems, information collection and distribution systems.
- ✓ interfaces to other online automated systems such as corporate knowledge base repositories.
- ✓ Automated gathering and reporting on key performance indicators (KPI) can be part of this system.

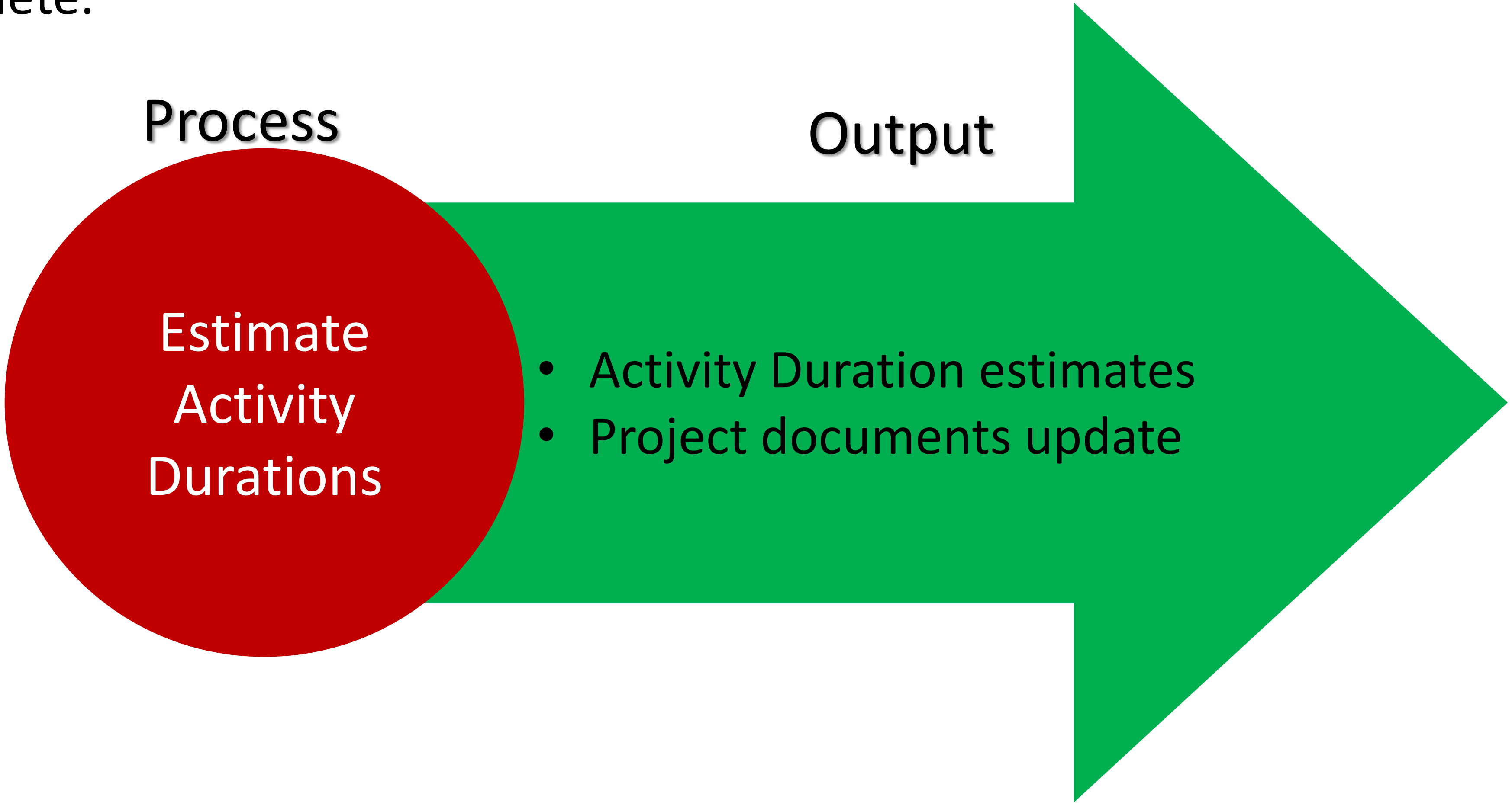
Sequence Activities

Output:

Project schedule network diagram	• Schematic displays of the project's activities and their logical relationship
Project Document Update	• Activity attributes • Activity list. • Assumption log. • Milestone list.

ESTIMATE ACTIVITY DURATIONS

- ✓ is the process of estimating the number of work periods needed to complete individual activities with estimated resources.
- ✓ The key benefit of this process is that it provides the amount of time each activity will take to complete.



Estimate Activity Durations

Estimate Activity Durations

Inputs

.1 Project management plan
- Schedule management plan
- Scope baseline

.2 Project documents
- Activity attributes
- Activity list
- Assumption log
- Lessons learned register
- Milestone list
- Project team assignments
- Resource breakdown structure
- Resource calendars
- Resource requirements
- Risk register

.3 Enterprise environmental factors

.4 Organizational process assets

Tools & Techniques

.1 Expert judgment

.2 Analogous estimating

.3 Parametric estimating

.4 Three-point estimating

.5 Bottom-up estimating

.6 Data analysis
- Alternatives analysis
- Reserve analysis

.7 Decision making

.8 Meetings

Outputs

.1 Duration estimates

.2 Basis of estimates

.3 Project documents updates
- Activity attributes
- Assumption log
- Lessons learned register

Estimate Activity Durations

Input:

Project Mgt Plan	• Schedule Management Plan • Schedule baselines
Project Documents	• Activity attributes • Activity list, Assumption log, Lessons learned register, Milestone list, Project team assignments, Resource breakdown Structure, Resource calendars, Resource requirements, Risk register
EEF & OPA	• EEF - Duration estimating databases and other reference data, Productivity metrics, Published commercial information, and Location of team members. • OPA - Historical duration information, Project calendars, Estimating policies, Scheduling methodology, and Lessons learned repository.

ESTIMATE ACTIVITY DURATIONS

Tools & Techniques:

Estimate Activity Durations

Tools & Techniques:

Estimate Activity Durations

Tools & Techniques:

ESTIMATE ACTIVITY DURATIONS

Tools & Techniques:

ESTIMATE ACTIVITY DURATIONS

Tools & Techniques:

Estimate Activity Durations

Tools & Techniques:

4. Three points estimates
   - To improve the accuracy of estimates
     - ✓ Optimistic (tO) *Estimate for all favorable conditions with no risks or changes*
     - ✓ Pessimistic (tP) *Estimate for all unfavorable conditions with all negative risks occurring and no mitigation*
     - ✓ Most likely (tM) *Estimate for both favorable and unfavorable conditions, with some risks occurring.*

ESTIMATE ACTIVITY DURATIONS

Tools & Techniques:

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   Depending on the assumed distribution of values within the range of the three estimates, the expected duration, tE, can be calculated. One commonly used formula is triangular distribution:

   tE = (tO + tM + tP) / 3.

ESTIMATE ACTIVITY DURATIONS

Tools & Techniques:

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     - ✓ Most likely (tM) *Estimate for both favorable and unfavorable conditions, with some risks occurring.*

   Depending on the assumed distribution of values within the range of the three estimates, the expected duration, tE, can be calculated. One commonly used formula is triangular distribution:
   $tE = (tO + tM + tP) / 3$.

Triangular distribution is used when there is insufficient historical data or when using judgmental data.

ESTIMATE ACTIVITY DURATIONS

Tools & Techniques:

5. Bottom-up estimating
   - is a method of estimating project duration or cost by aggregating the estimates of the lower-level components of the WBS.
6. Data analysis
7. Decision-making
8. Meetings

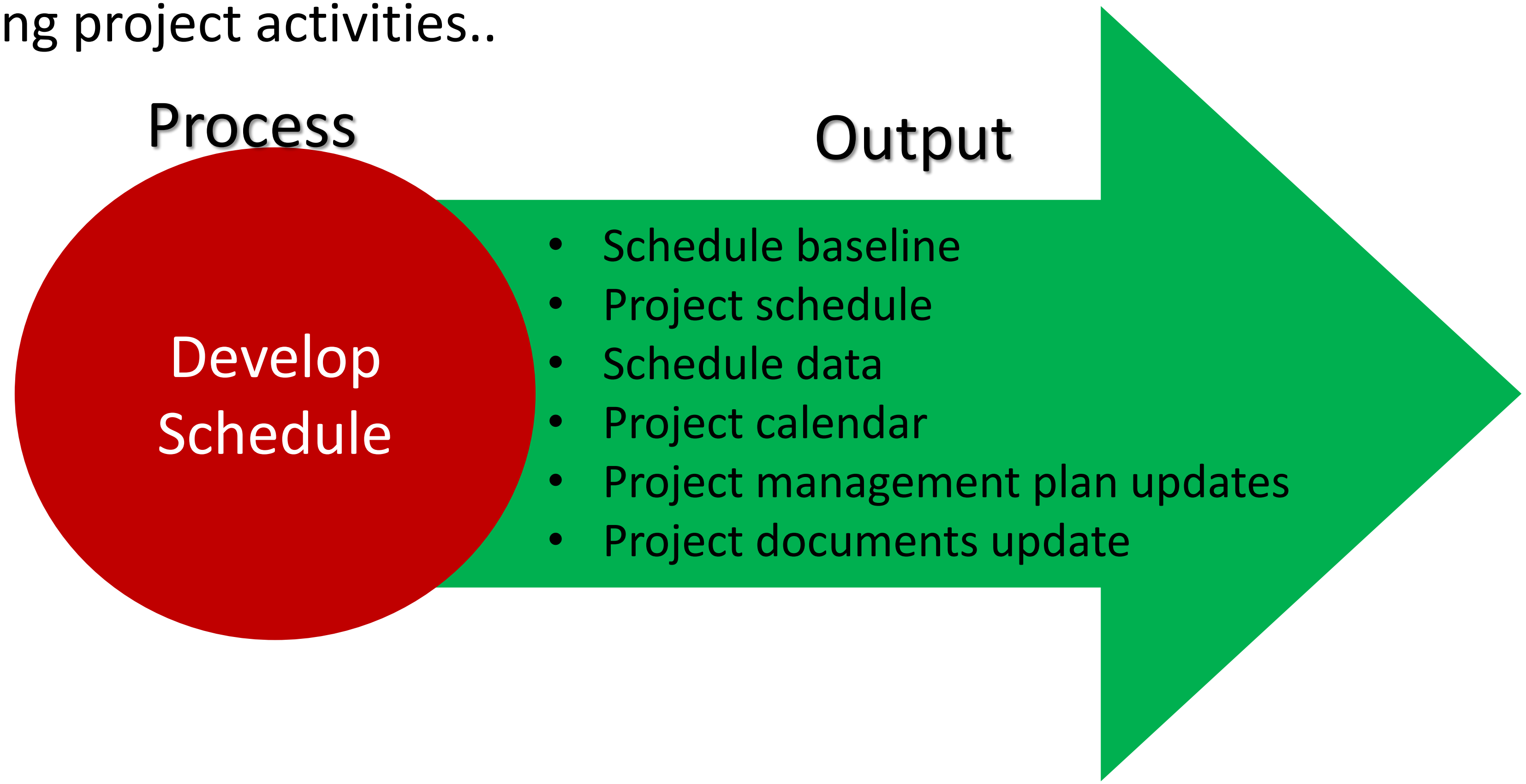
Estimate Activity Durations

Output:

Duration Estimates	• Duration estimates are quantitative assessments of the likely number of time periods that are required to complete an activity, a phase, or a project. • A range of 2 weeks ± 2 days, which indicates that the activity will take at least 8 days and not more than 12 (assuming a 5-day work week); or • A 15% probability of exceeding 3 weeks, which indicates a high probability—85%—that the activity will take 3 weeks or less.
Basis of estimates	• How it was developed • Assumption & Constraints • Confidence level etc.
Project Documents Update	• Activity Attributes • Assumption log • Lesson learned register

DEVELOP SCHEDULE

- ✓ is the process of analyzing activity sequences, durations, resource requirements, and schedule constraints to create a schedule model for project execution and monitoring and controlling.
- ✓ The key benefit of this process is that it generates a schedule model with planned dates for completing project activities..



DEVELOP SCHEDULE

Develop Schedule

Inputs

.1 Project management plan
- Schedule management plan
- Scope baseline

.2 Project documents
- Activity attributes
- Activity list
- Assumption log
- Basis of estimates
- Duration estimates
- Lessons learned register
- Milestone list
- Project schedule network diagrams
- Project team assignments
- Resource calendars
- Resource requirements
- Risk register

.3 Agreements

.4 Enterprise environmental factors

.5 Organizational process assets

Tools & Techniques

.1 Schedule network analysis

.2 Critical path method

.3 Resource optimization

.4 Data analysis
- What-if scenario analysis
- Simulation

.5 Leads and lags

.6 Schedule compression

.7 Project management information system

.8 Agile release planning

Outputs

.1 Schedule baseline

.2 Project schedule

.3 Schedule data

.4 Project calendars

.5 Change requests

.6 Project management plan updates
- Schedule management plan
- Cost baseline

.7 Project documents updates
- Activity attributes
- Assumption log
- Duration estimates
- Lessons learned register
- Resource requirements
- Risk register

Develop Schedule

Input:

Project Mgt Plan	• Schedule Management Plan • Scope baselines
Project Documents	• Activity attributes, Activity list, Assumption log, Basis of estimates, Duration estimates, Lessons learned register, Milestone list, Project schedule network diagrams, Project team assignments, Resource calendars, Resource requirements, Risk register
Agreements	• Vendors may have an input to the project schedule as they develop the details of how they will perform the project work to meet contractual commitments.
EEF &OPA	• EEF - Government or industry standards, and Communication channels. • OPA - Scheduling methodology containing the policies governing schedule model development and maintenance, and Project calendar(s).

Develop Schedule

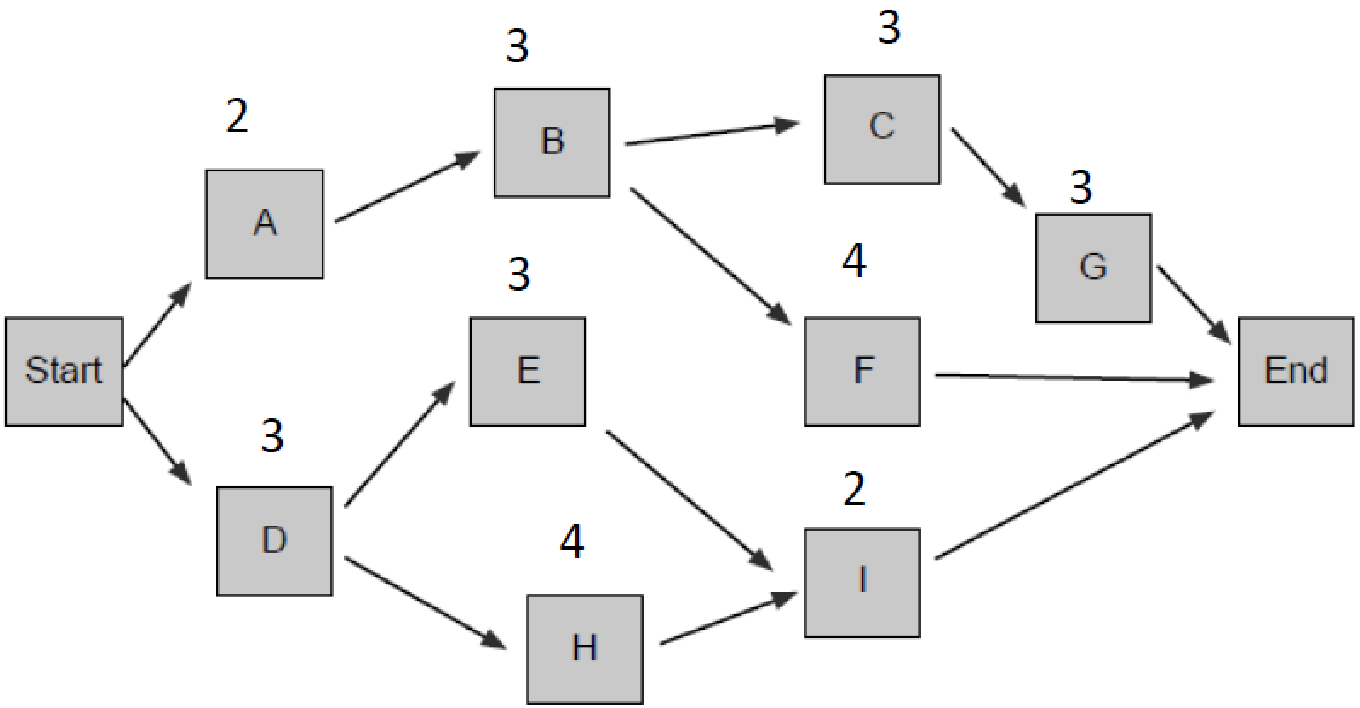
Tools & Techniques:

1. Schedule network analysis
    - is the primary technique used to generate the project schedule model. It employs several other techniques such as critical path method, resource optimization techniques, and modeling techniques.
2. Critical Path Method
    - A method used to estimate the minimum project duration
    - Determine the schedule flexibility
    - Calculates Early start, early finish, late start and late finish
    - Performs forward and backward pass
    - Without regarded for any resource limitation

Develop Schedule

Tools & Techniques: Critical Path Method

Name	Predecessor
Start	—
A	Start
B	A
C	B
D	Start
E	D
F	B
G	C
H	D
I	E, H
Finish	F, G, I



Develop Schedule

Tools & Techniques: Critical Path Method

DEVELOP SCHEDULE

Tools & Techniques: Critical Path Method

Abbreviations:

ES – Early Start

LS – Late Start

EF – Early Finish

LF – Late Finish

P – Predecessor

S – Successor

CP – Critical Path

D - Duration

Develop Schedule

Tools & Techniques: Critical Path Method

Abbreviations:

ES – Early Start

LS – Late Start

EF – Early Finish

LF – Late Finish

P – Predecessor

S – Successor

CP – Critical Path

D - Duration

Formulas:

0 Method

ESs= max (ESp+ Dp)

ES = EF of P

EF = ES + D

LFp = min(LFs - Dp)

LF = LS of S

LS = LF - D

1 Method

ES: EF of Pred+1

EF: (ES + Duration)-1

LF: LS of successor-1

LS: (LF-duration)+1

DEVELOP SCHEDULE

Tools & Techniques: Critical Path Method

Abbreviations:

ES – Early Start

LS – Late Start

EF – Early Finish

LF – Late Finish

P – Predecessor

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LS = LF - D

1 Method

ES: EF of Pred+1

EF: (ES + Duration)-1

LF: LS of successor-1

LS: (LF-duration)+1

<table>
<tr><td>ES</td><td>Dur</td><td>EF</td></tr>
<tr><td colspan="3">Activity Name</td></tr>
<tr><td>LS</td><td>Float/ Slack</td><td>LF</td></tr>
</table>

DEVELOP SCHEDULE

Tools & Techniques: Critical Path Method

Abbreviations:
ES – Early Start
LS – Late Start
EF – Early Finish
LF – Late Finish
P – Predecessor
S – Successor
CP – Critical Path
D - Duration

Formulas:

0 Method

ESs= max (ESp+ Dp)
ES = EF of P
EF = ES + D
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1 Method

ES: EF of Pred+1
EF: (ES + Duration)-1
LF: LS of successor-1
LS: (LF-duration)+1

ES	Dur	EF
Activity Name		
LS	Float/ Slack	LF

The critical path is the sequence of activities with the longest duration.

Develop Schedule

Tools & Techniques: Critical Path Method

Concept	Formula	Interpretation
Free Float Determines how many days you can delay an activity without delaying the ES of the next activity.	Free Float = ES (S) – EF (P)	Number of days this activity can be delayed without delaying the ES of the next activity
Total Float Determines how many days you can delay an activity without delaying the project.	Total Float = LS – ES Total Float = LF – EF	Number of days this activity can be delayed without delaying the project.

Develop Schedule

Tools & Techniques: Critical Path Method

ES: EF of Pred+1

EF: (ES + Duration)-1

LF: LS of successor-1

LS: (LF-duration)+1

DEVELOP SCHEDULE

Tools & Techniques: Critical Path Method

ES: EF of Pred+1

EF: (ES + Duration)-1

LF: LS of successor-1

LS: (LF-duration)+1

ES	Dur	EF
Activity Name		
LS	**Float/ Slack**	**LF**

DEVELOP SCHEDULE

Tools & Techniques: Critical Path Method

ES: EF of Pred+1
EF: (ES + Duration)-1
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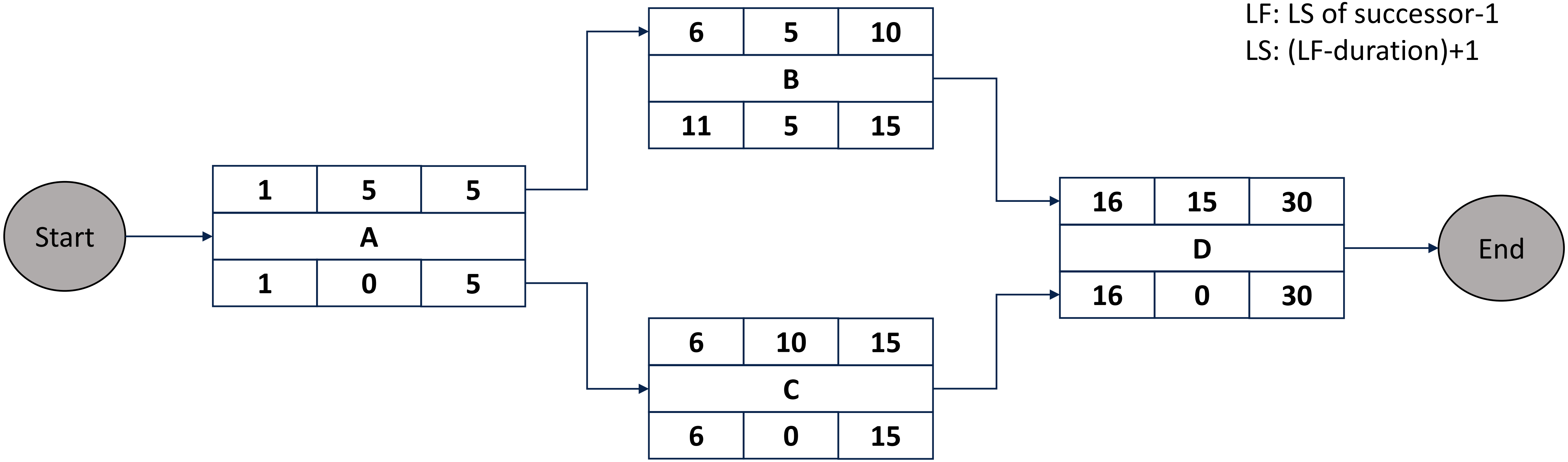
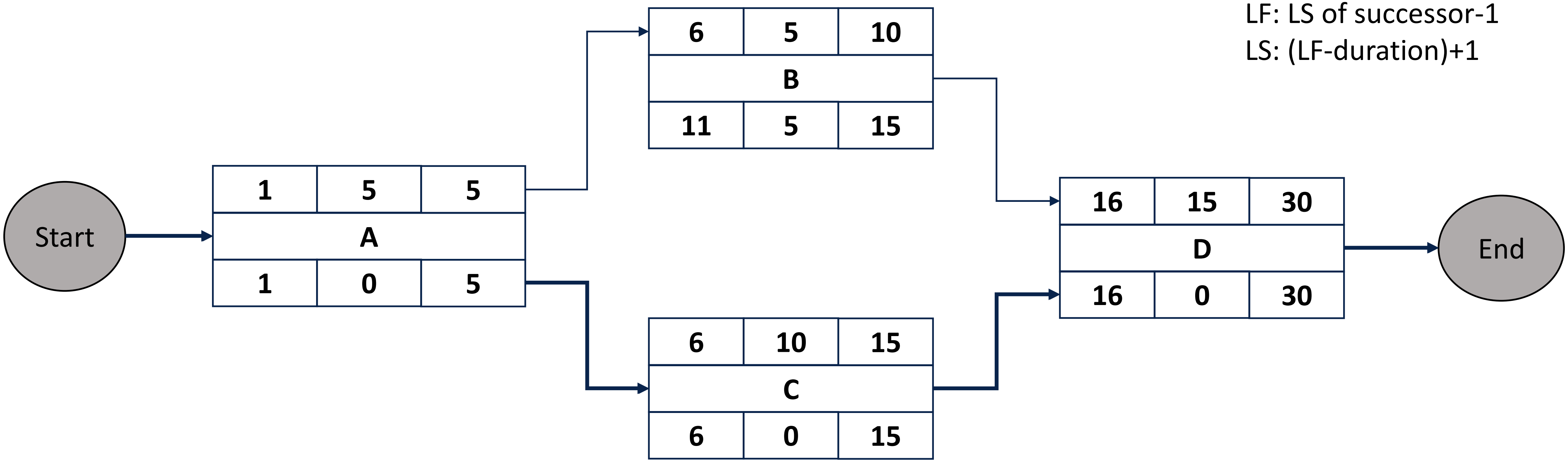


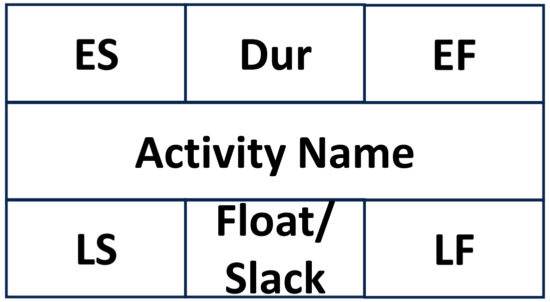
ES	Dur	EF
Activity Name		
LS	Float/ Slack	LF

DEVELOP SCHEDULE

Tools & Techniques: Critical Path Method

ES: EF of Pred+1
EF: (ES + Duration)-1
LF: LS of successor-1
LS: (LF-duration)+1





DEVELOP SCHEDULE

Tools & Techniques: Critical Path Method

Activity	Immediate Predecessor	Duration (Mon)
A	-	3
B	-	4
C	-	6
D	B	3
E	A	9
F	A	1
G	B	4
H	C, D	5
I	C, D	4
J	E	3
K	F, G, H	6
L	F, G, H	3
M	I	6
N	J, K	9

DEVELOP SCHEDULE

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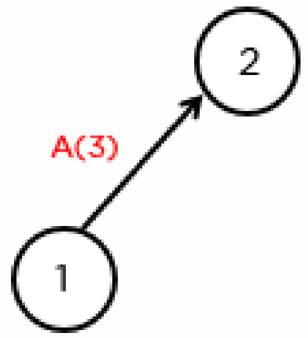

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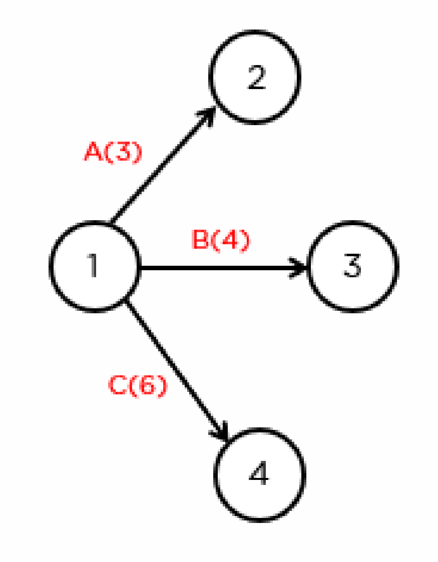

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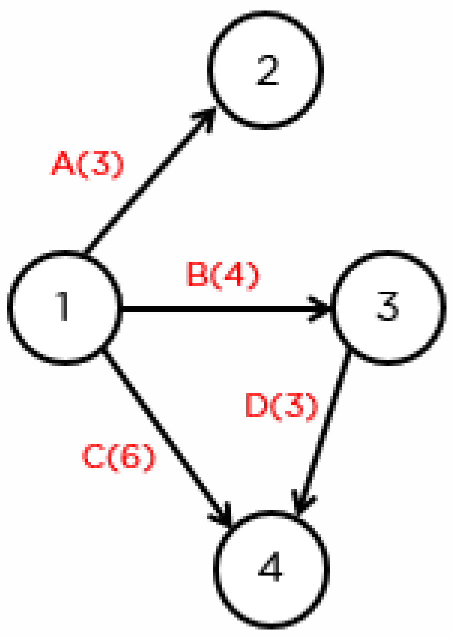

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Tools & Techniques: Critical Path Method

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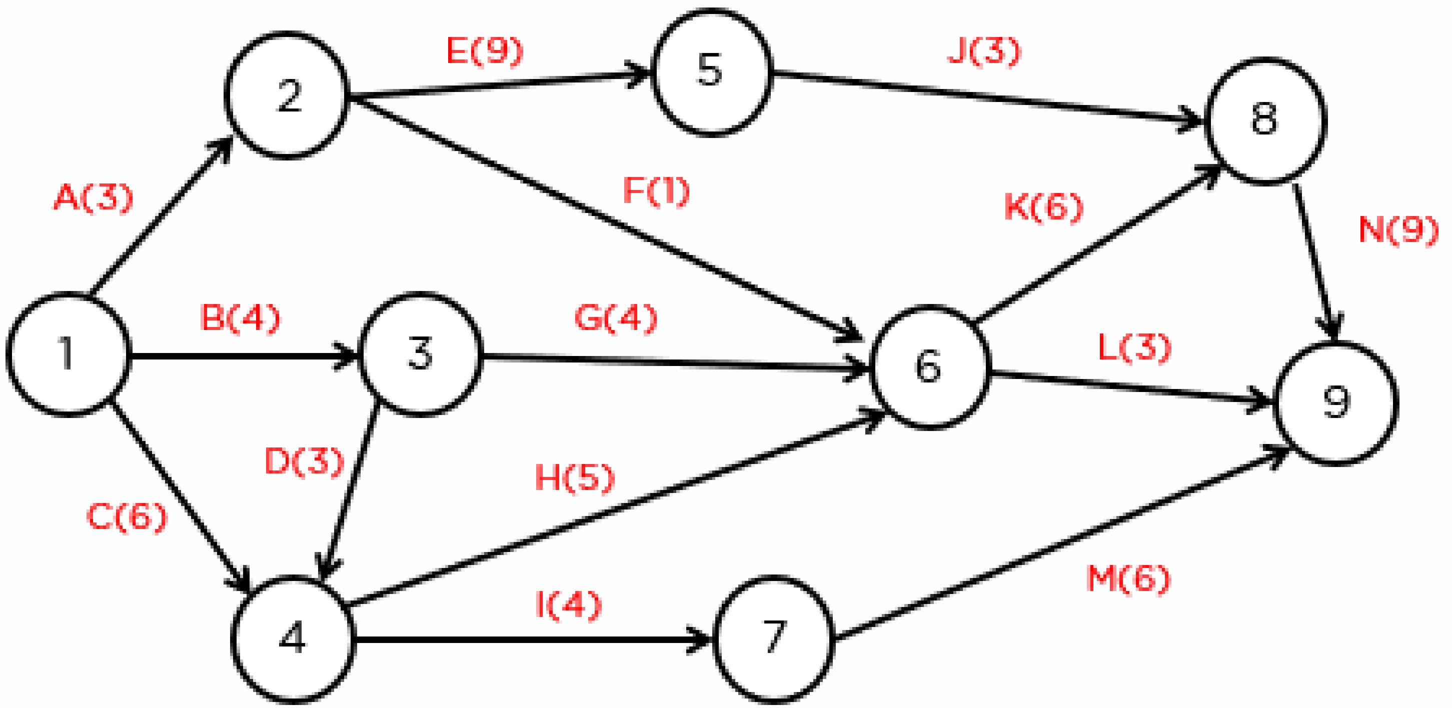
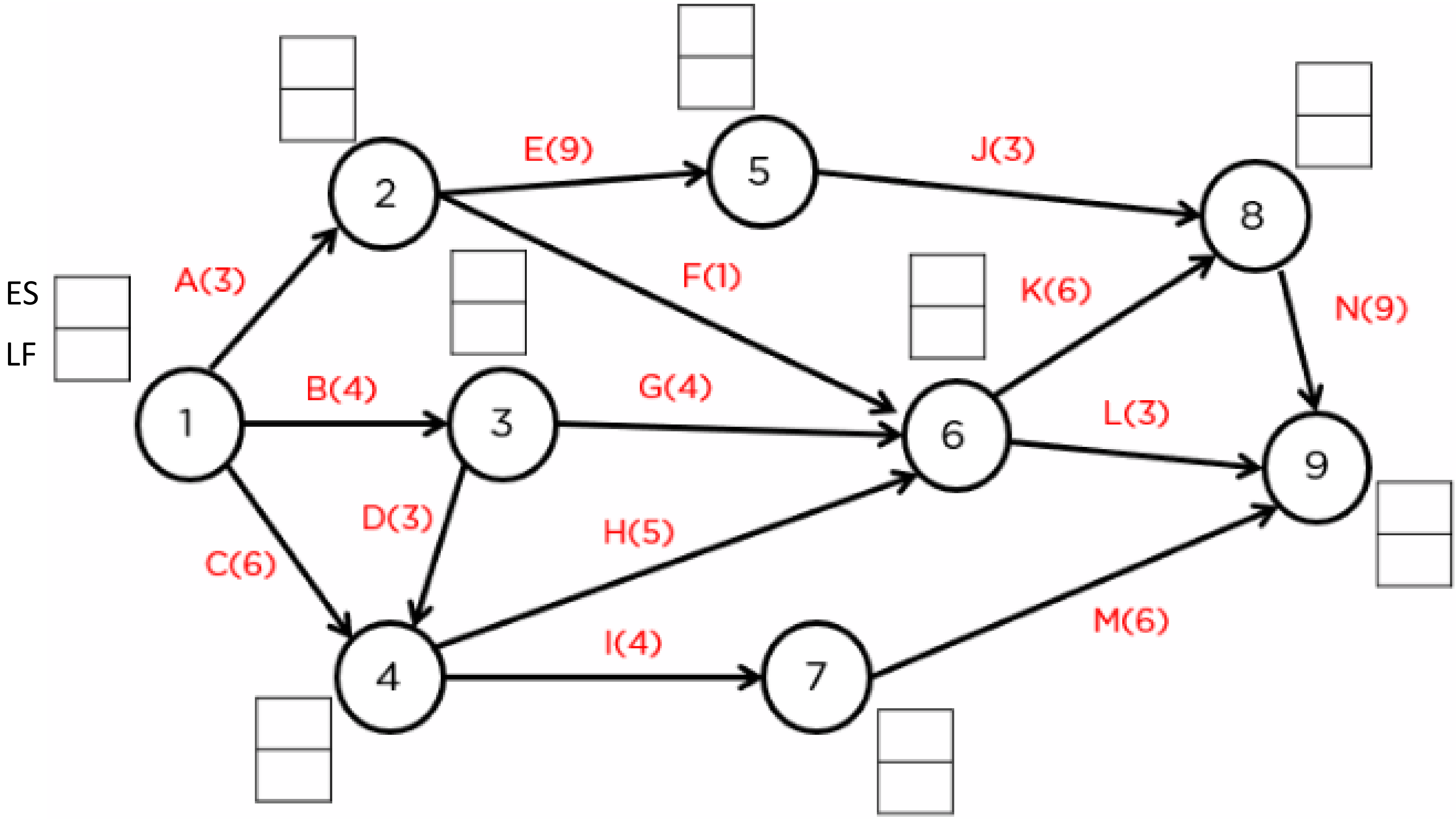


DEVELOP SCHEDULE

Tools & Techniques: Critical Path Method

ESs= max (ESp+ Dp)   LFp = min(LFs - Dp)



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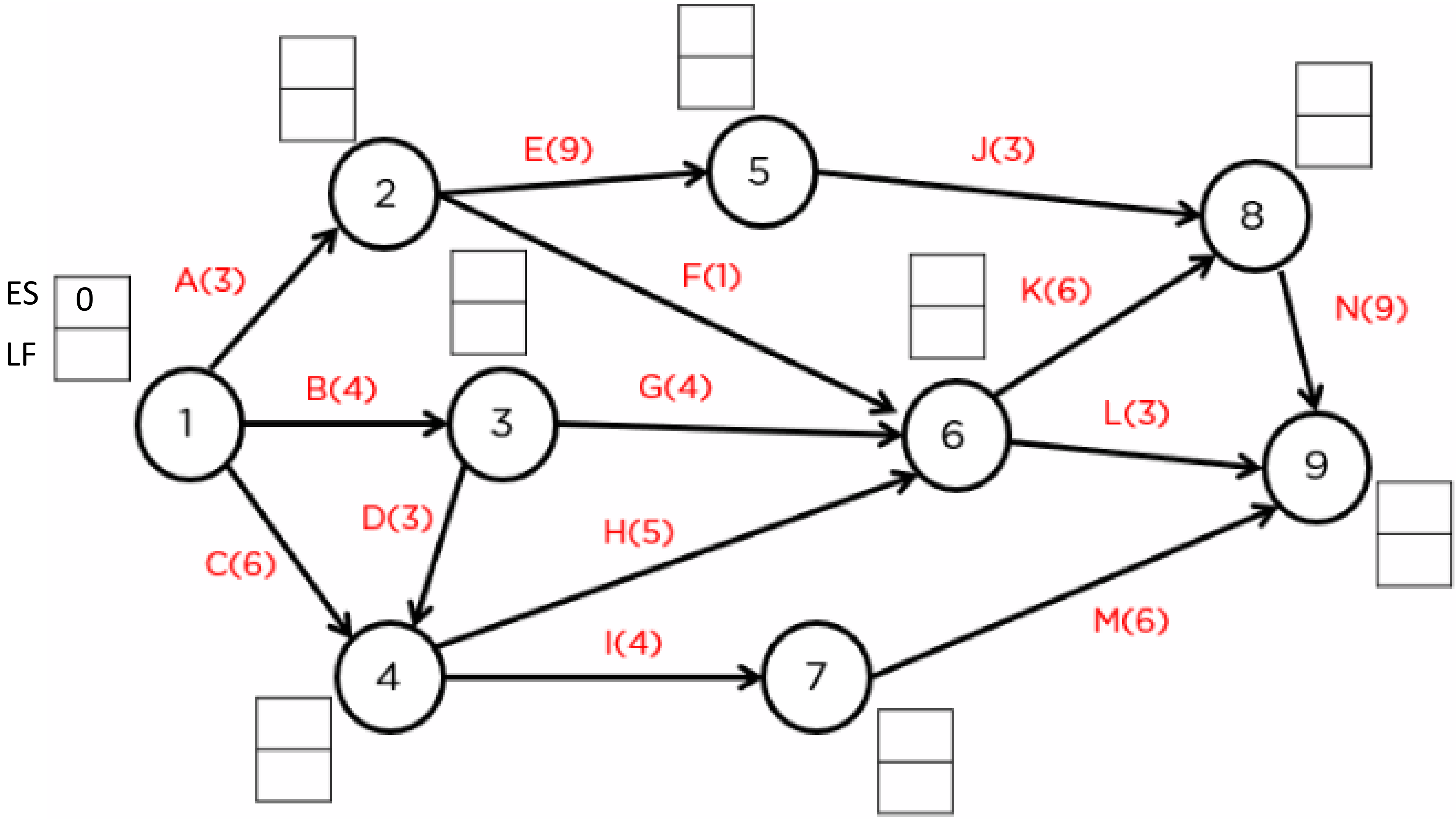

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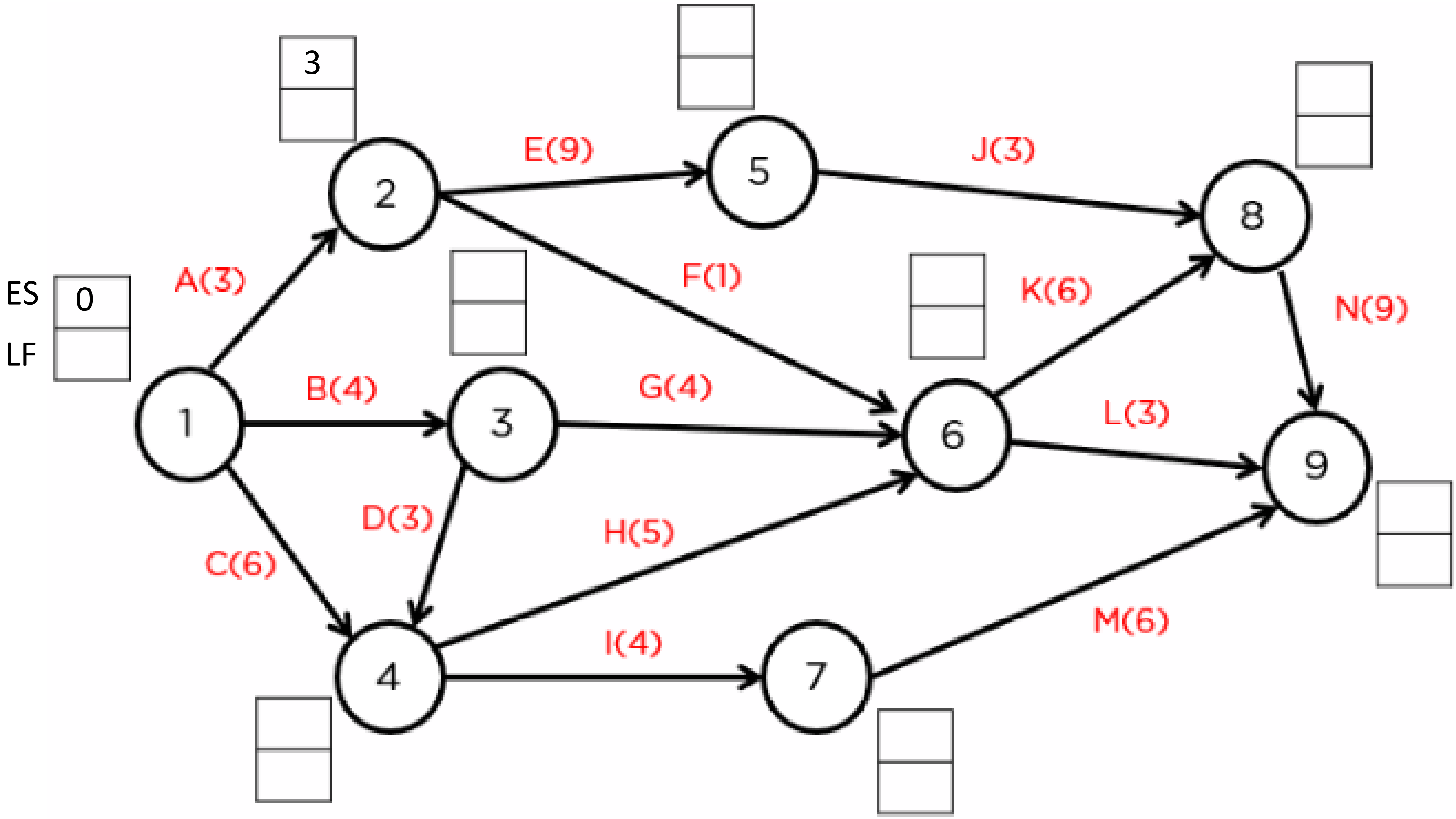

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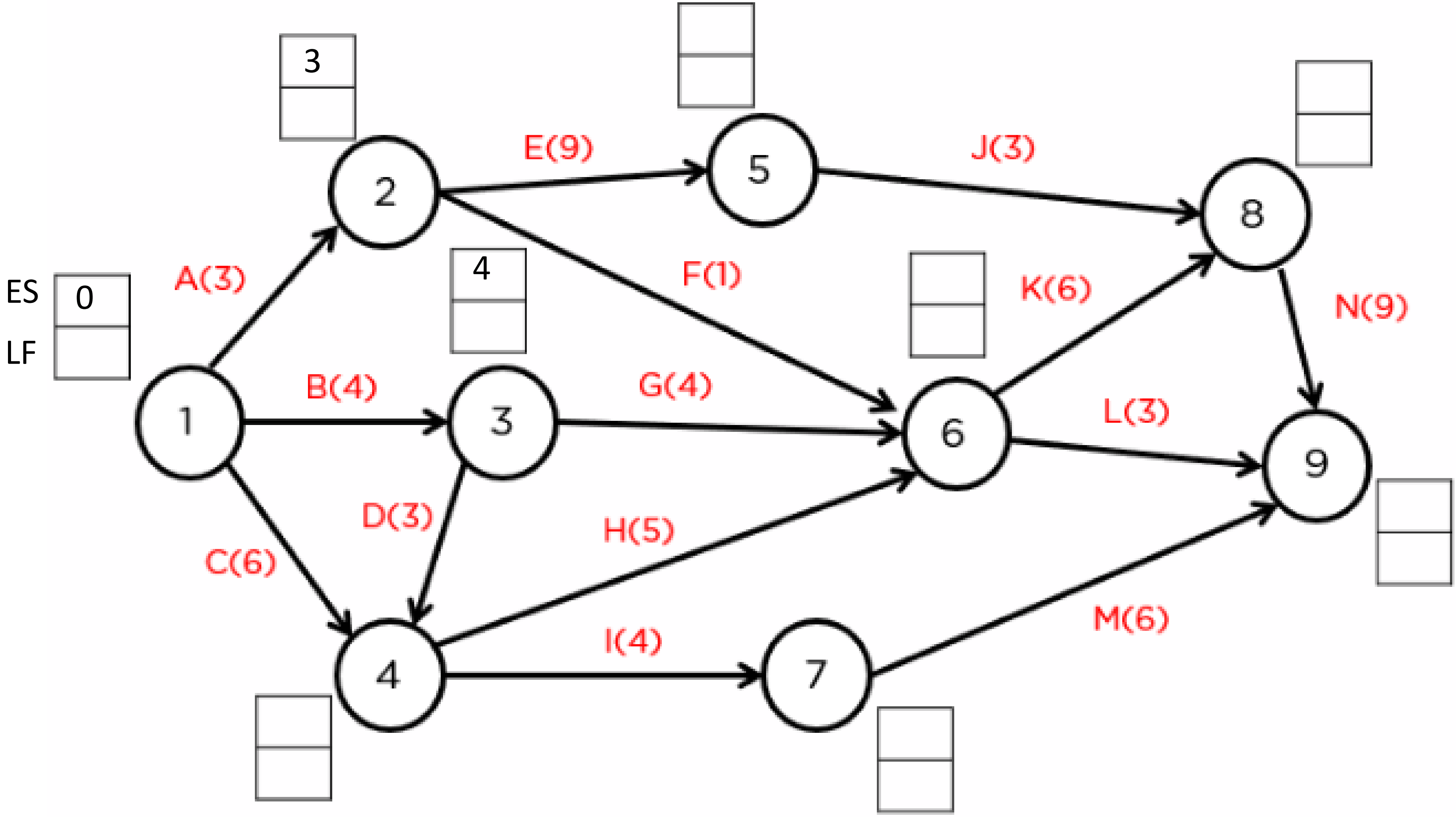

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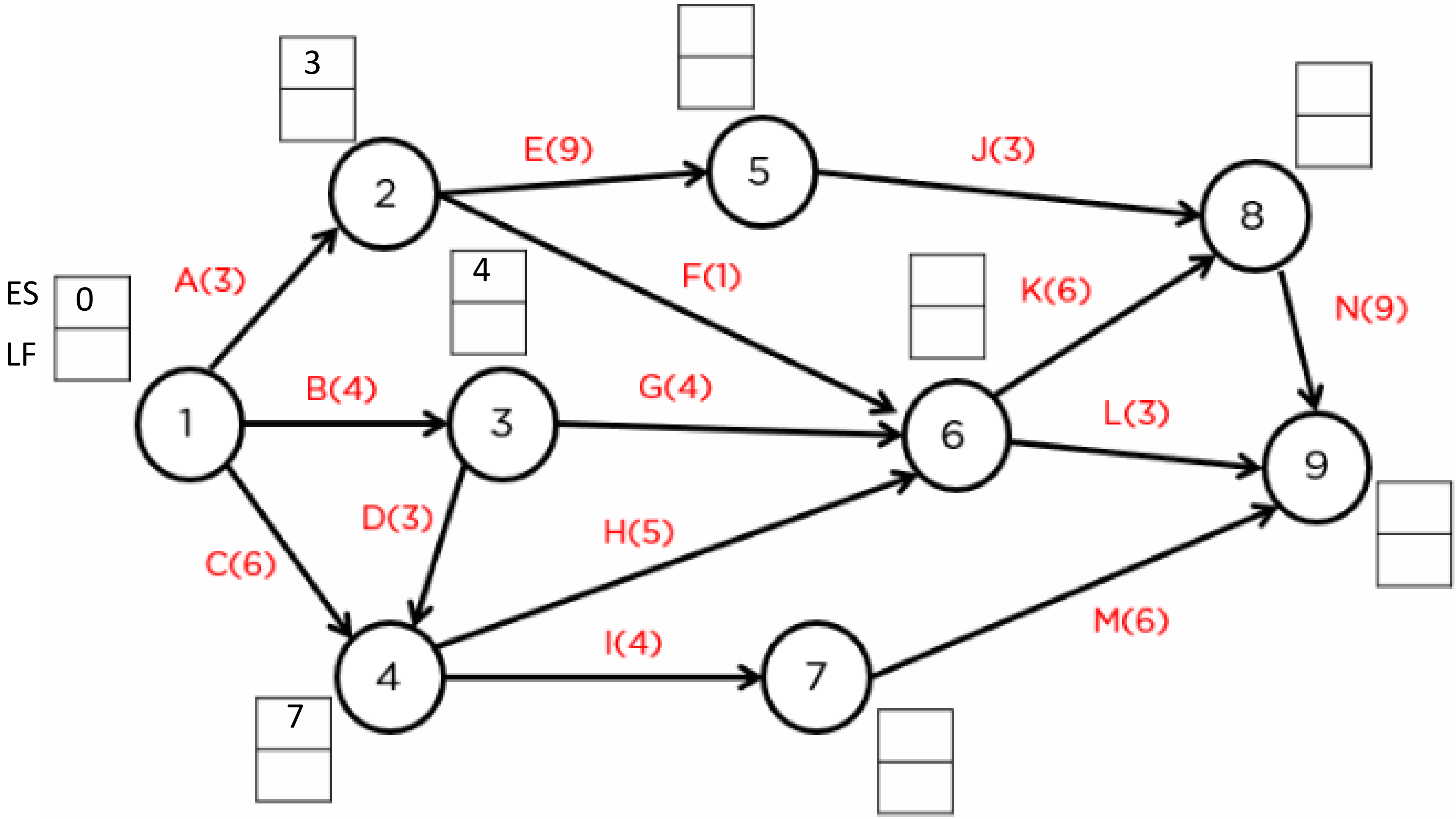

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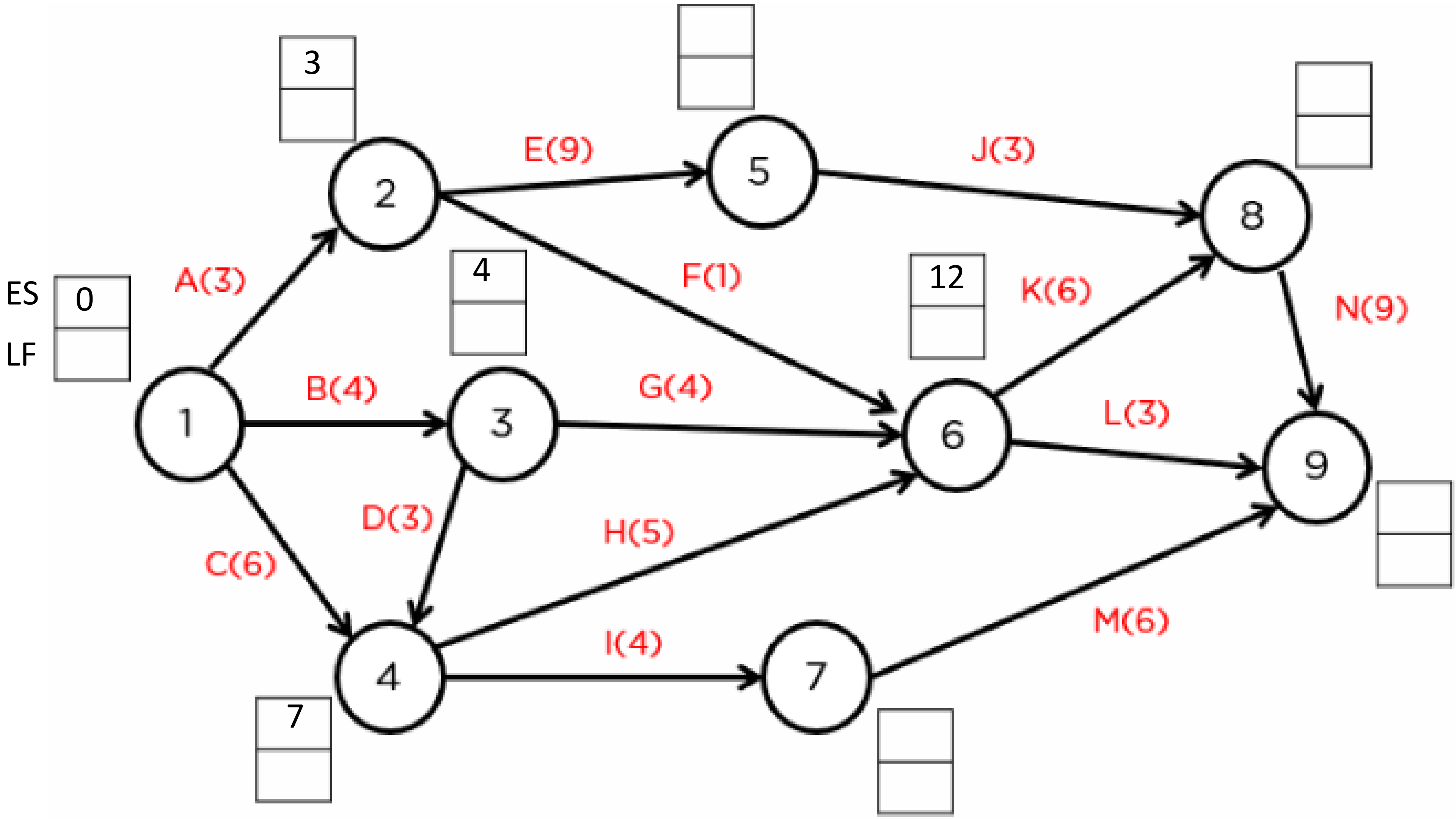

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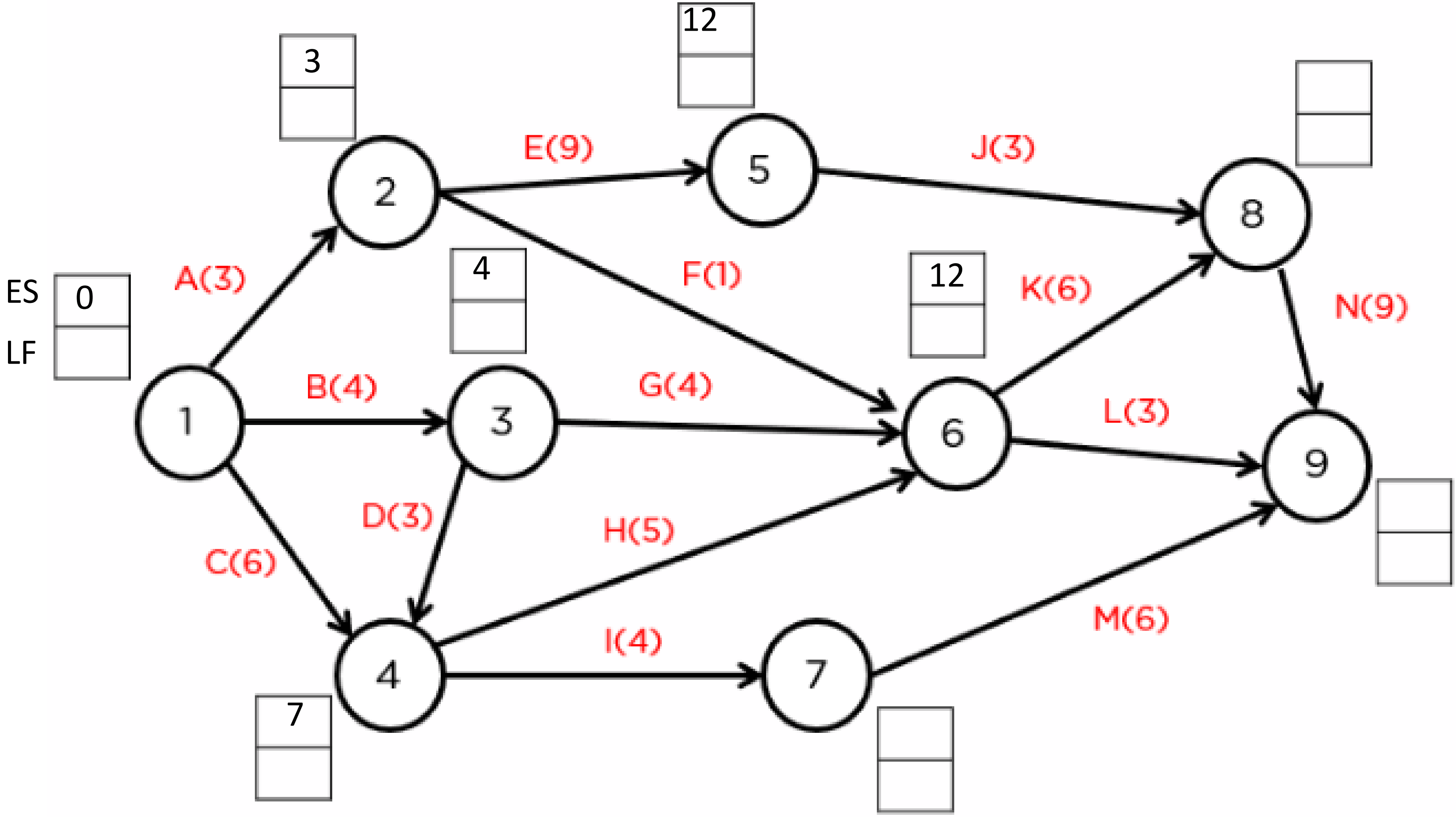

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Tools & Techniques: Critical Path Method

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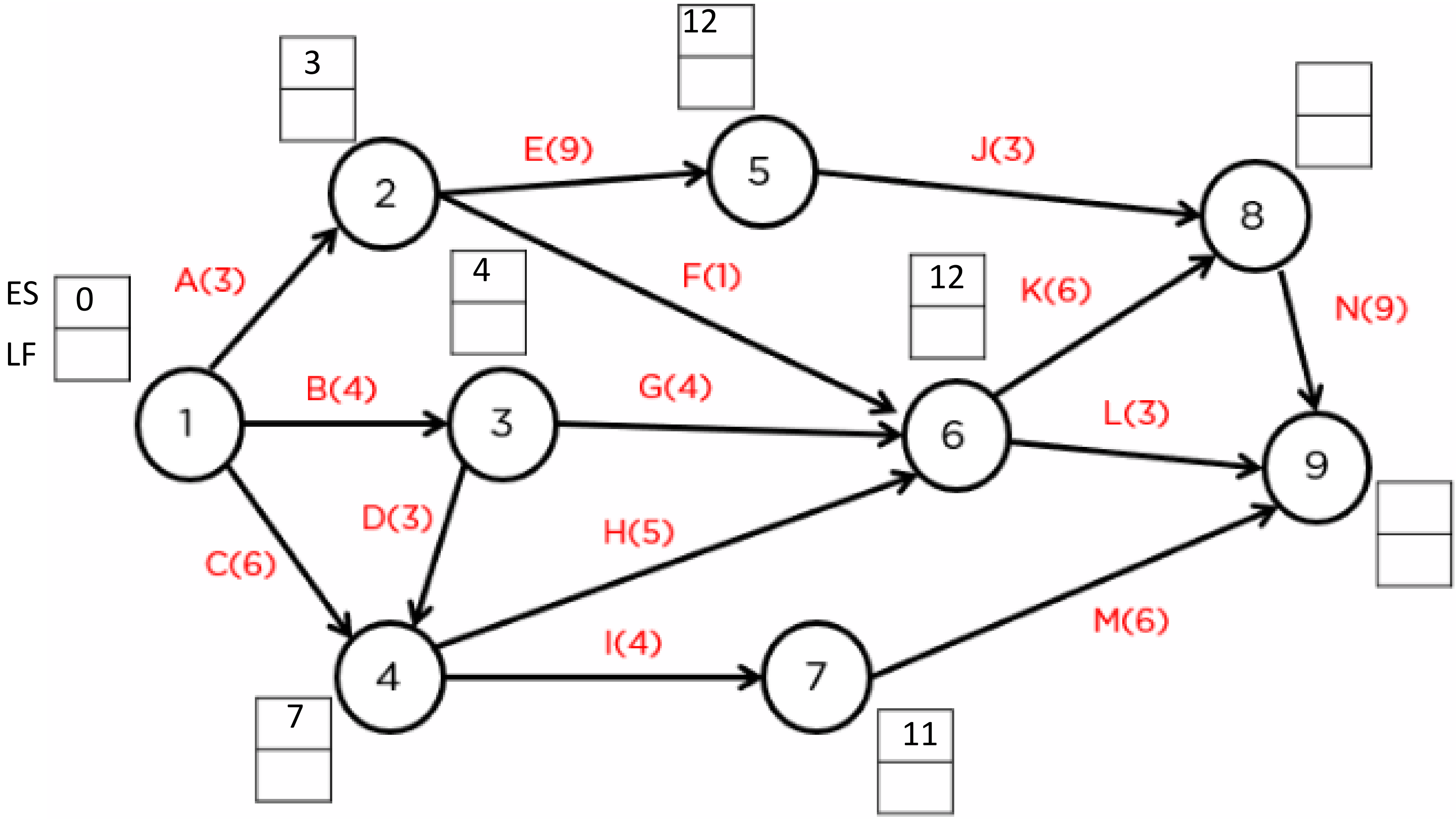
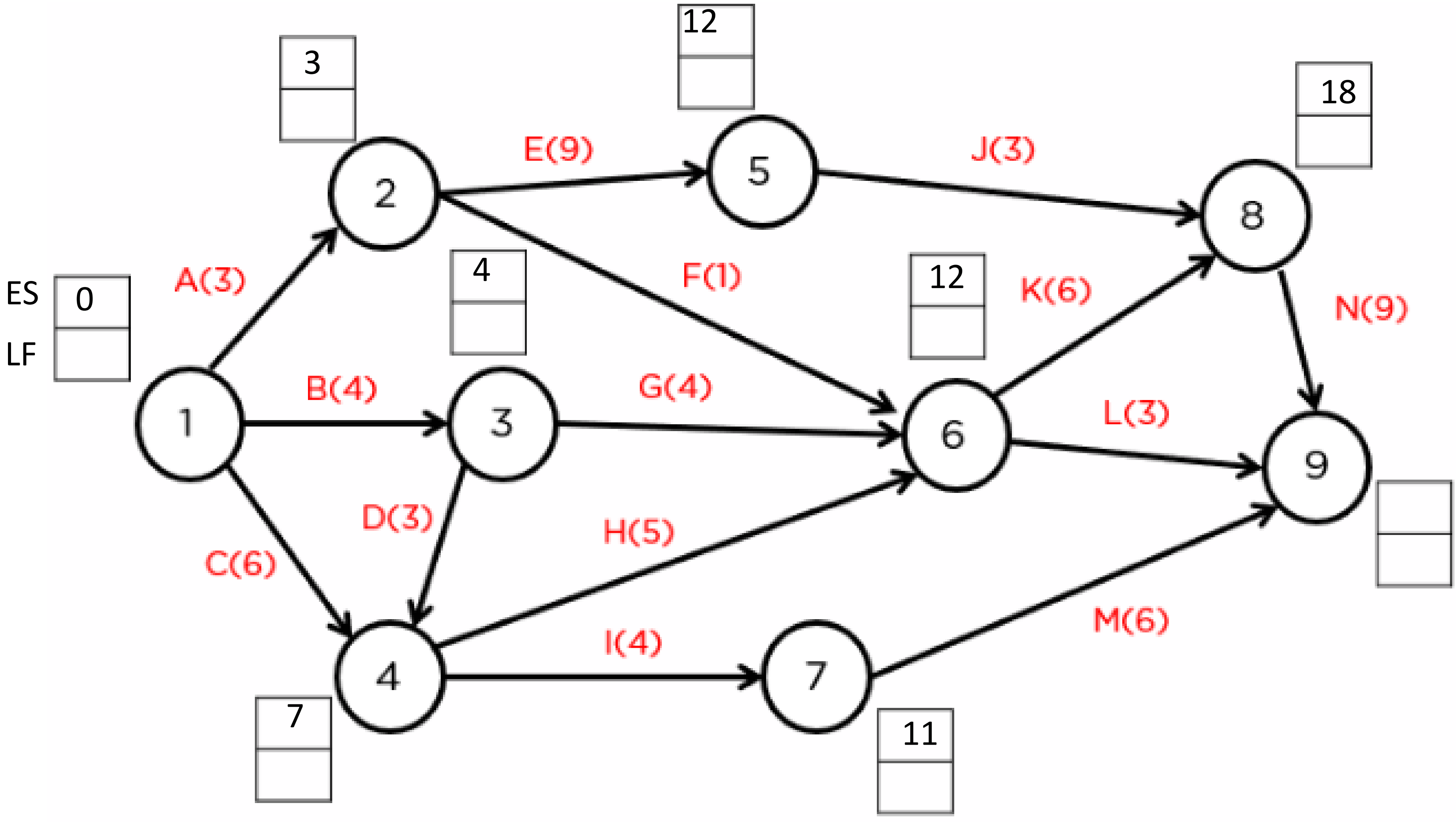


DEVELOP SCHEDULE

Tools & Techniques: Critical Path Method

$ES_s = \max(ES_p + D_p)$ $LF_p = \min(LF_s - D_p)$



Develop Schedule

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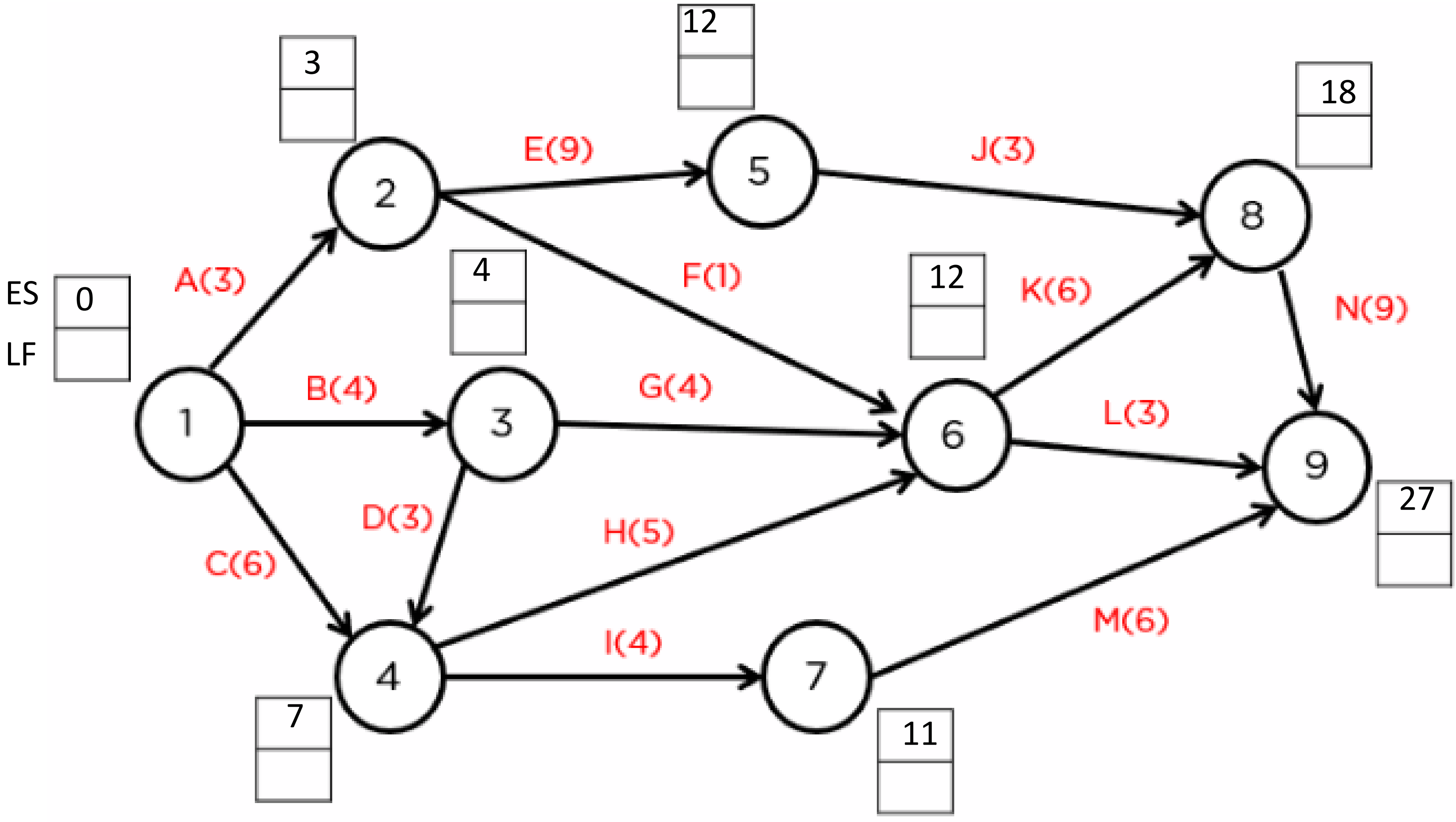

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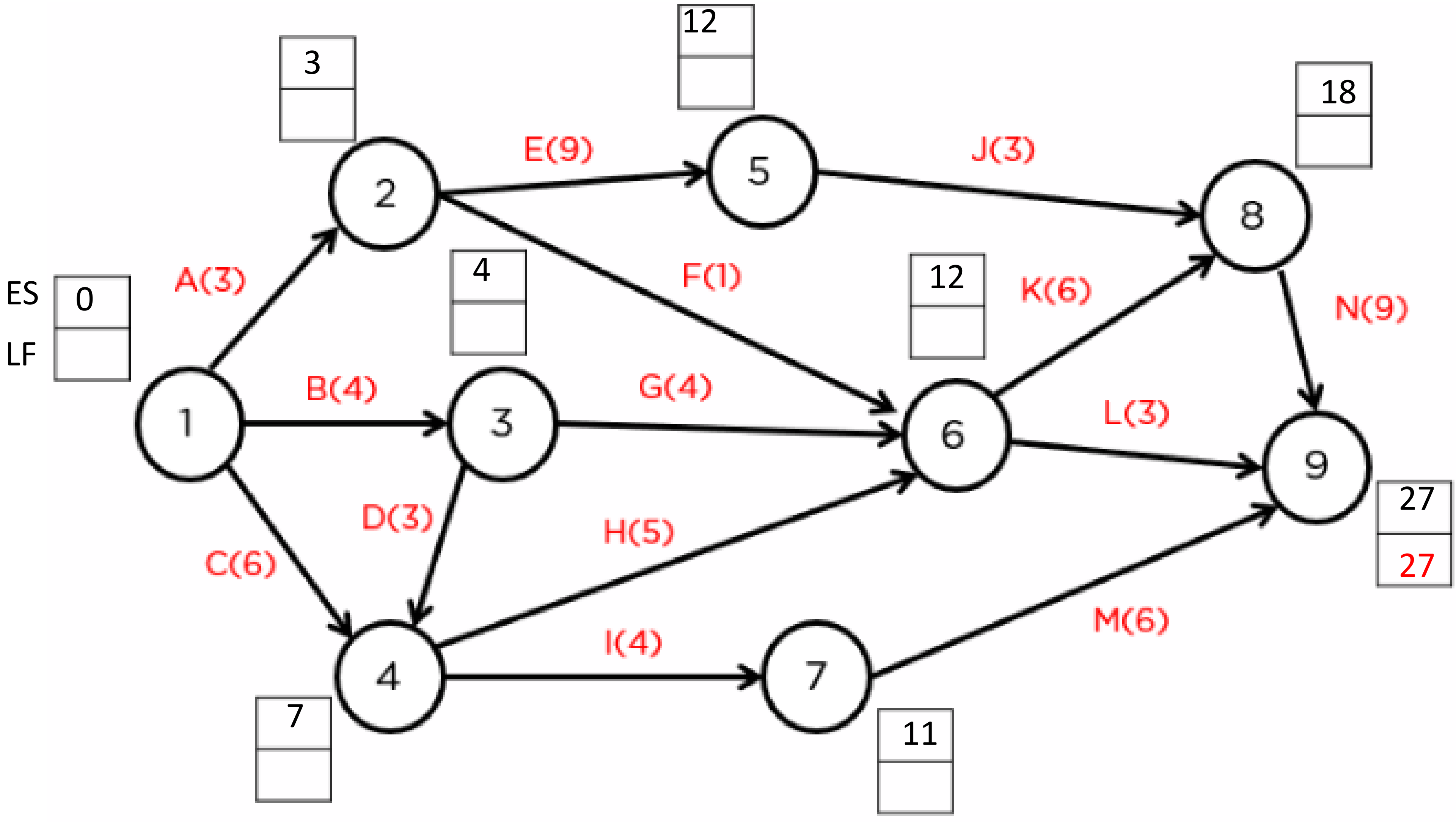

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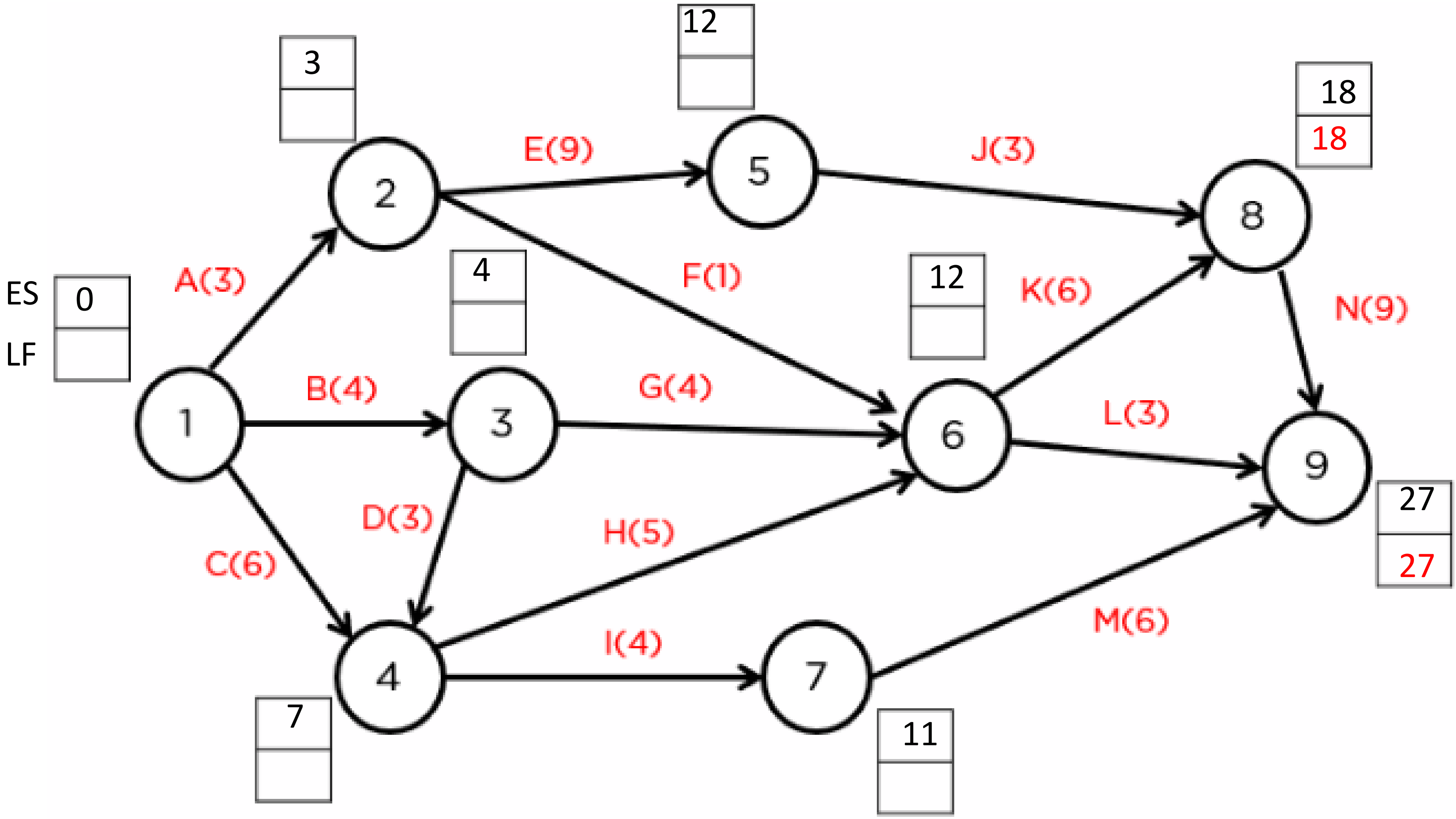

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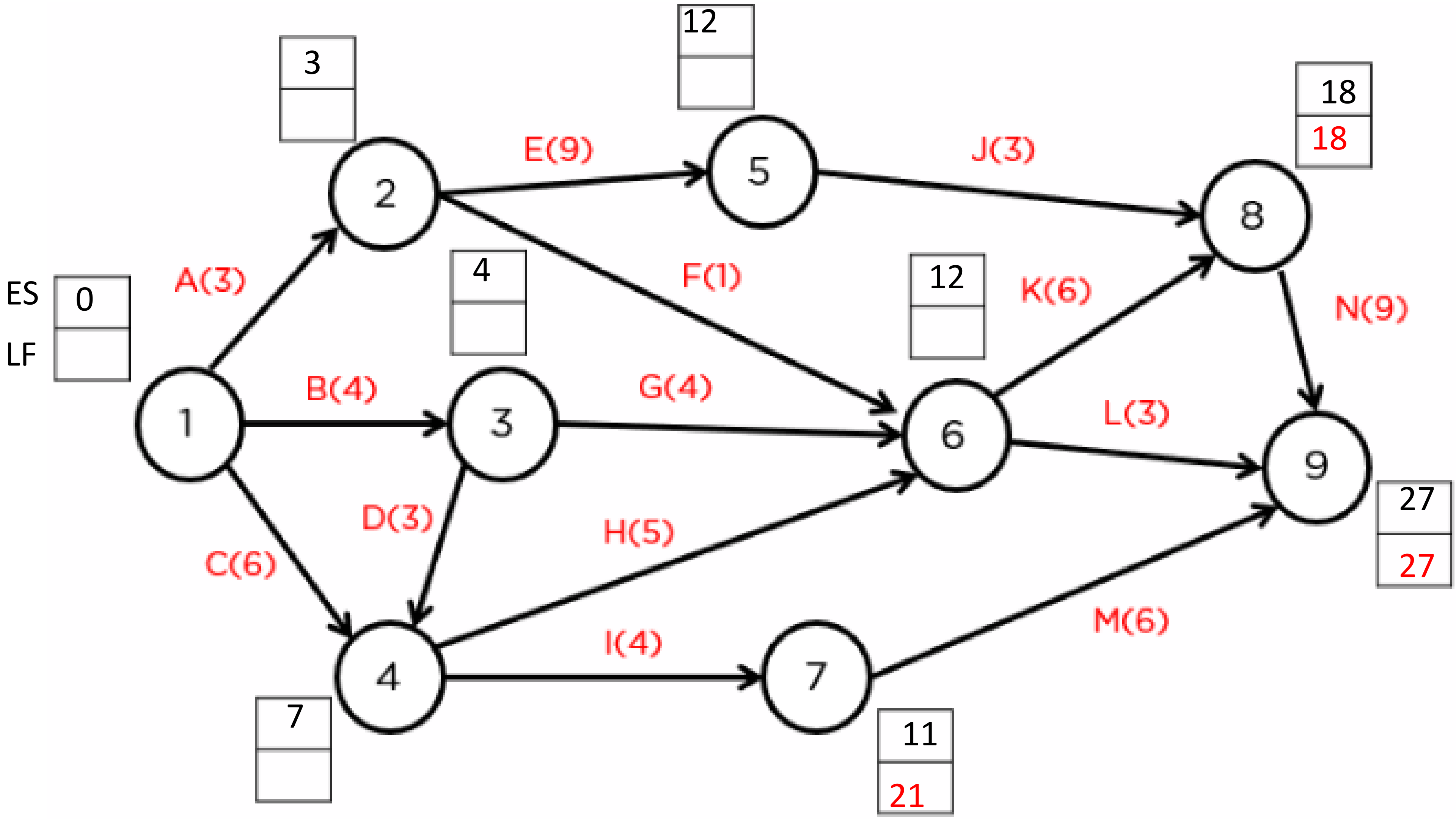
Tools & Techniques: Critical Path Method

ESs= max (ESp+ Dp) LFp = min(LFs - Dp)



DEVELOP SCHEDULE

Tools & Techniques: Critical Path Method

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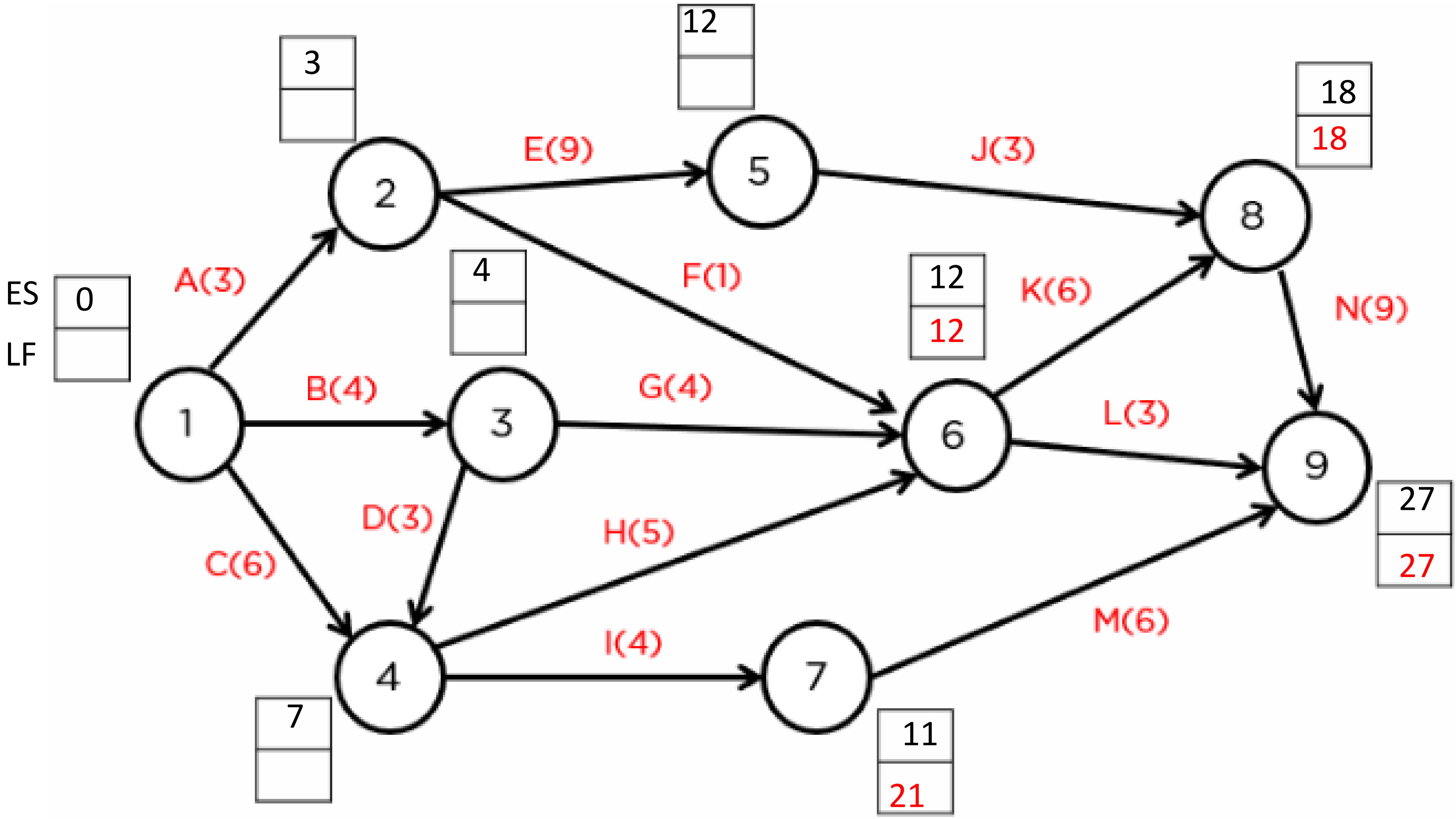
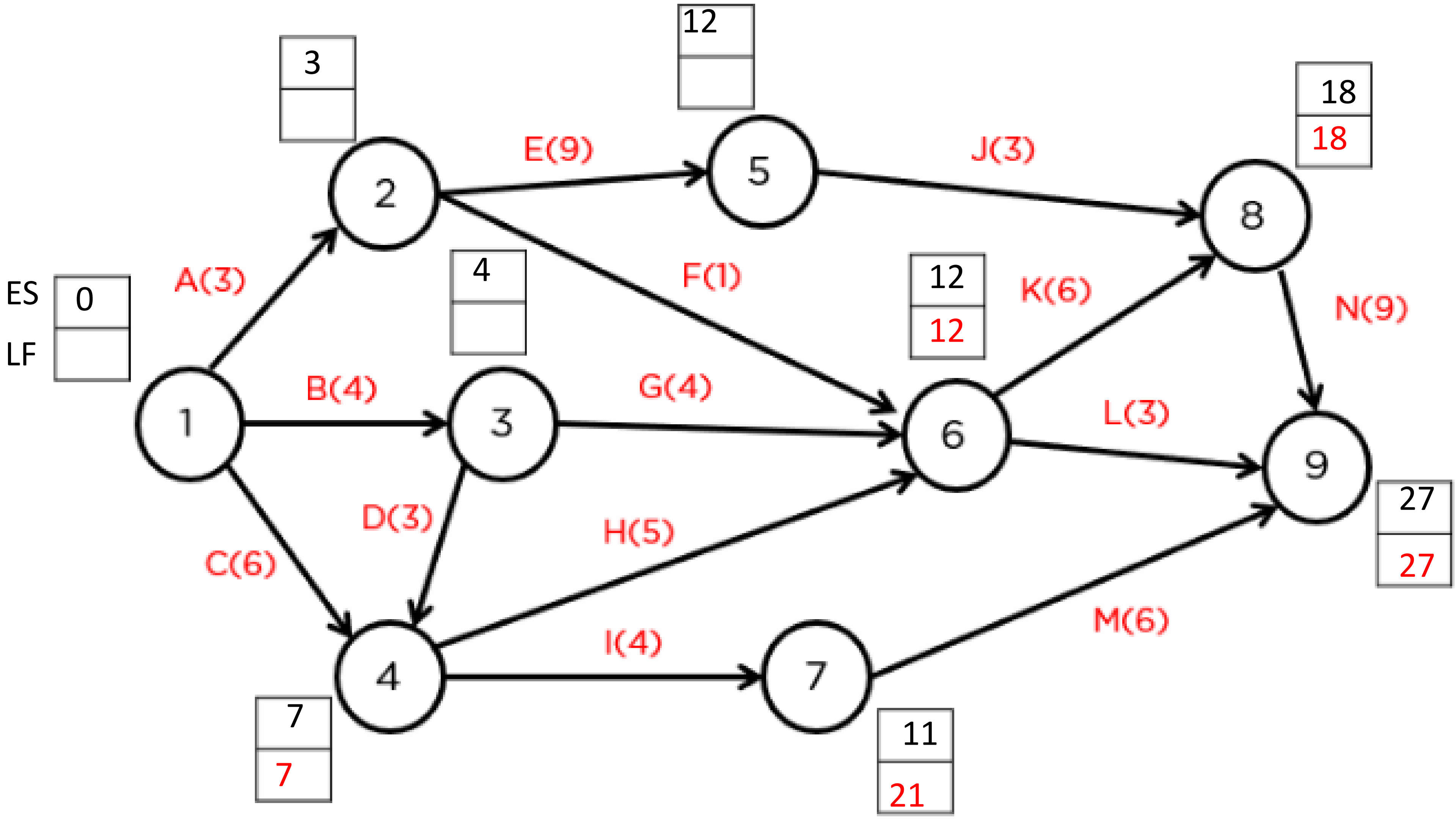


DEVELOP SCHEDULE

Tools & Techniques: Critical Path Method

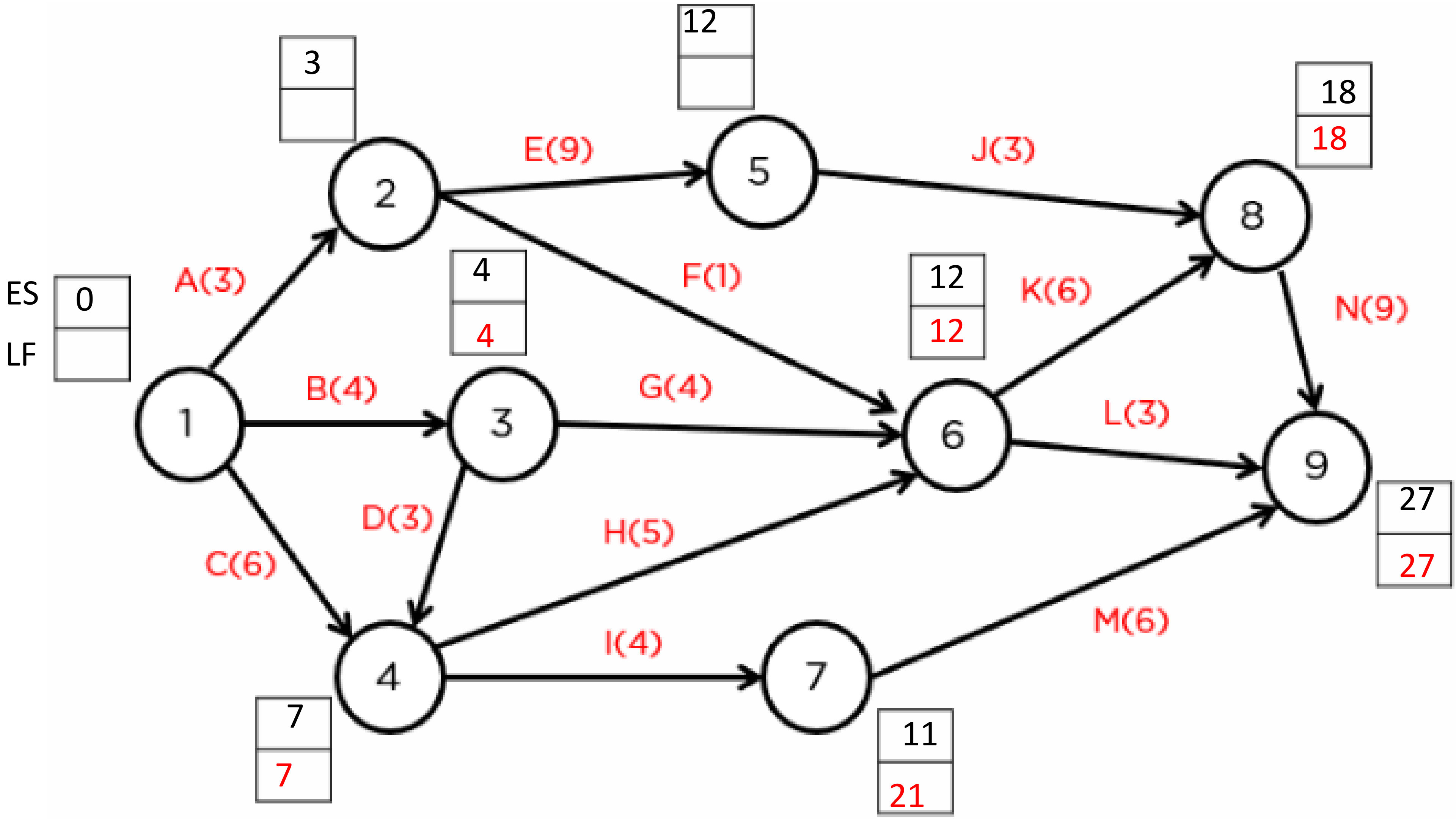
ESs= max (ESp+ Dp)   LFp = min(LFs - Dp)



Develop Schedule

Tools & Techniques: Critical Path Method

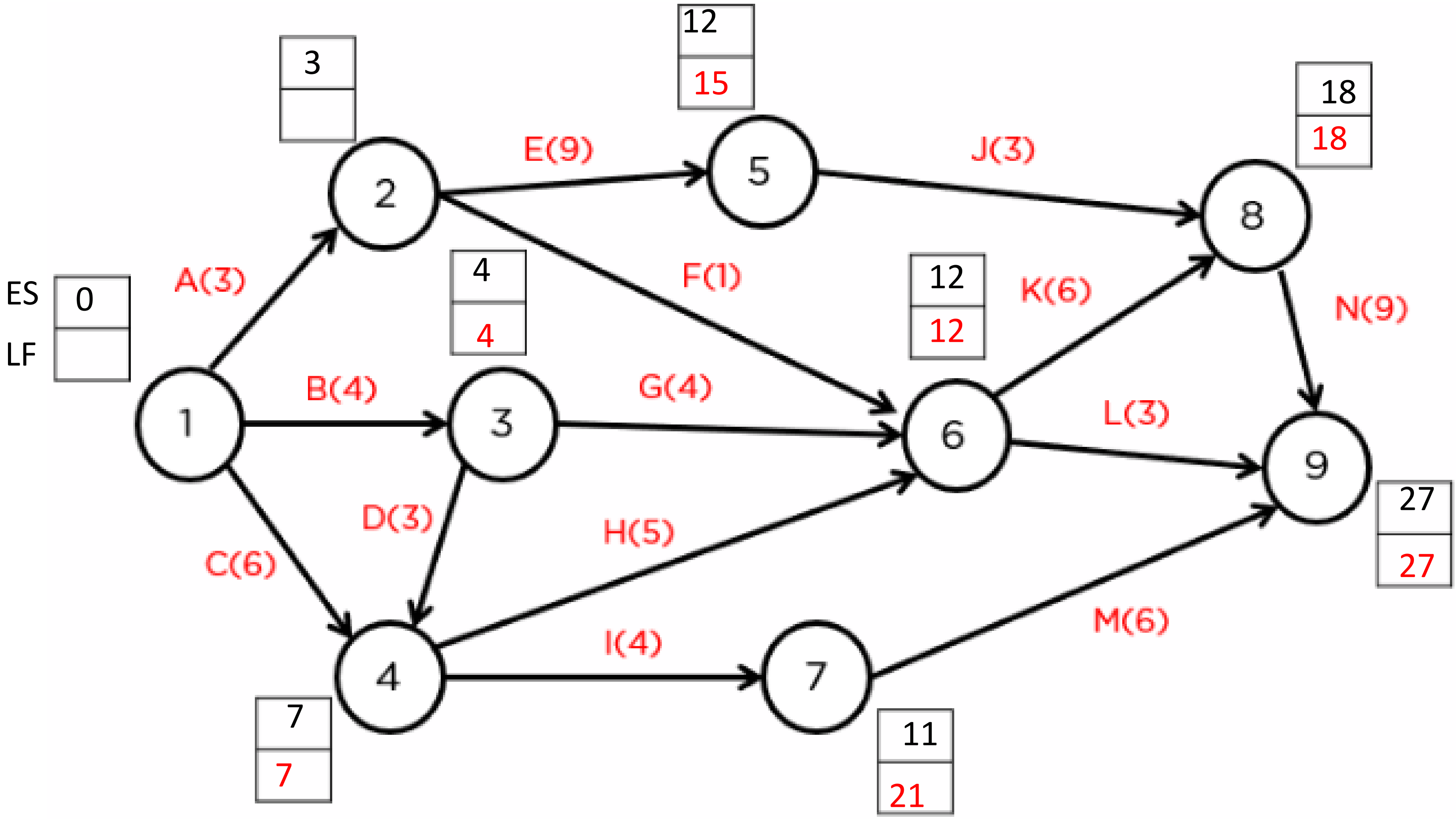
ESs= max (ESp+ Dp)   LFp = min(LFs - Dp)



DEVELOP SCHEDULE

Tools & Techniques: Critical Path Method

$ES_s = \max(ES_p + D_p)$ $LF_p = \min(LF_s - D_p)$



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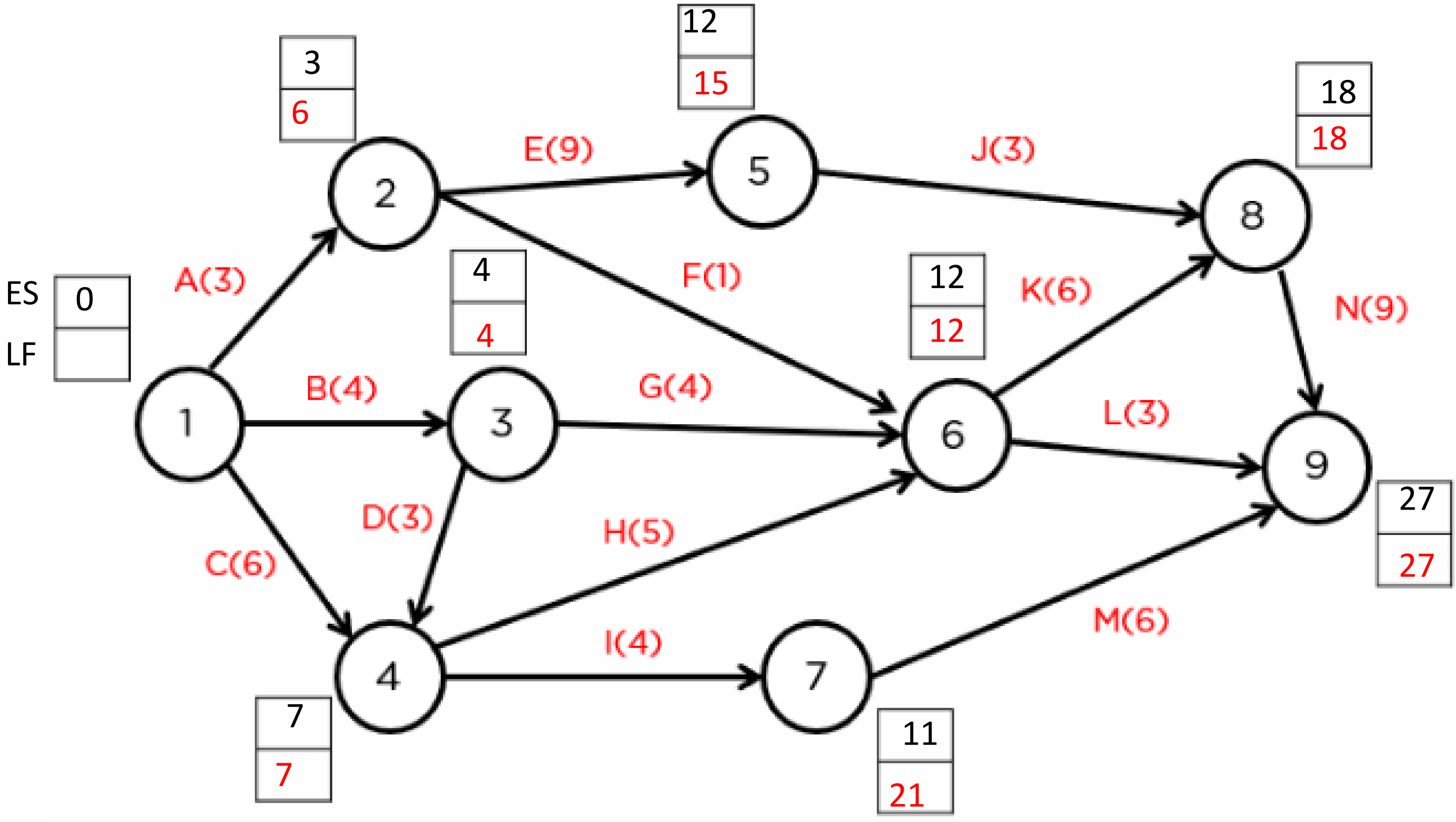
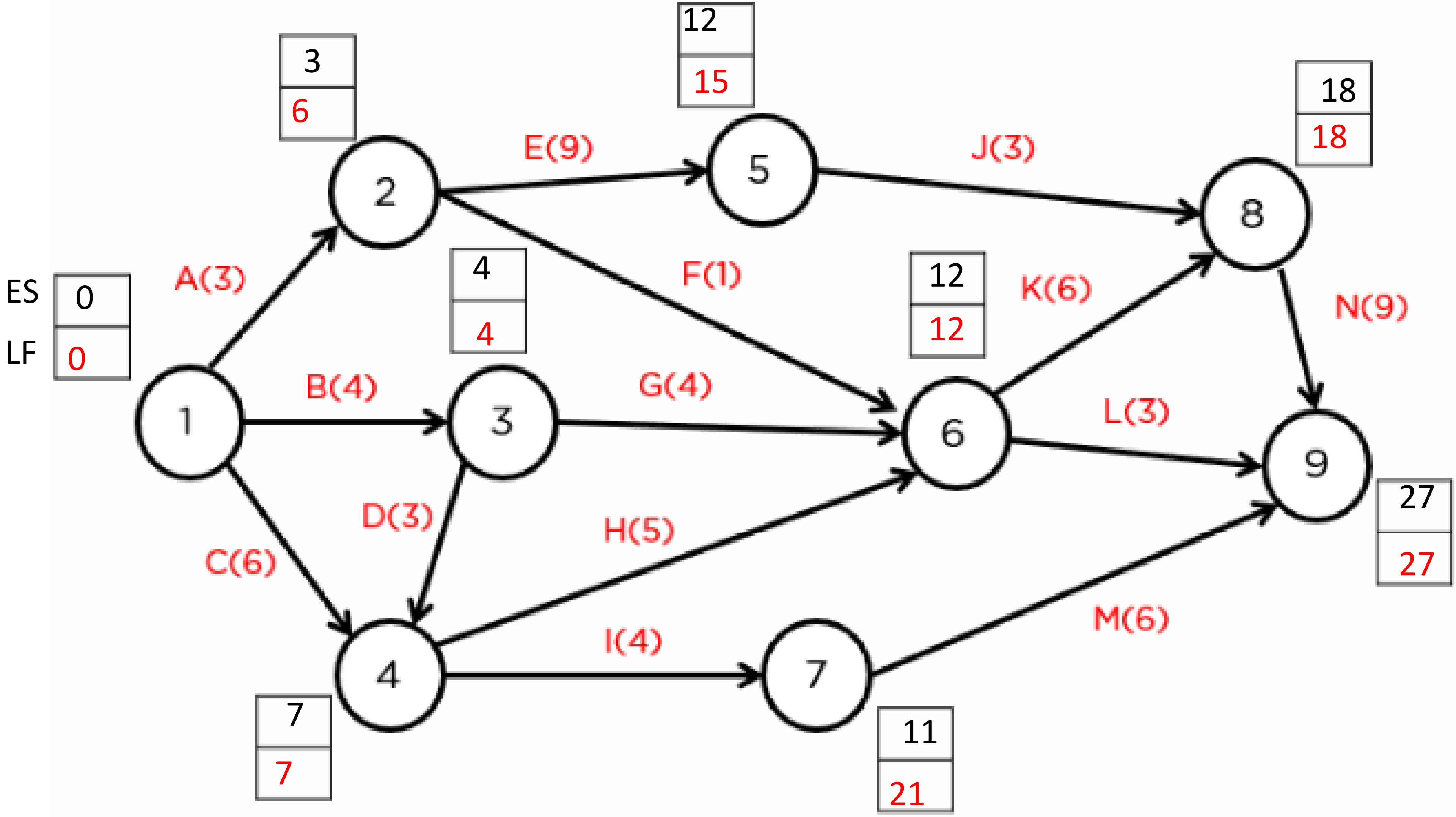


Develop Schedule

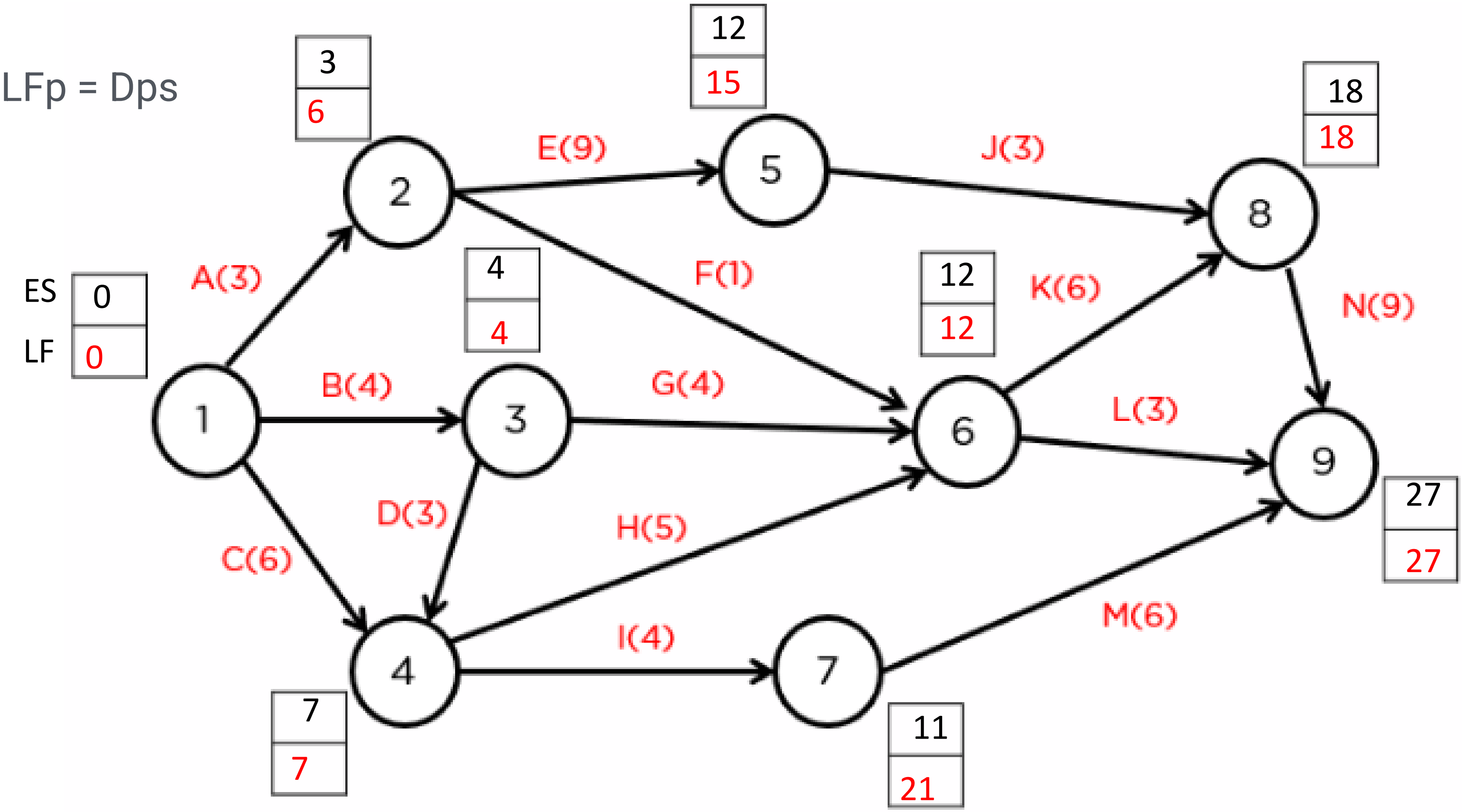
Tools & Techniques: Critical Path Method

ESs= max (ESp+ Dp)   LFp = min(LFs - Dp)



DEVELOP SCHEDULE

ESp = LFs
ESs = LFs
ESs - ESp = LFs - LFp = Dps



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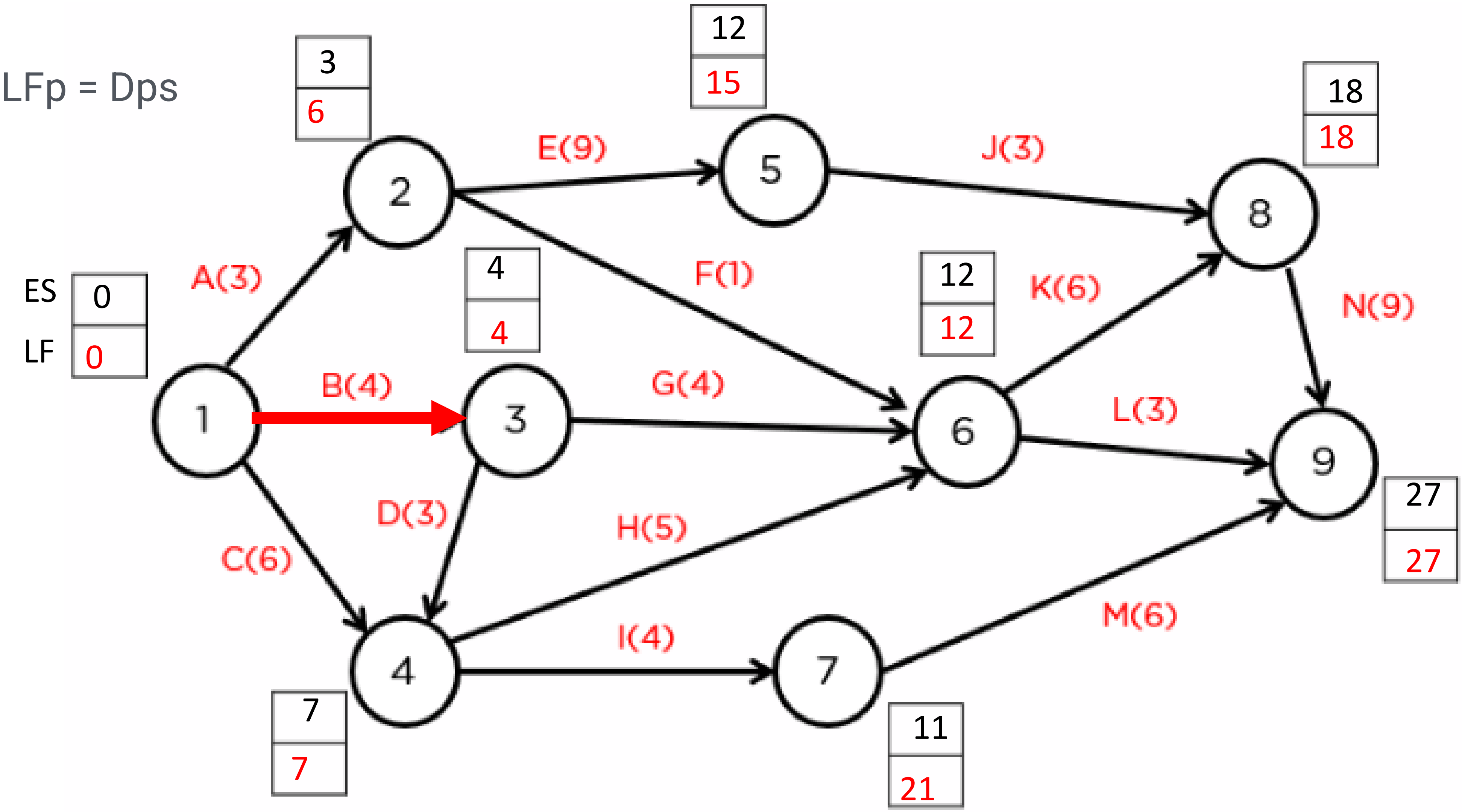

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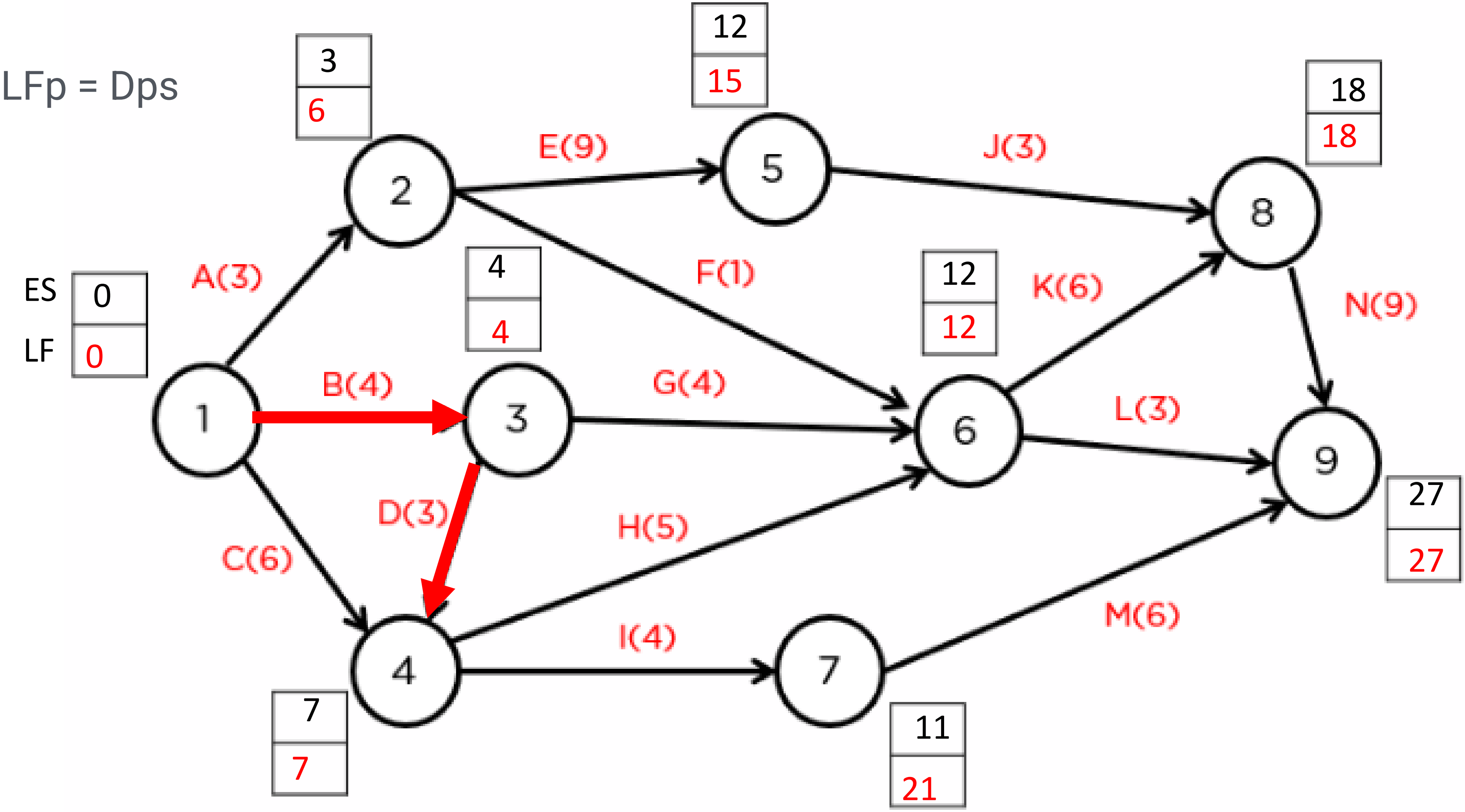

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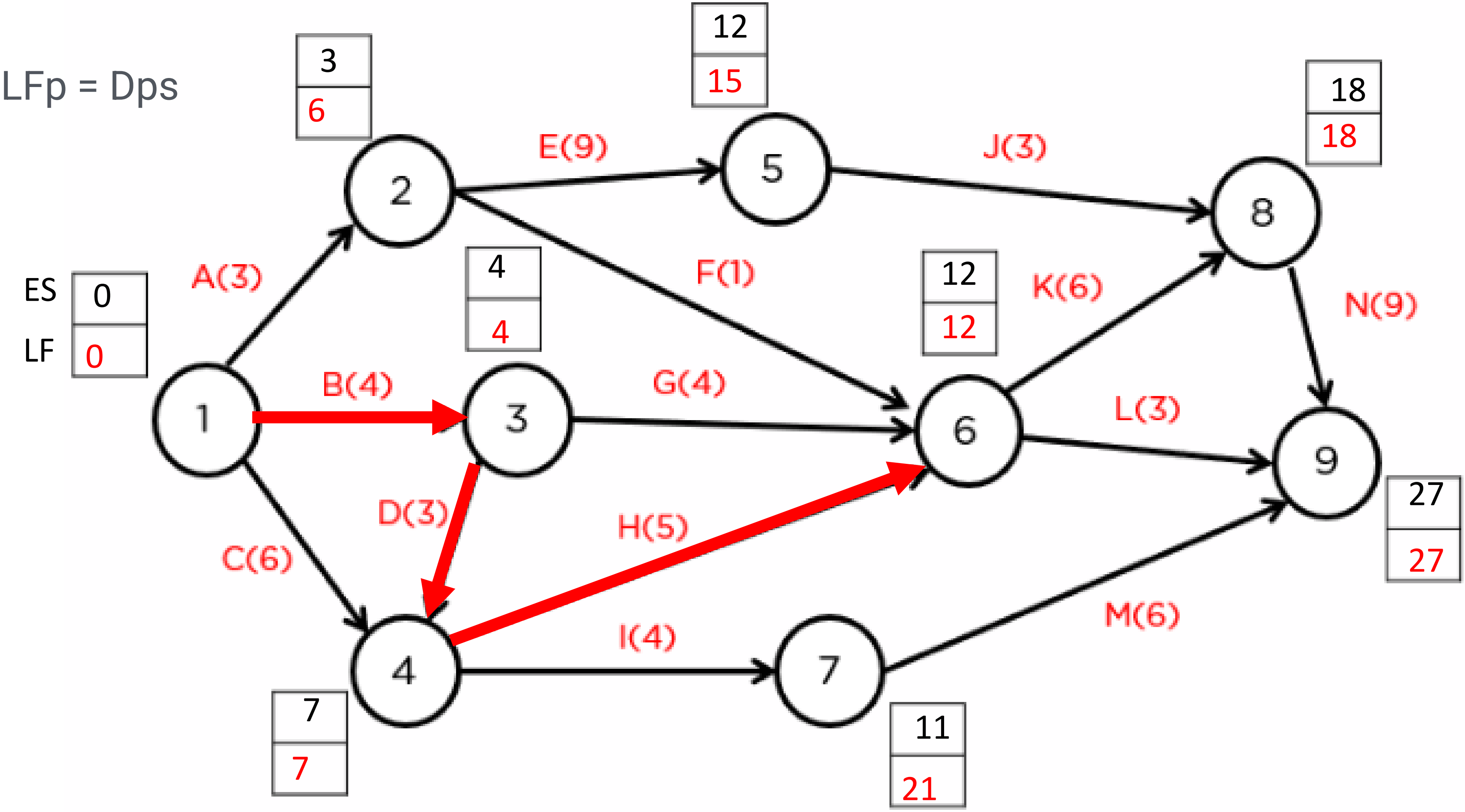

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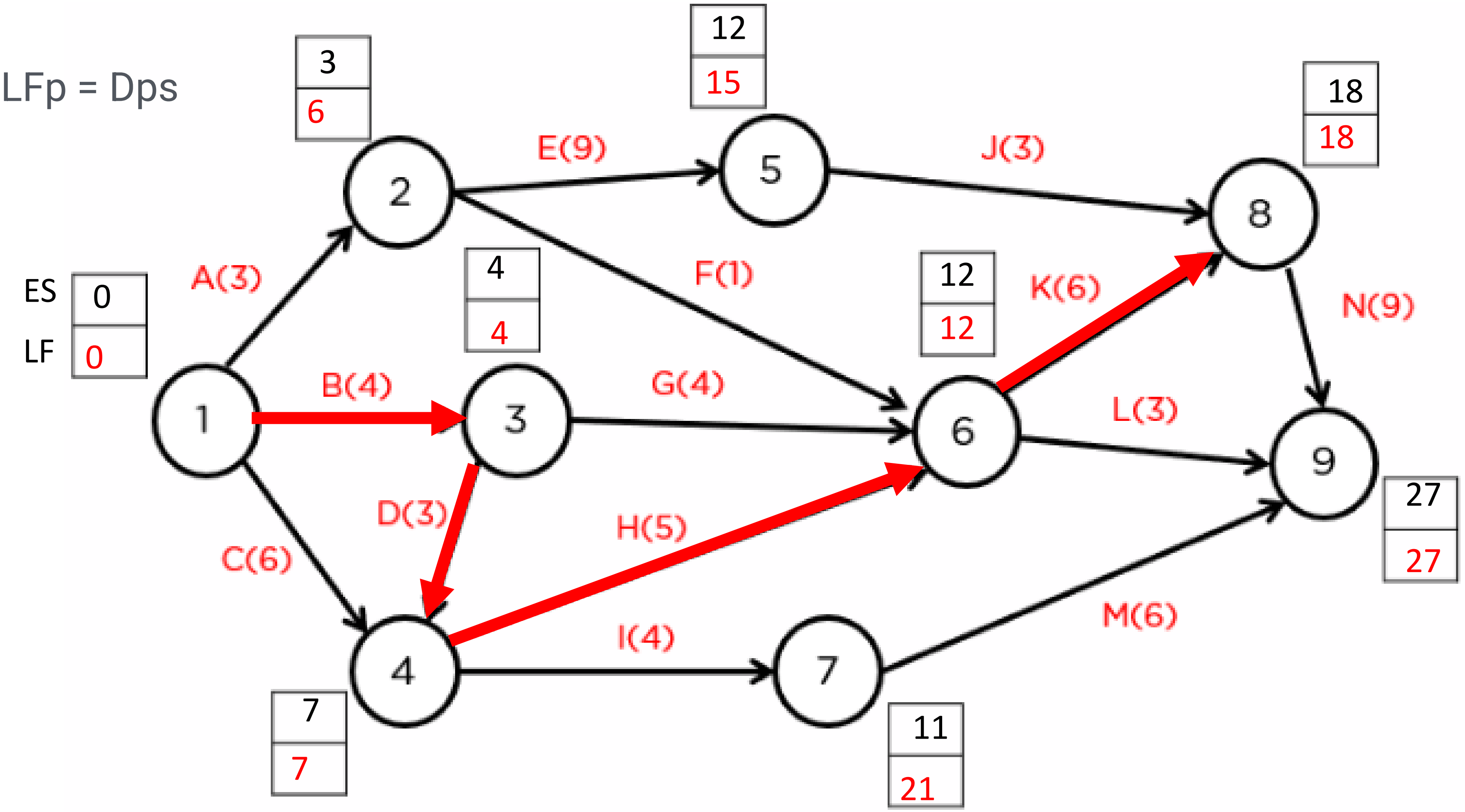

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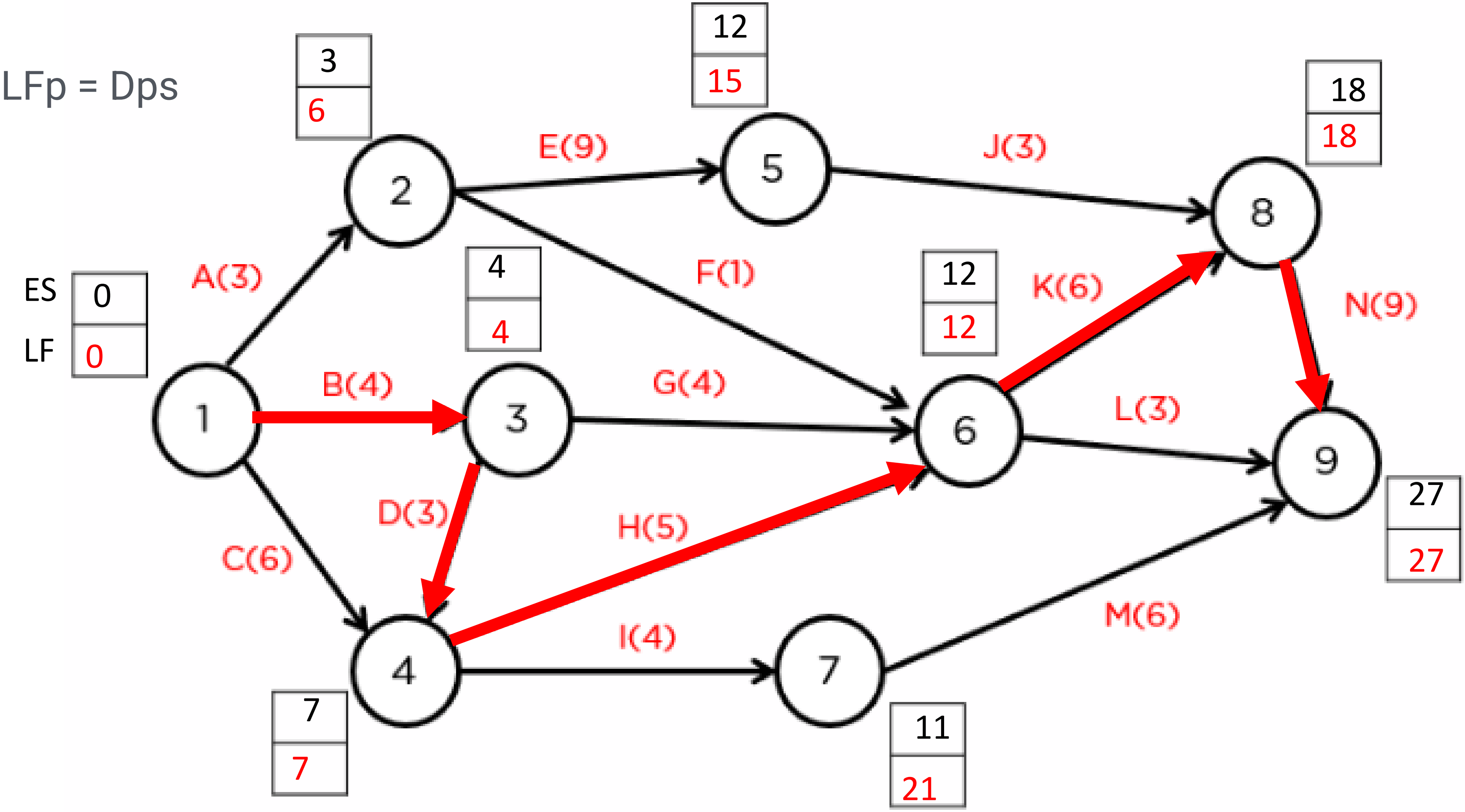

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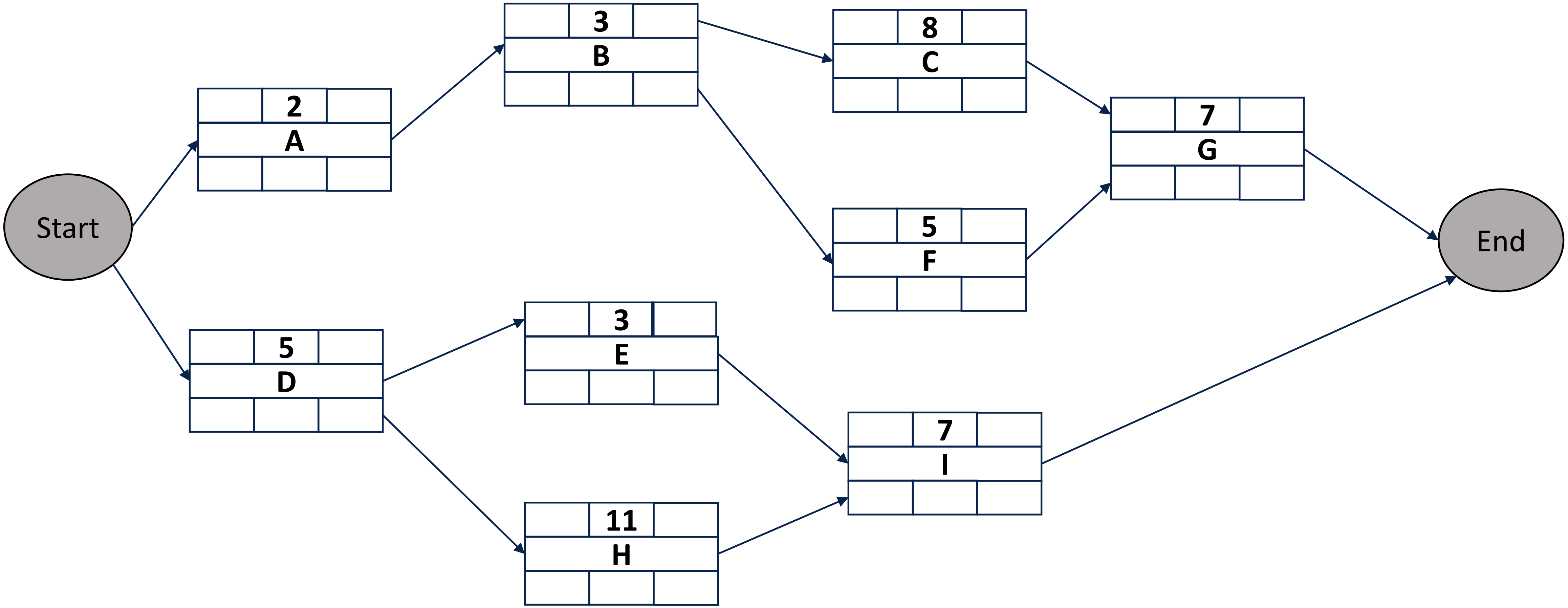

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Tools & Techniques: Critical Path Method

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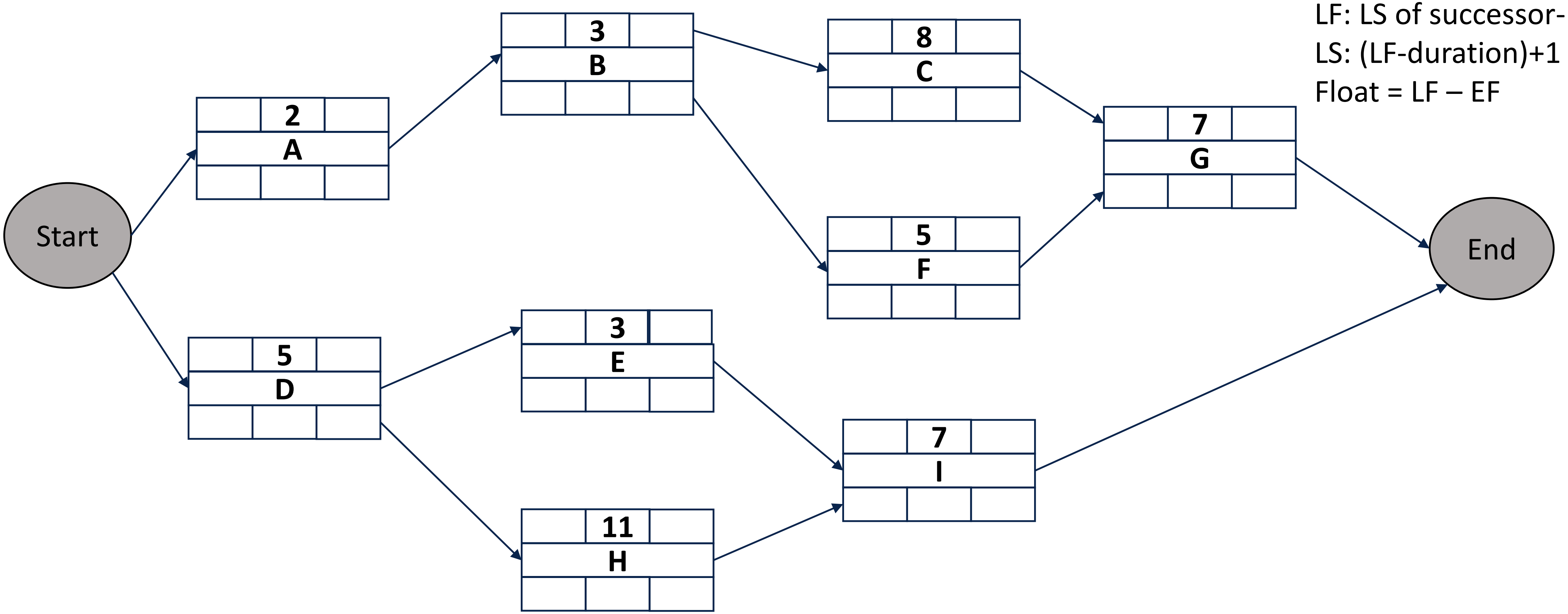

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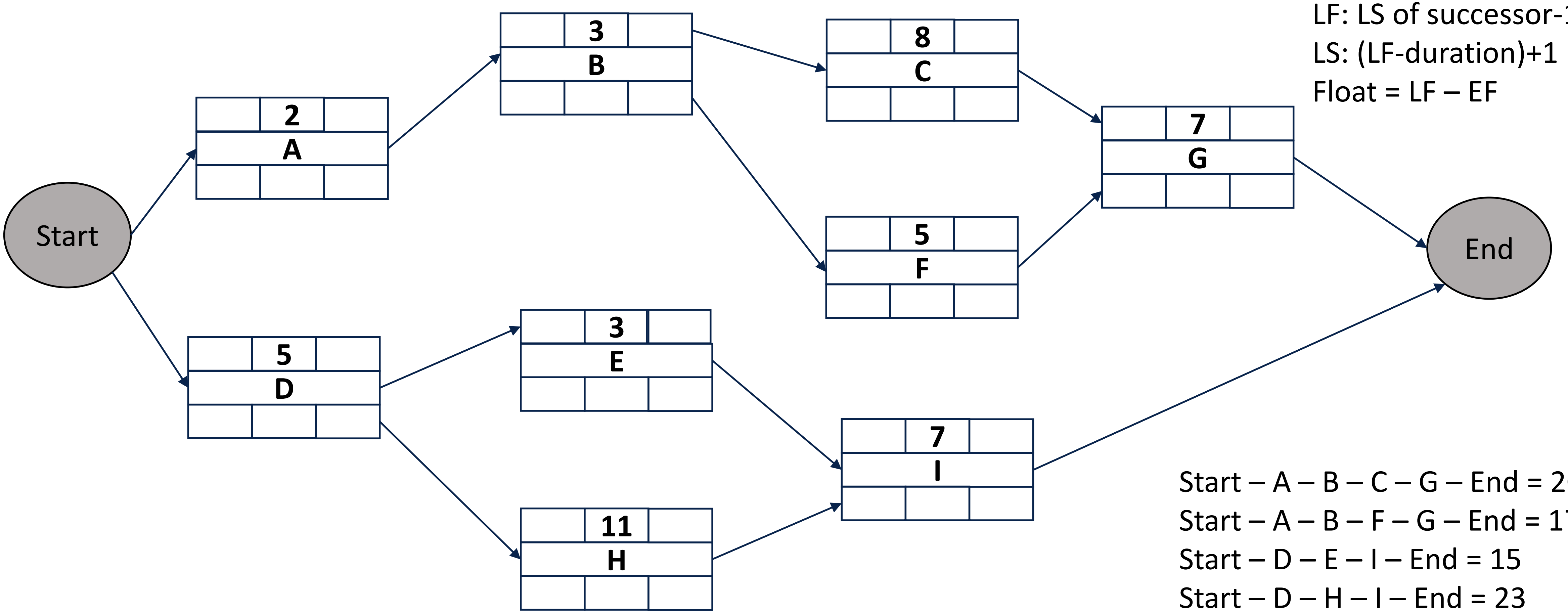

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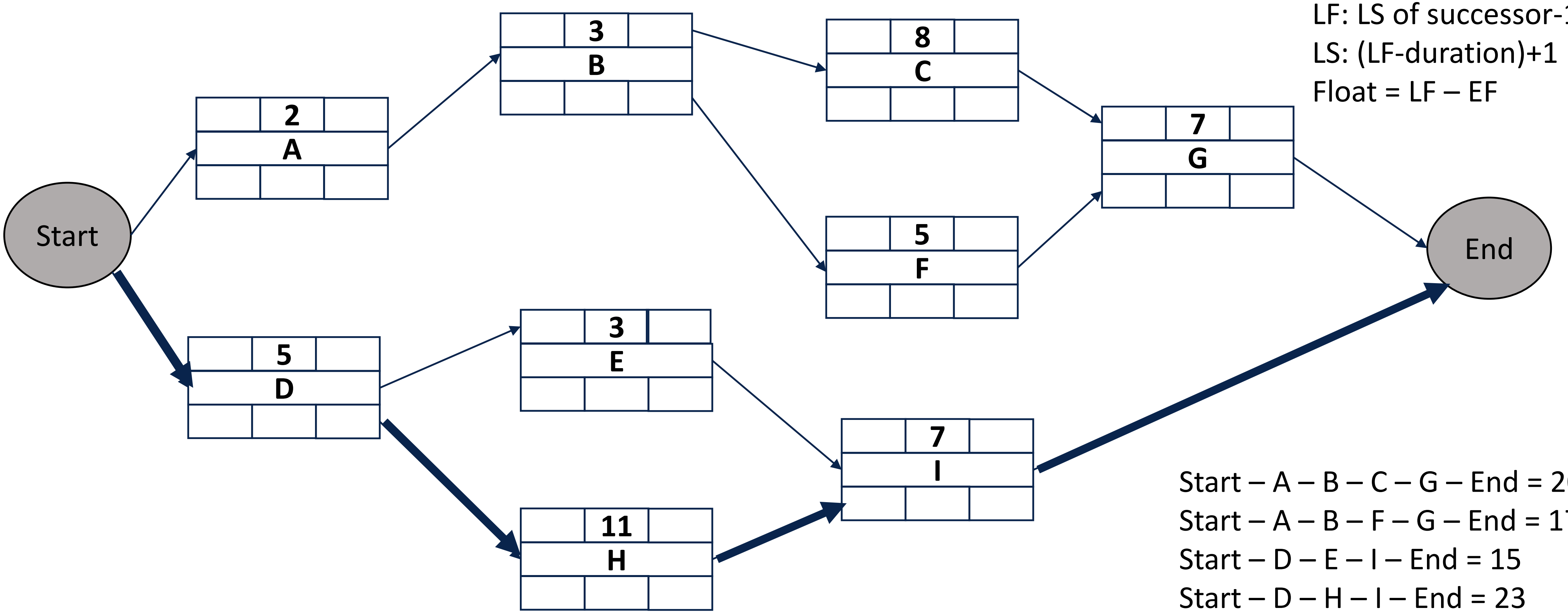

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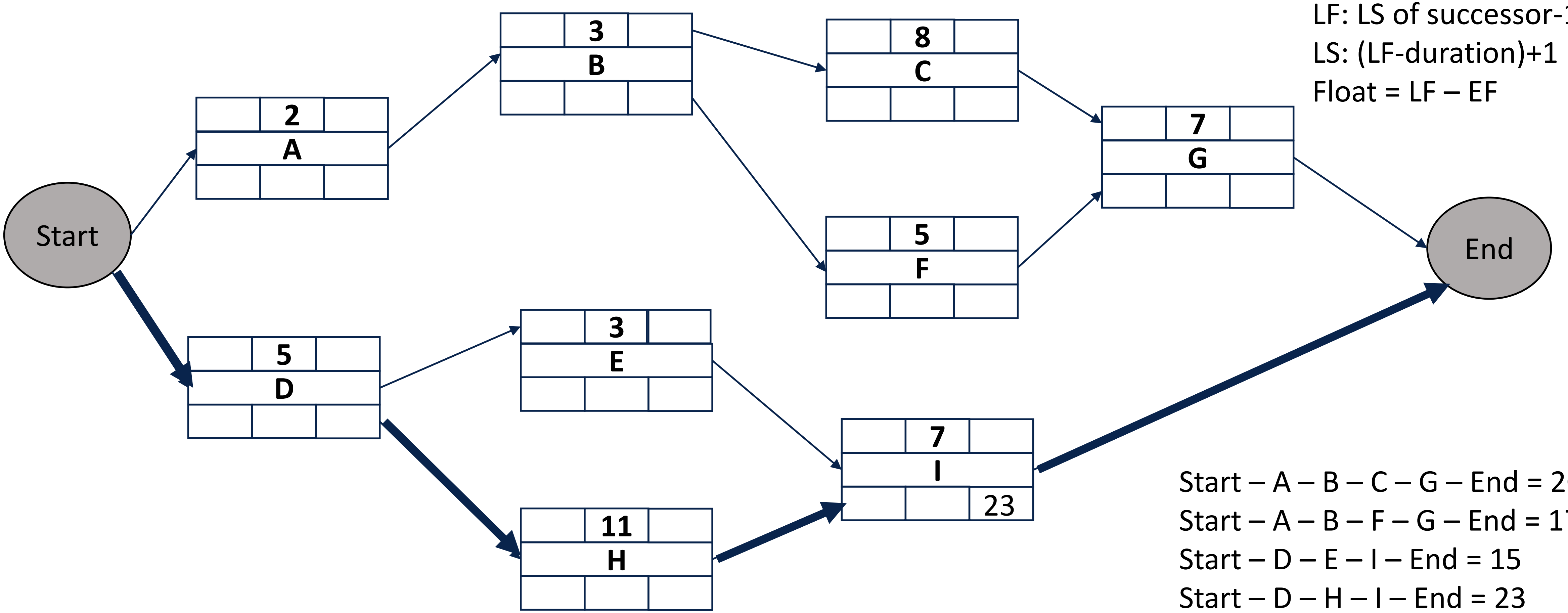

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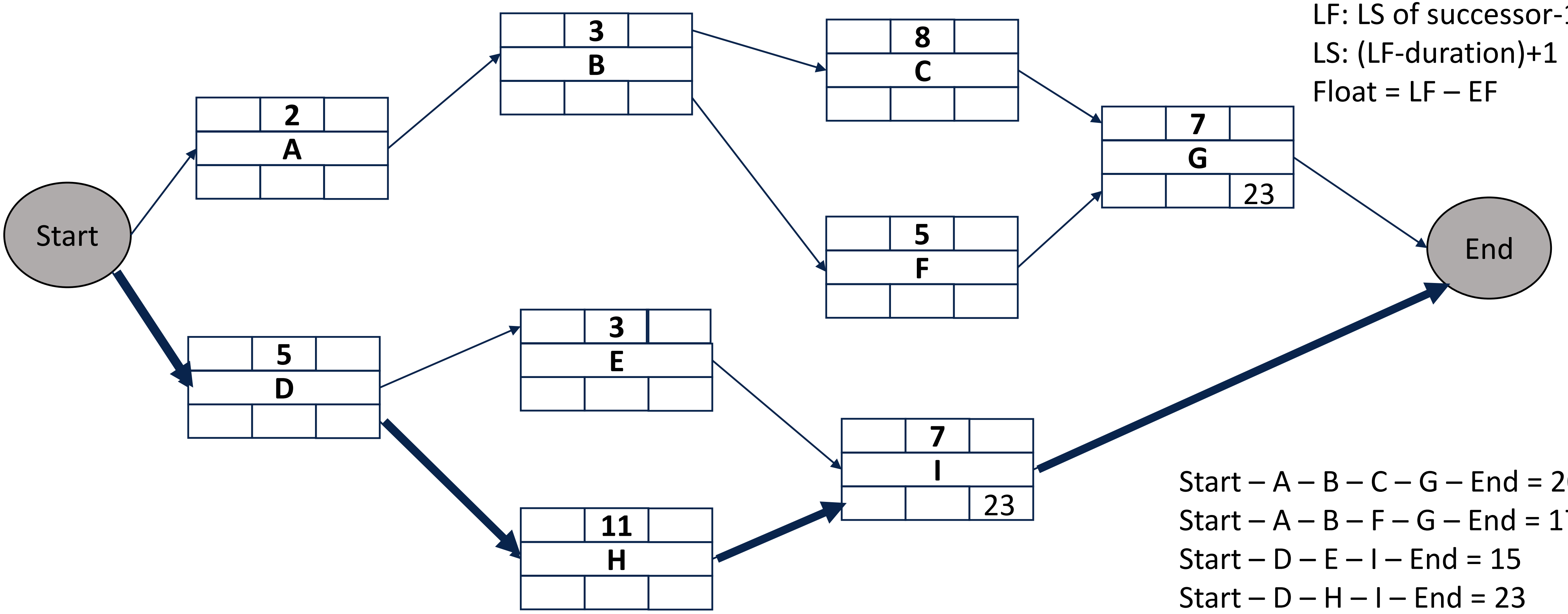

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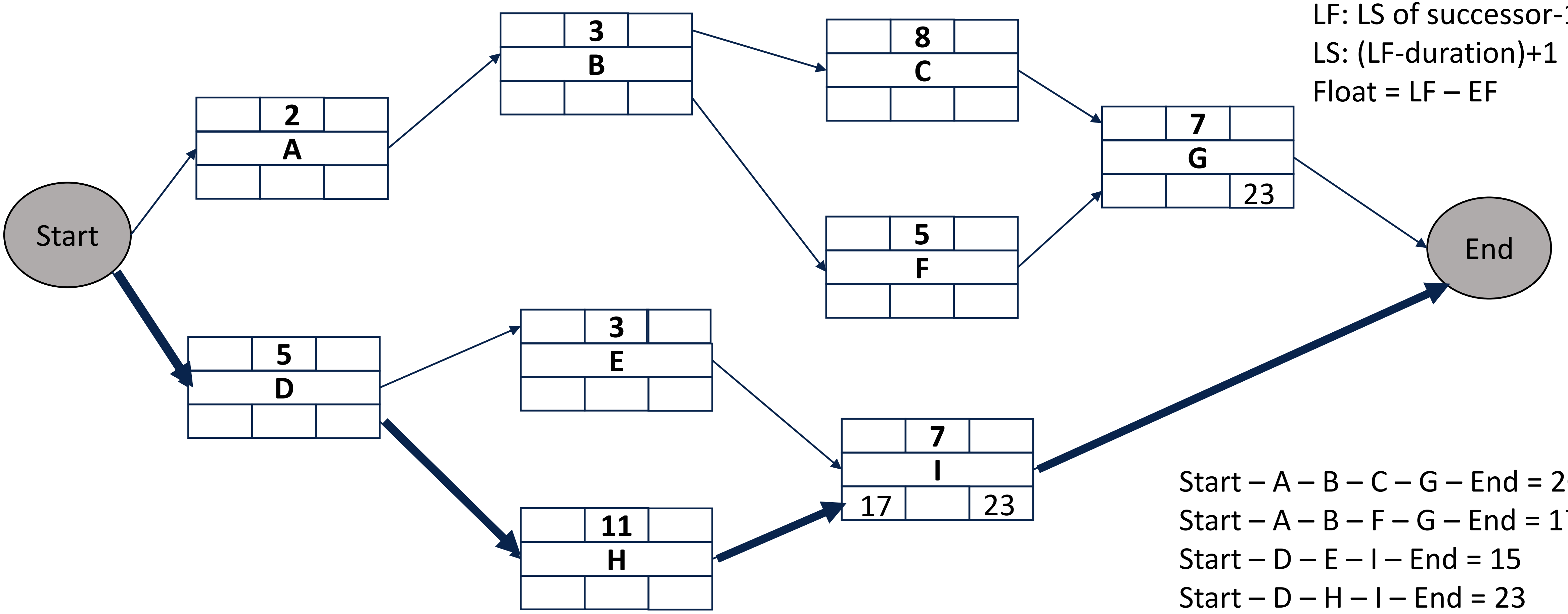

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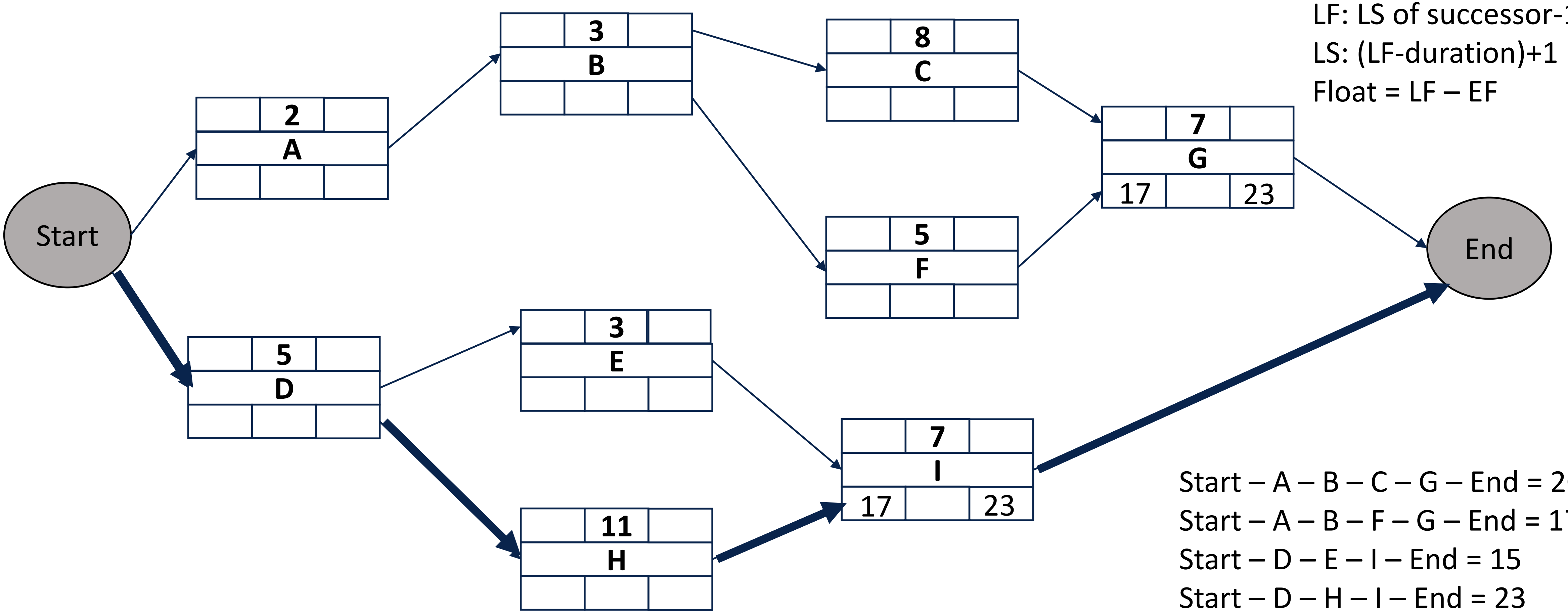

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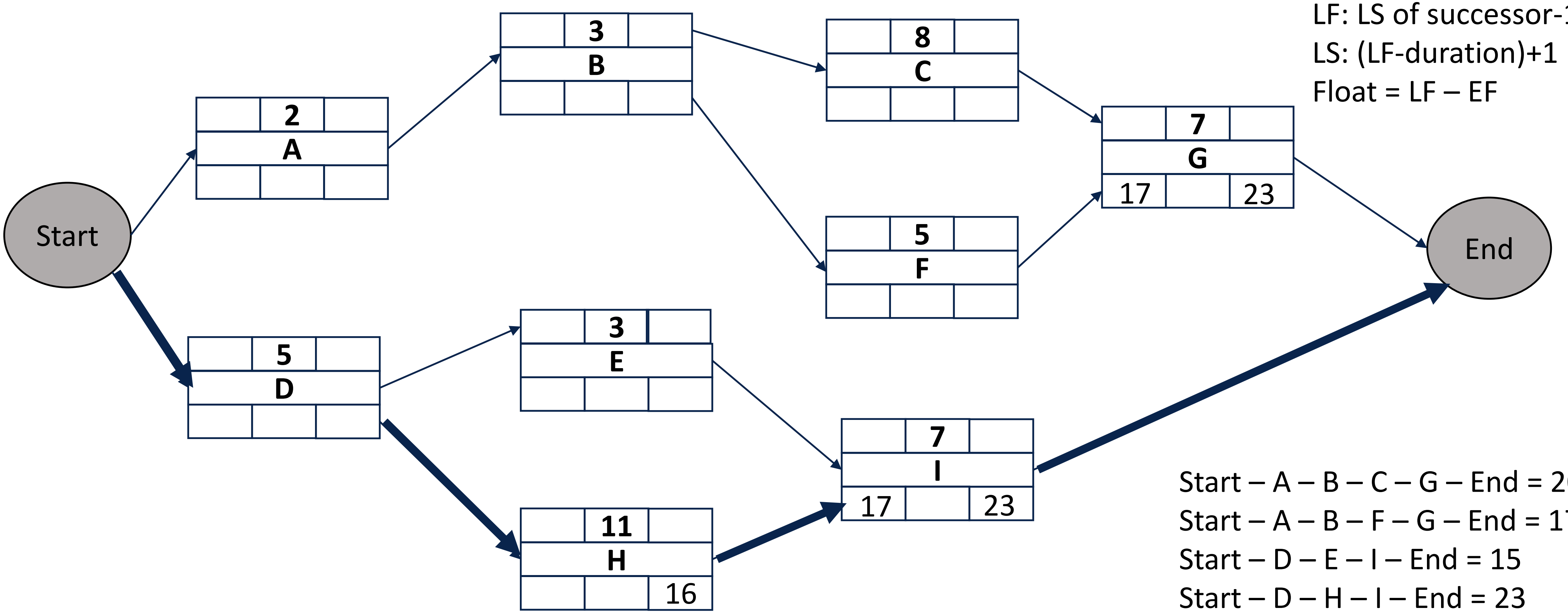

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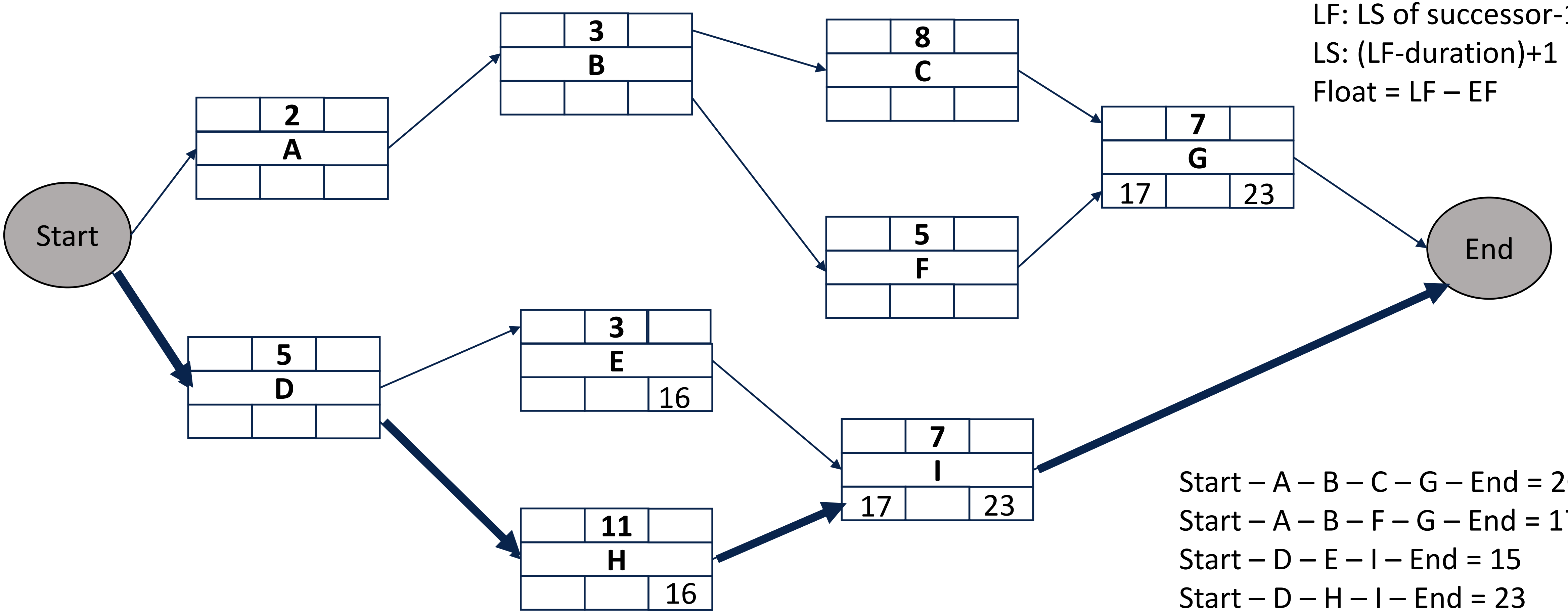

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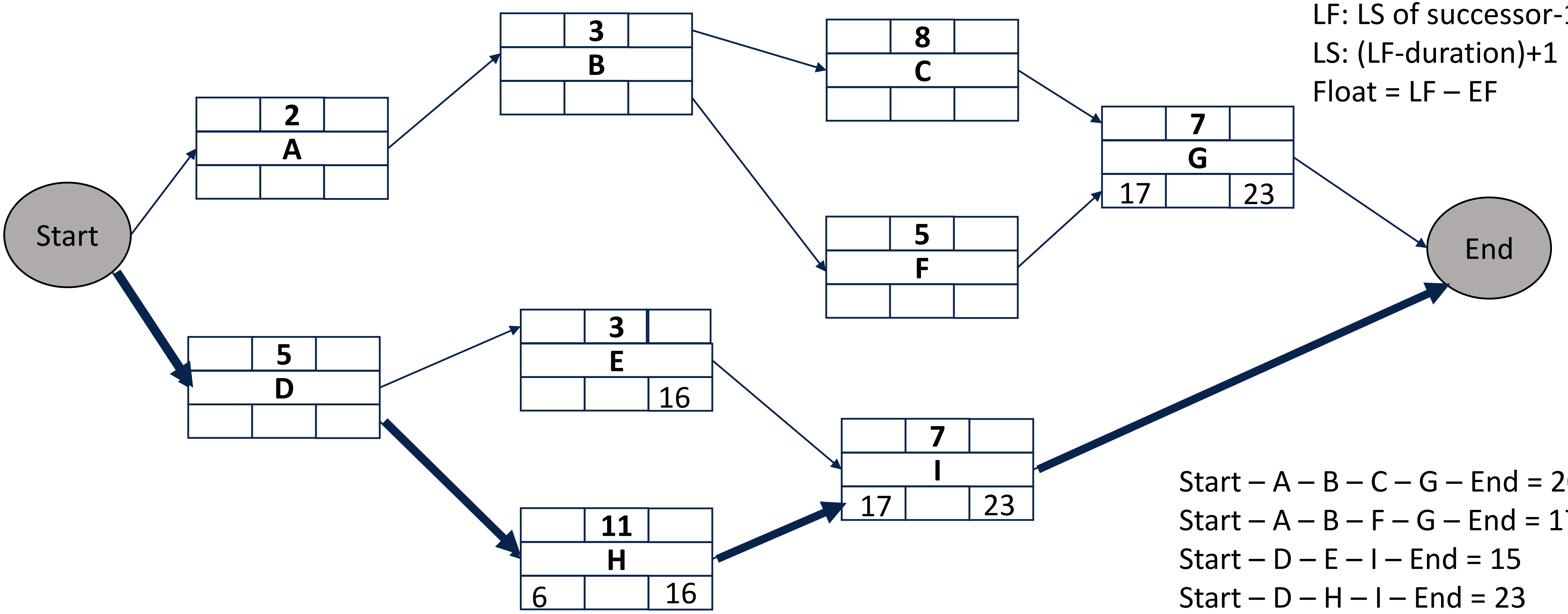

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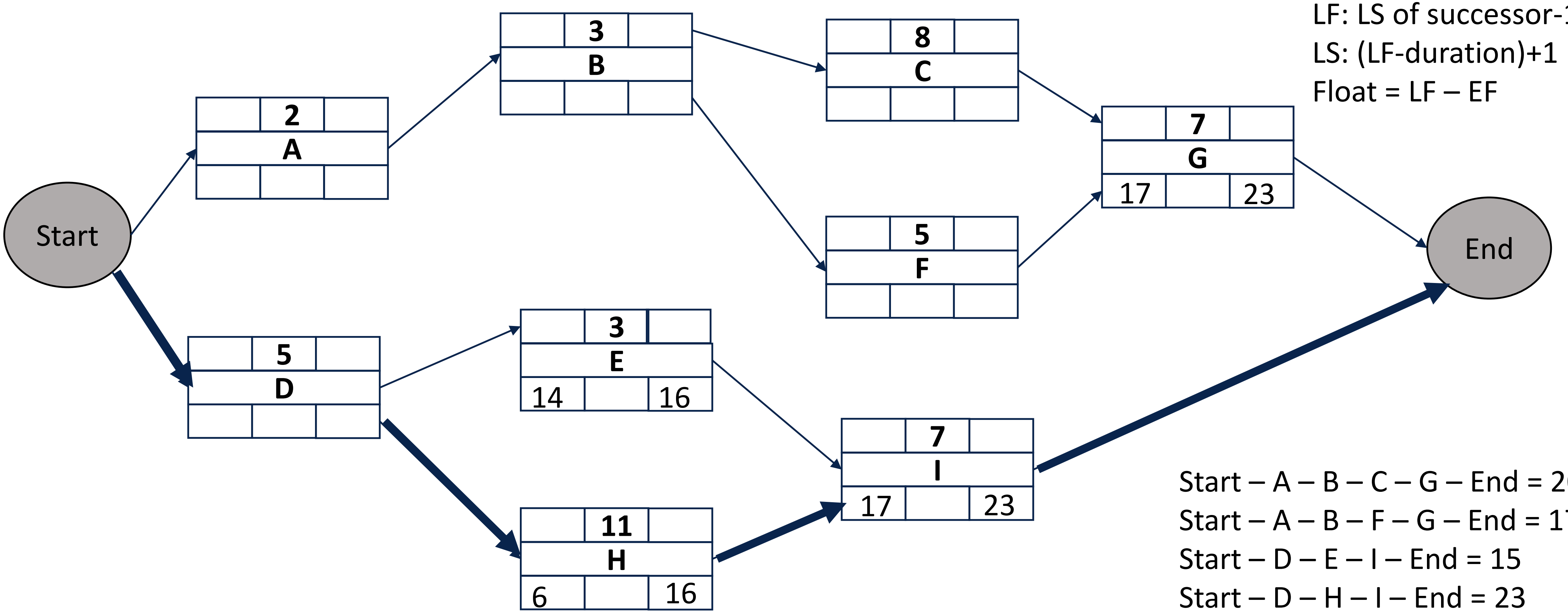

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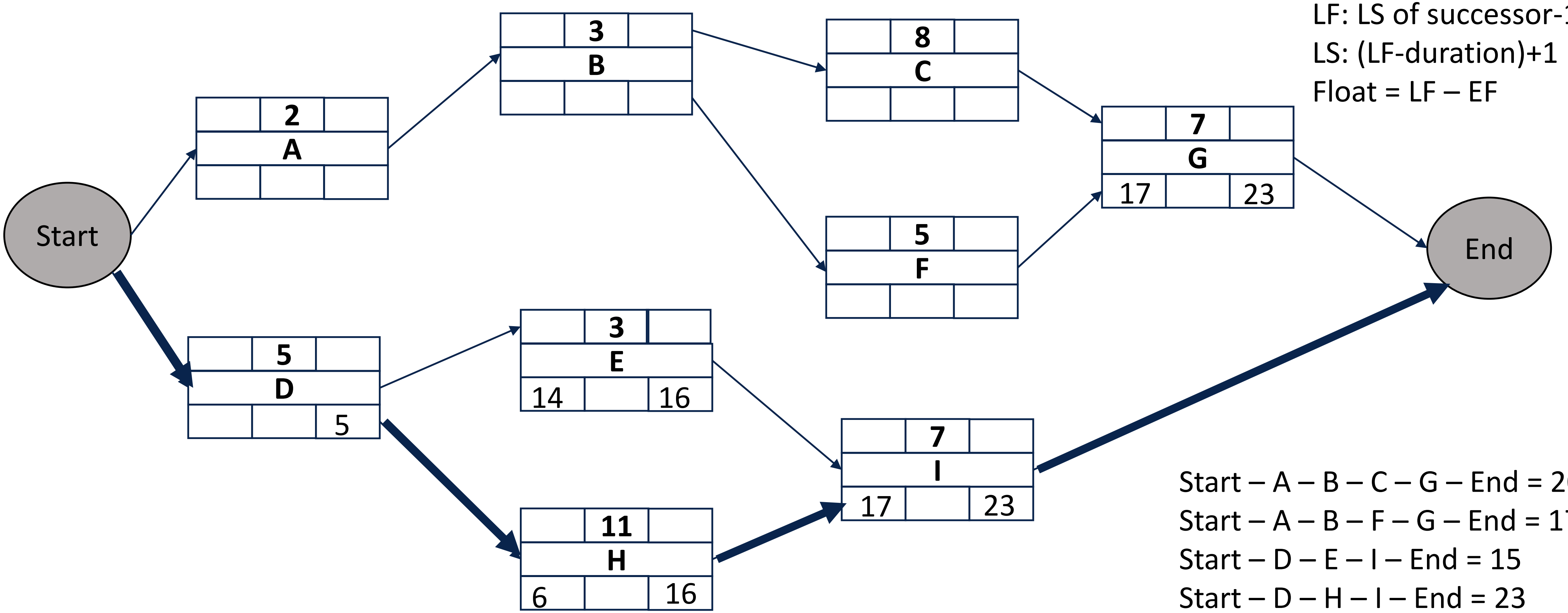

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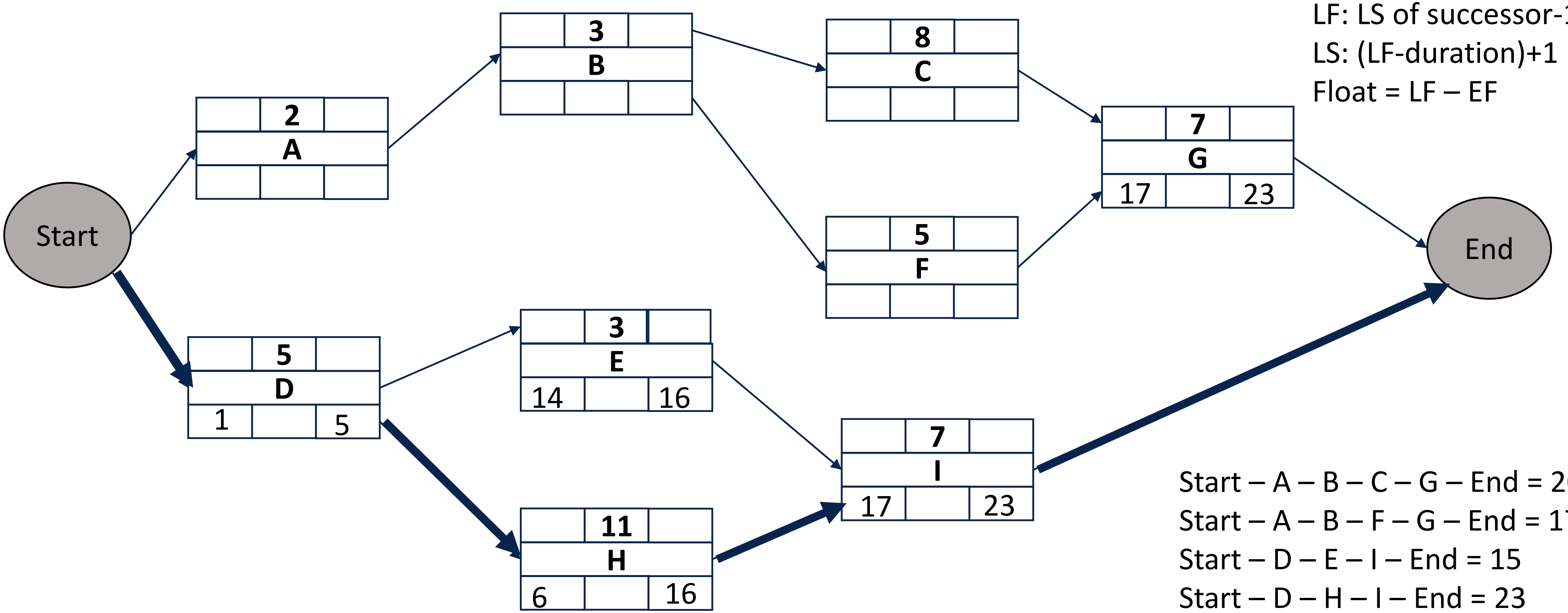

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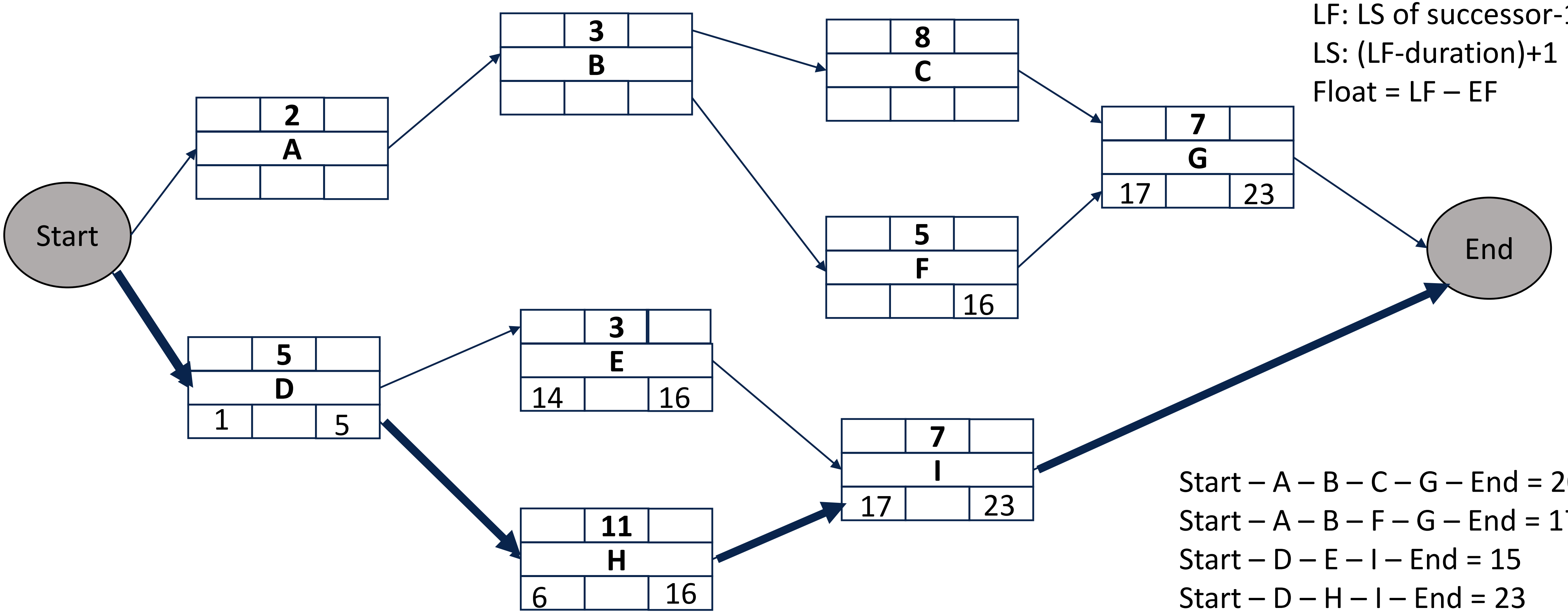

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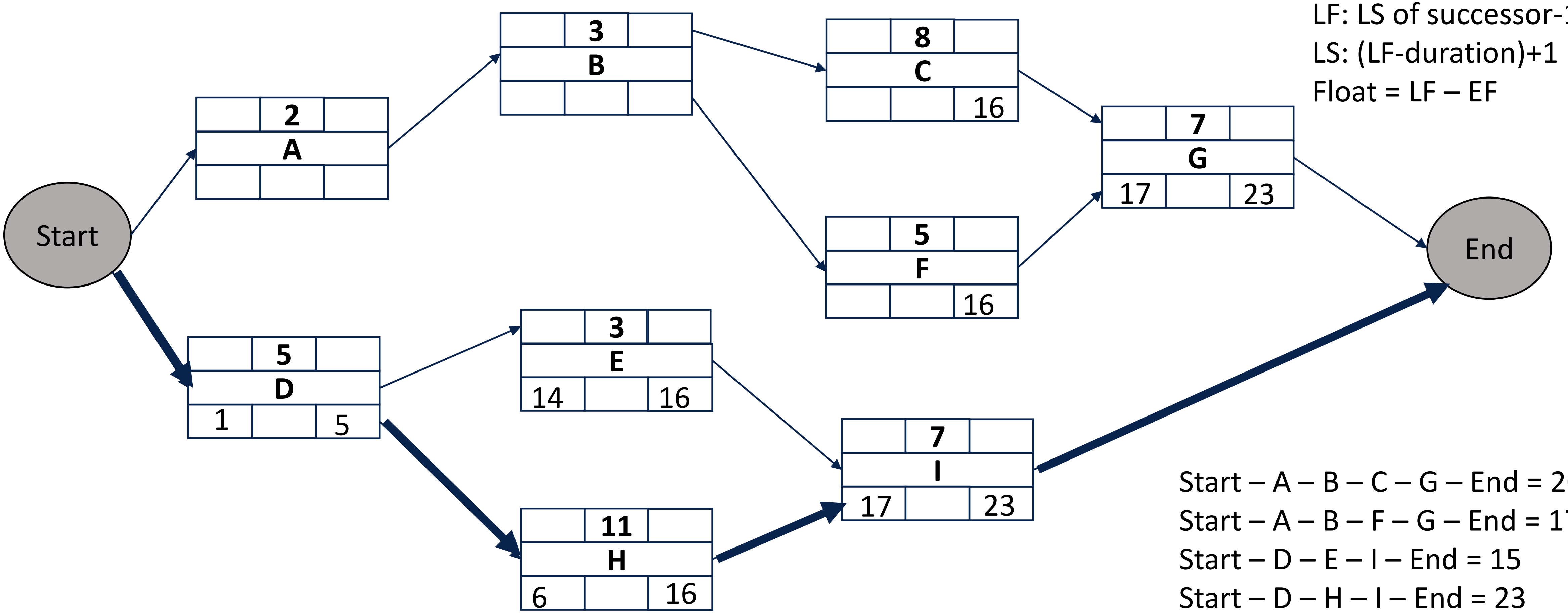

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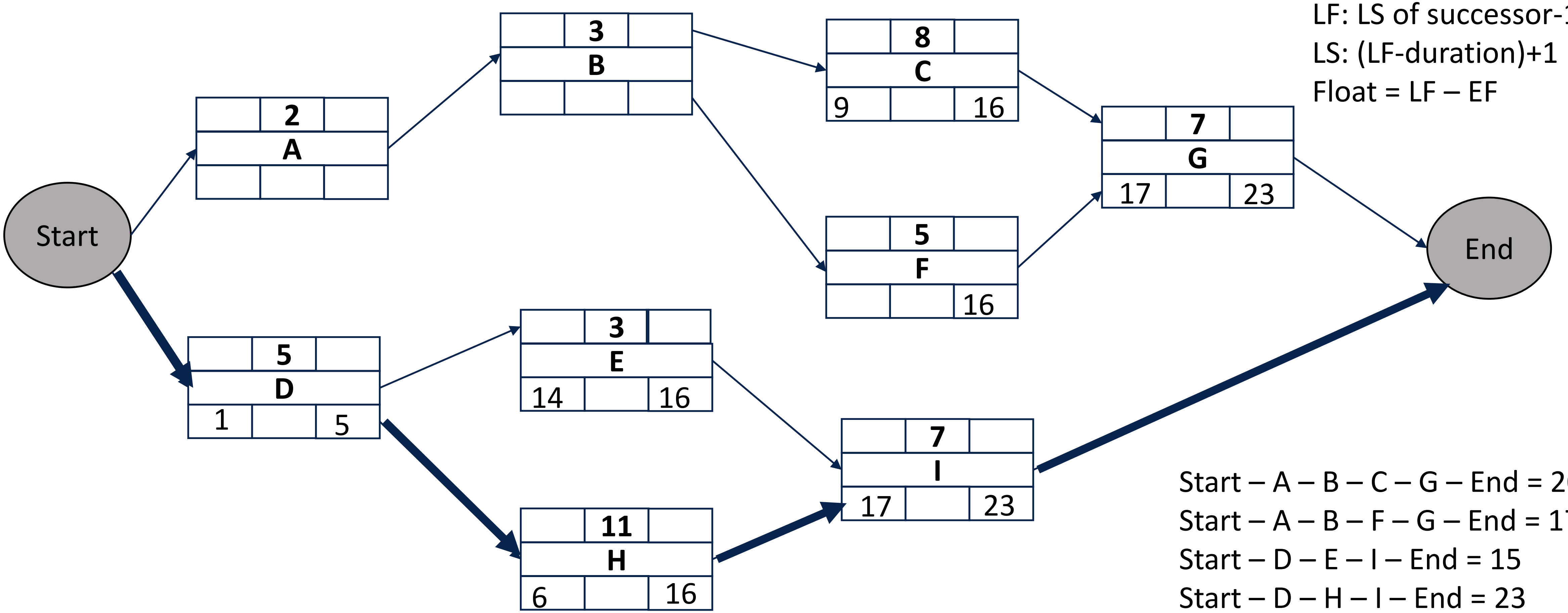

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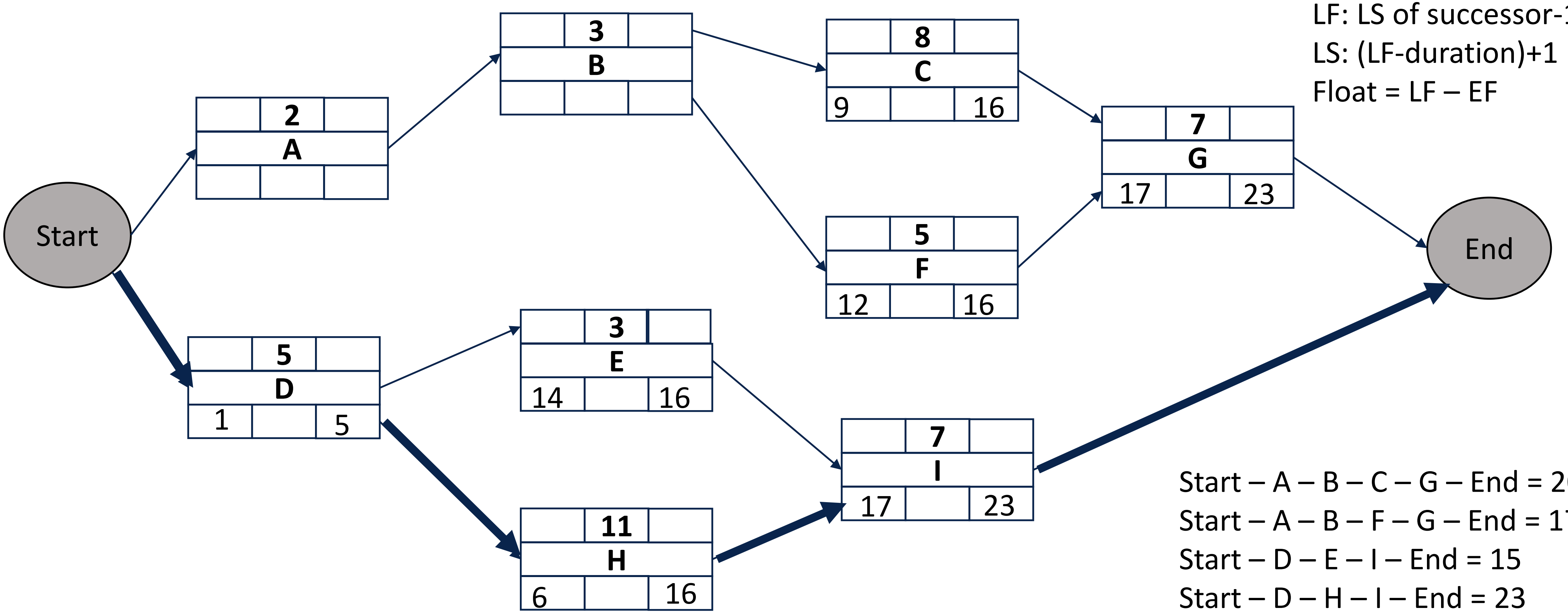

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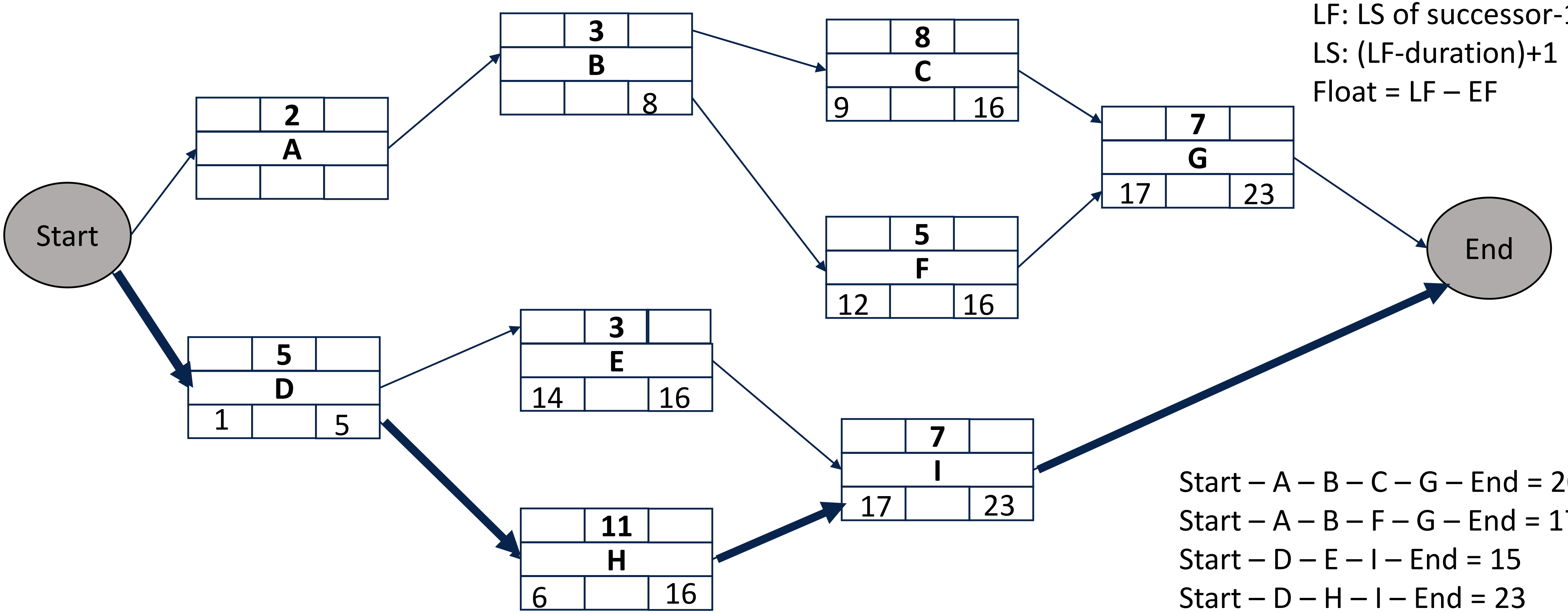

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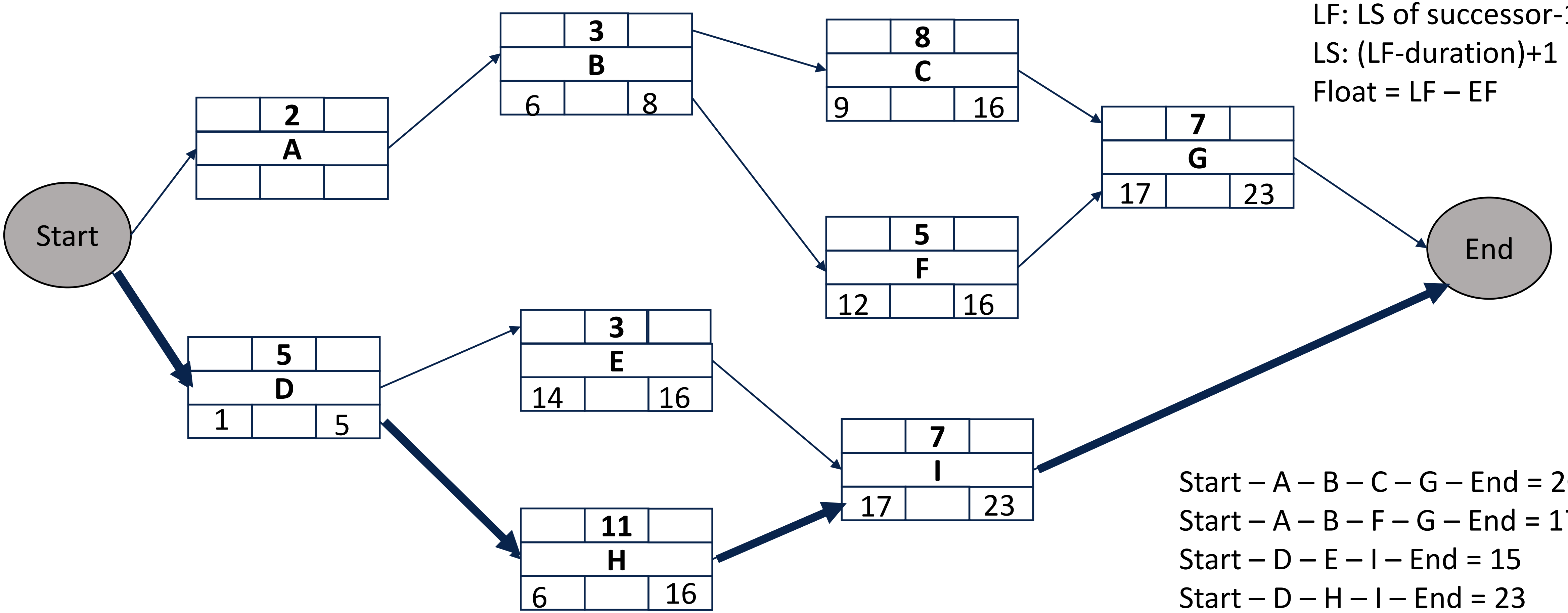

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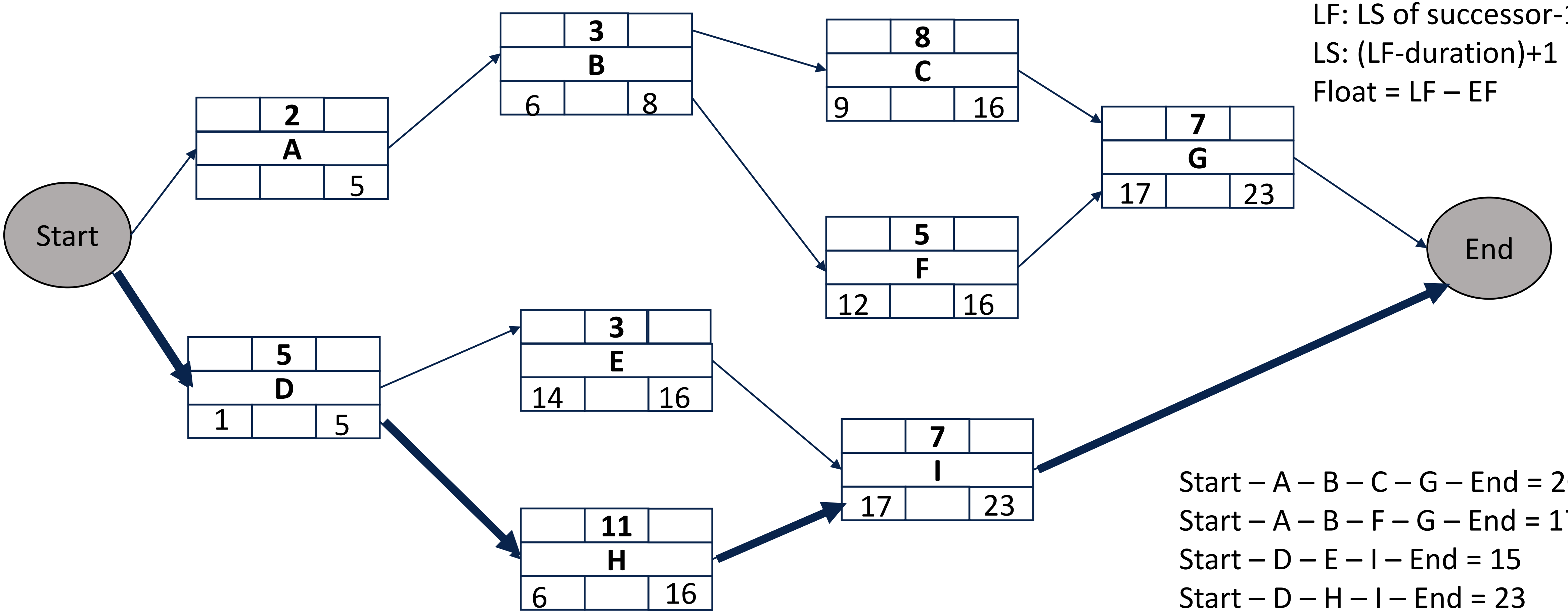

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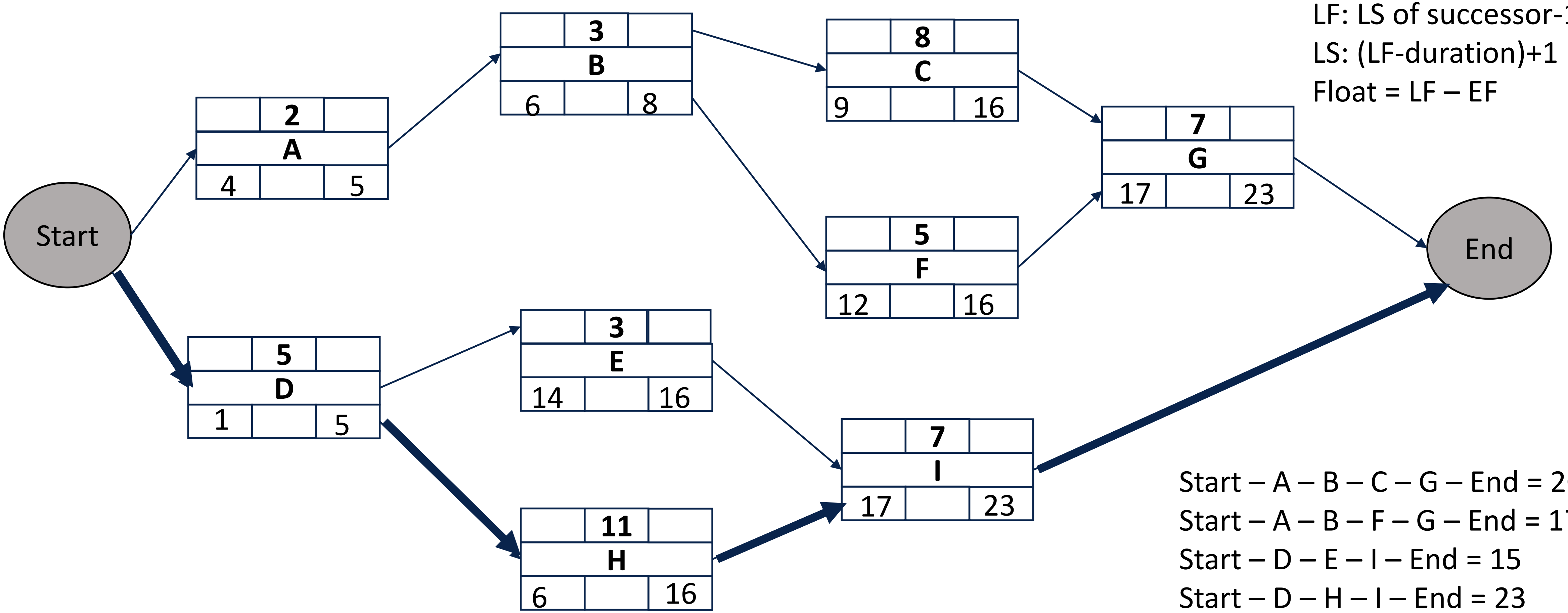

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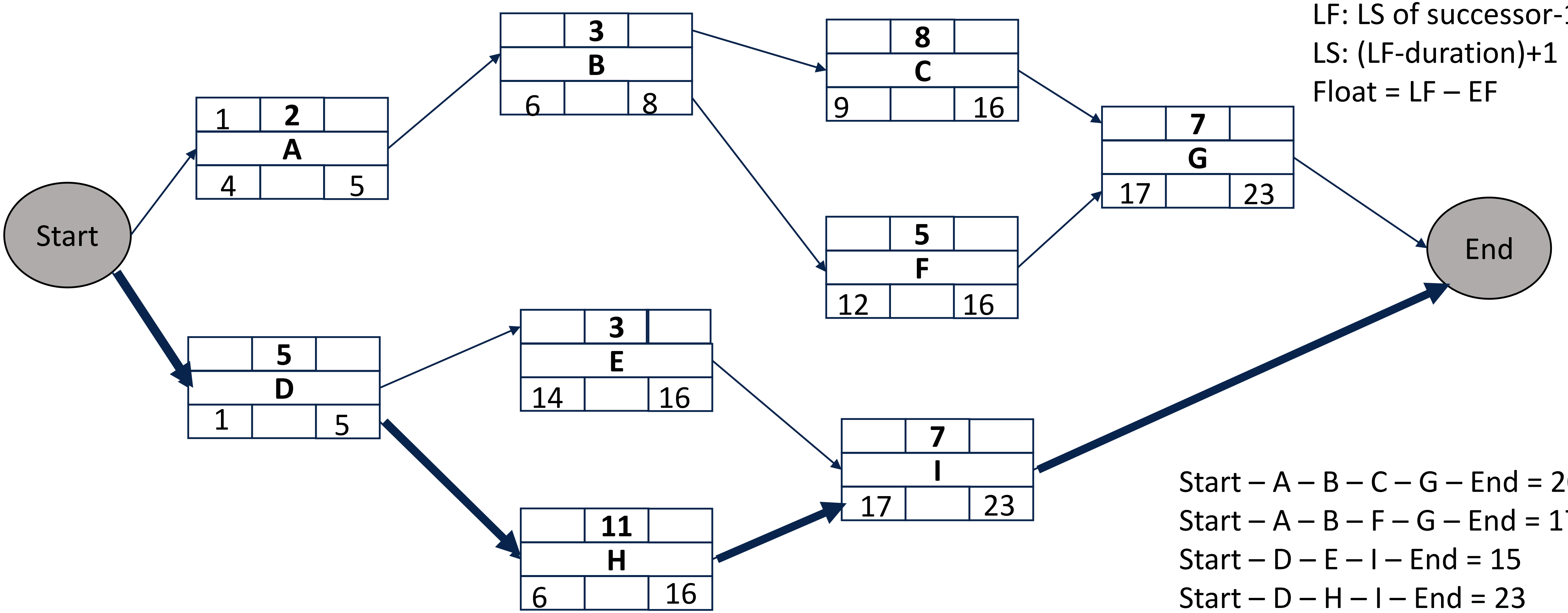

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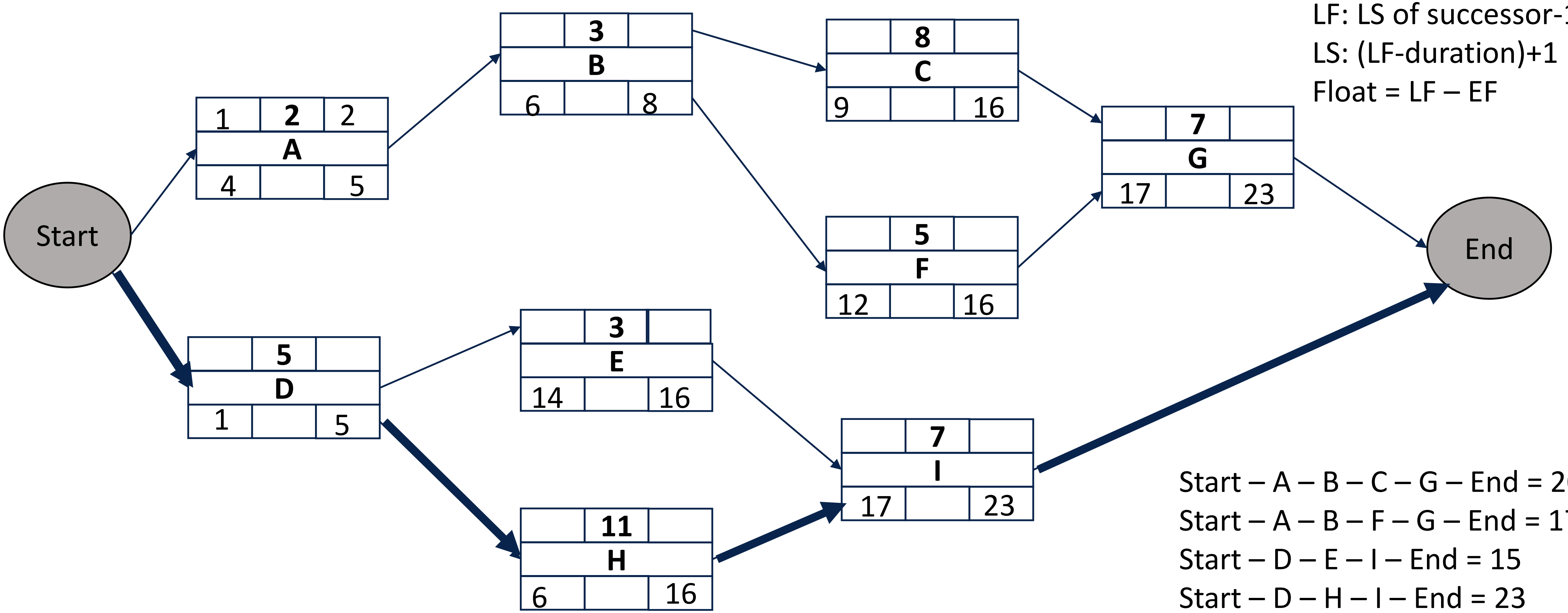

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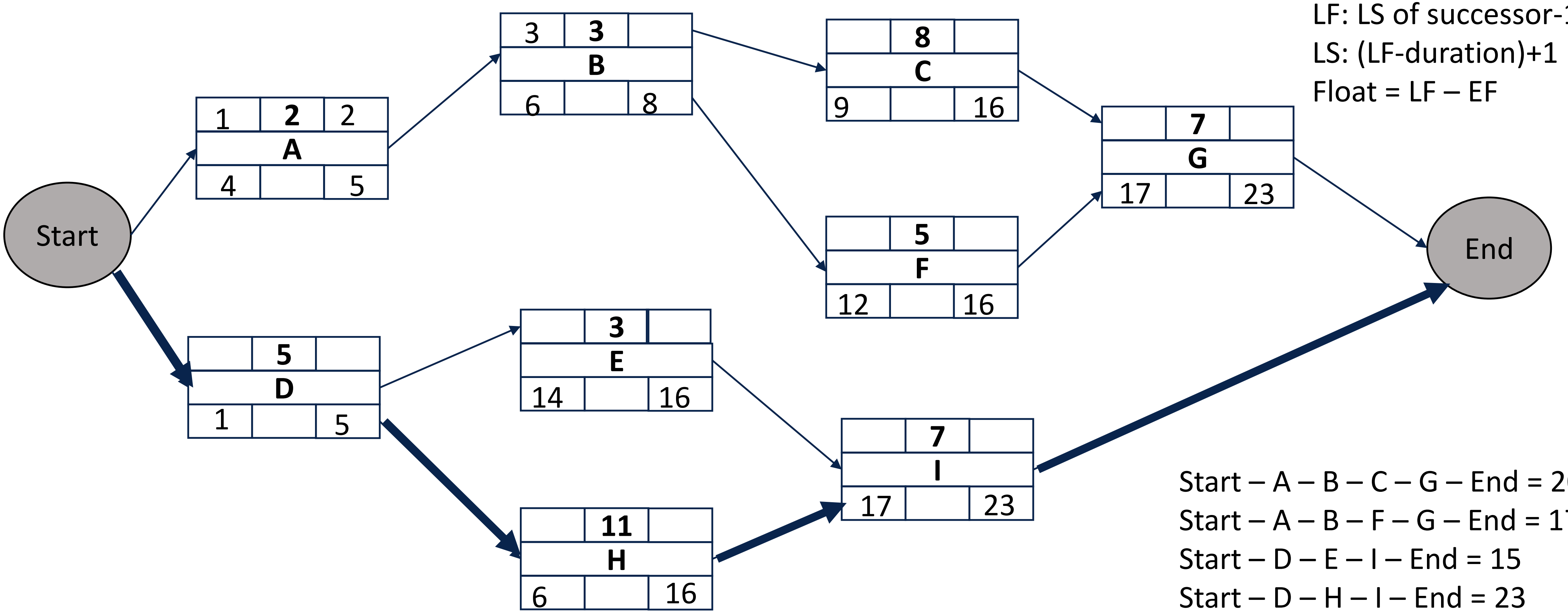

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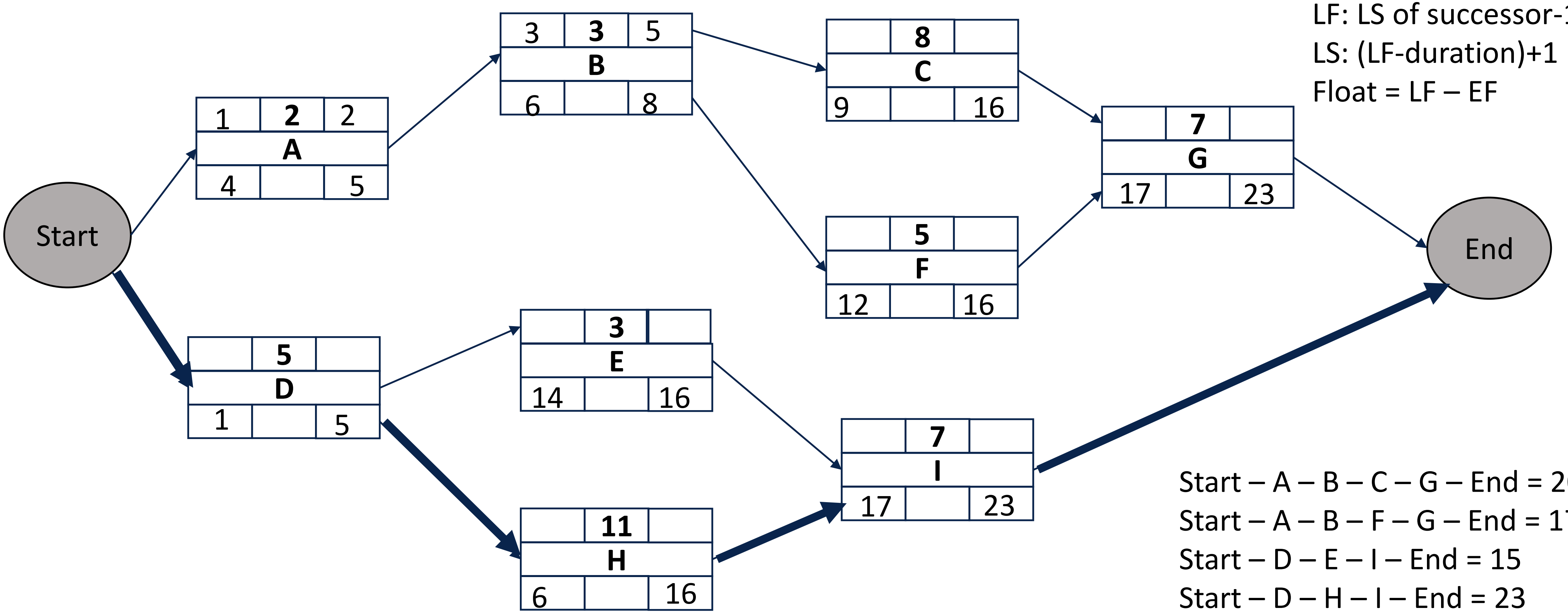

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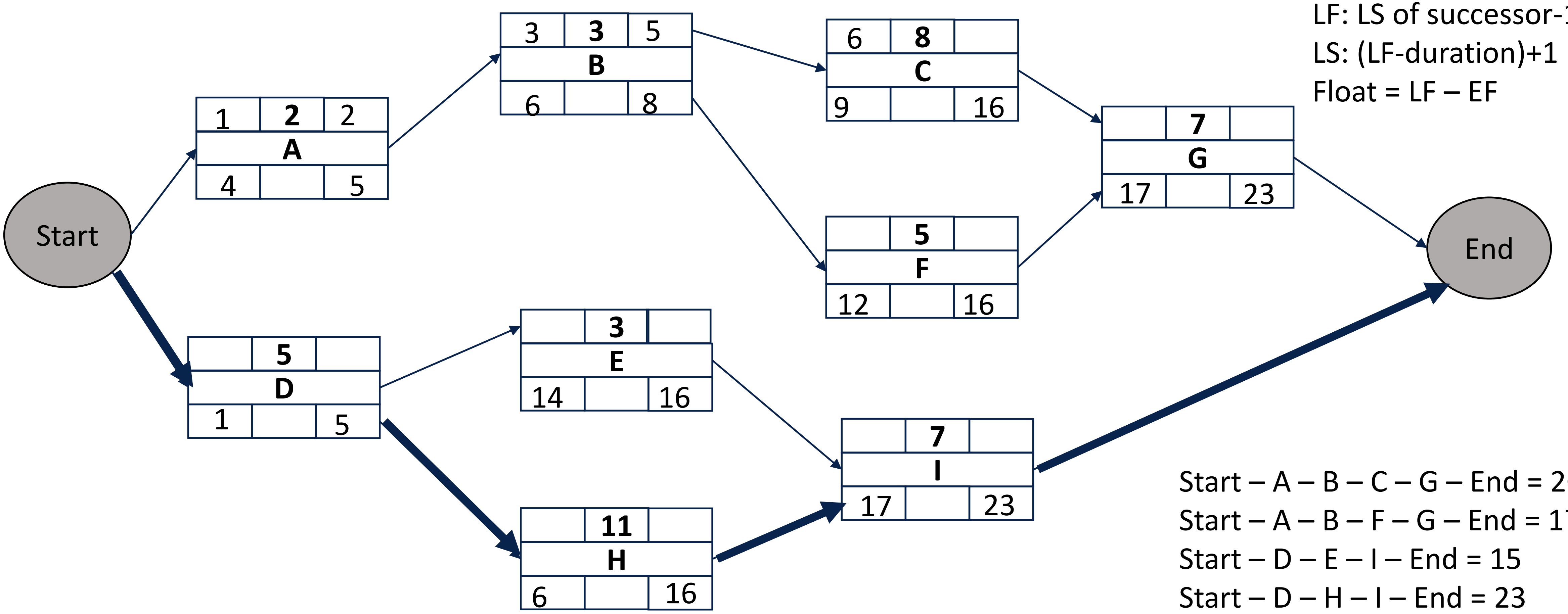

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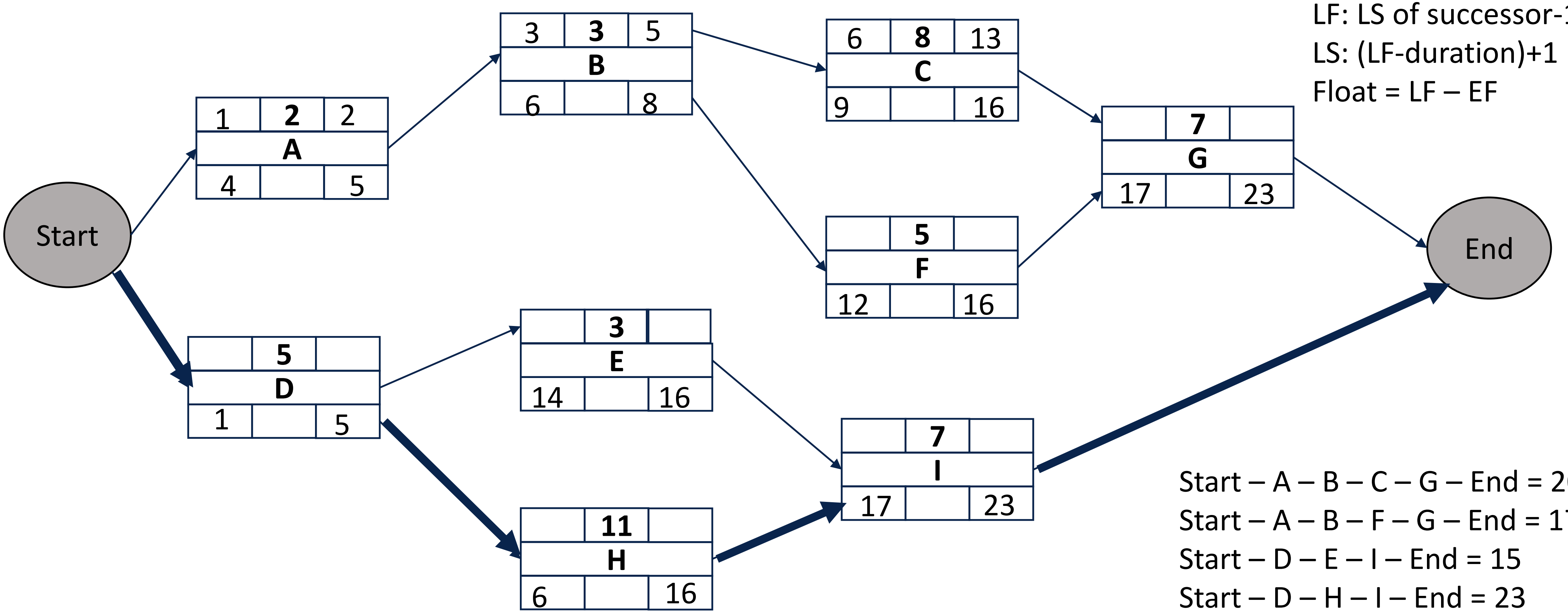

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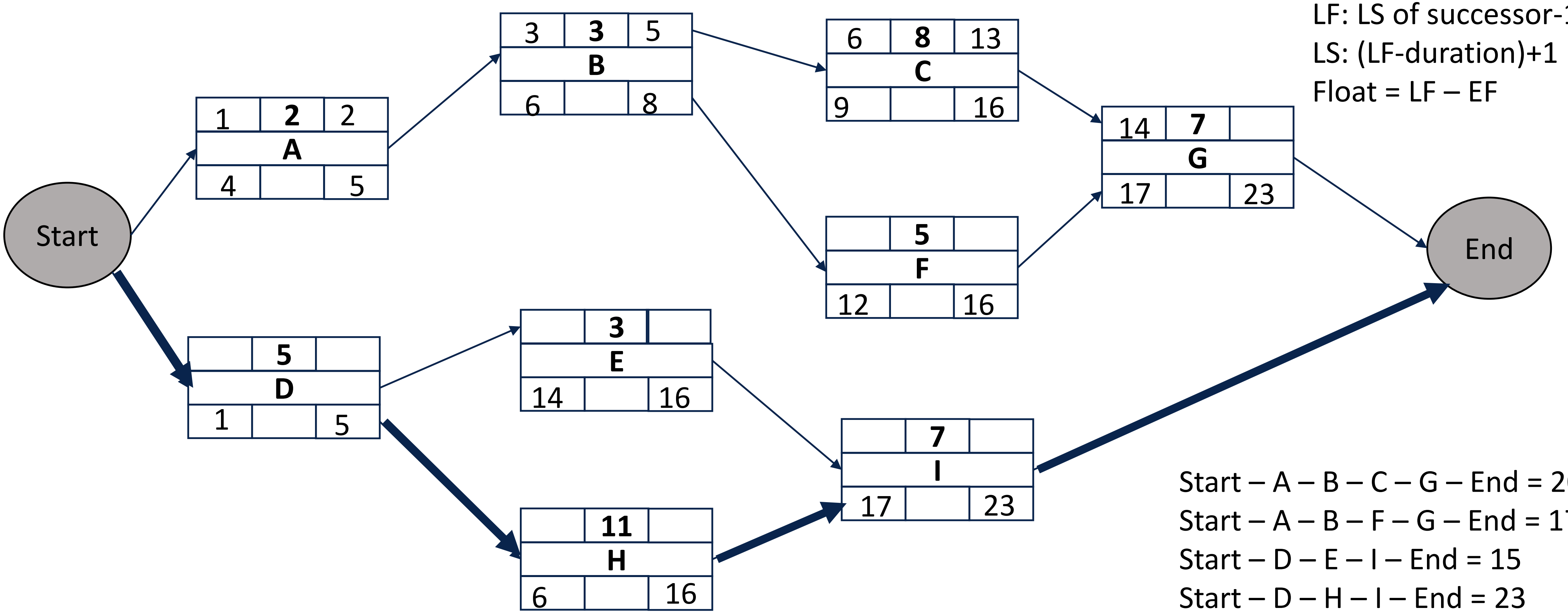

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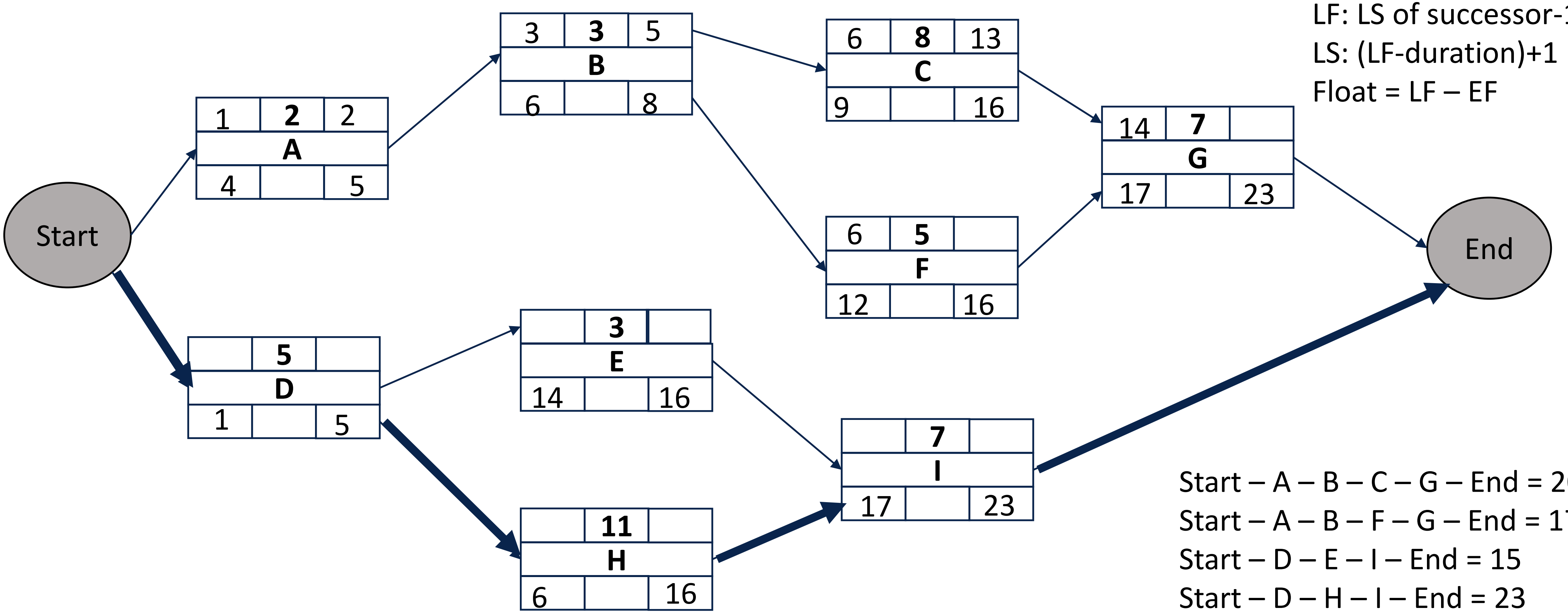

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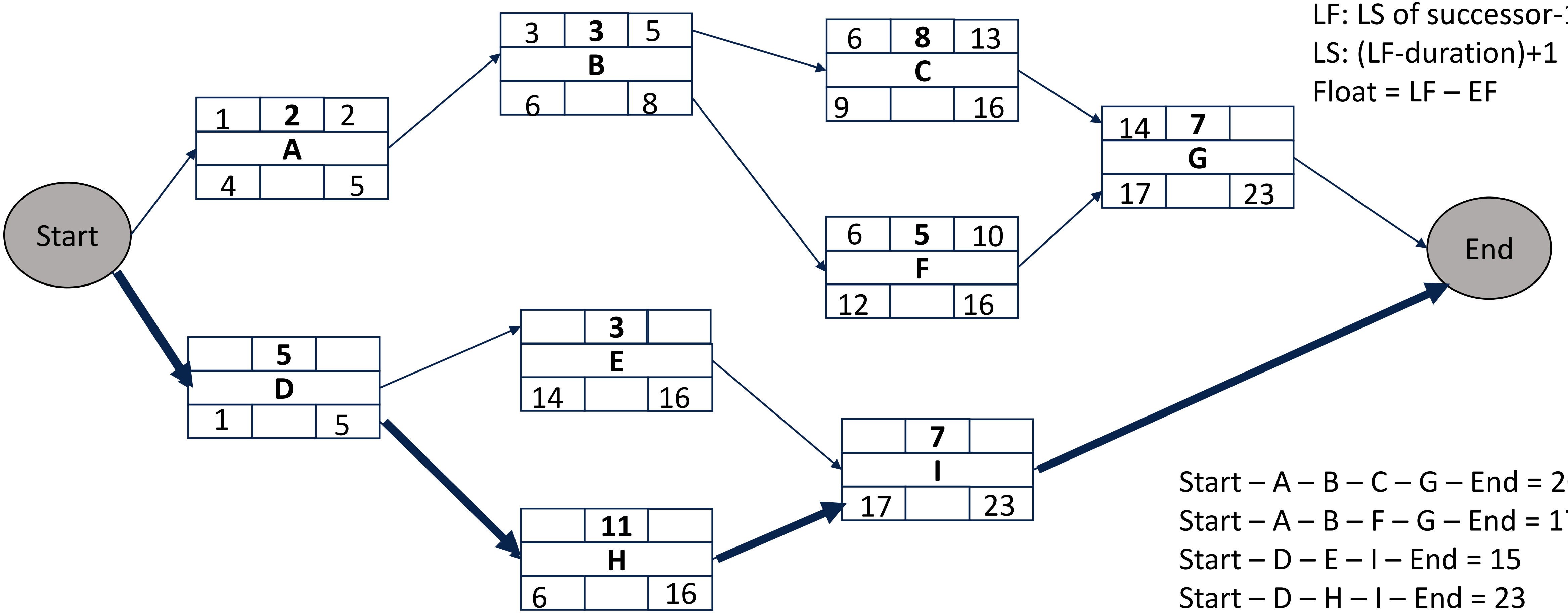

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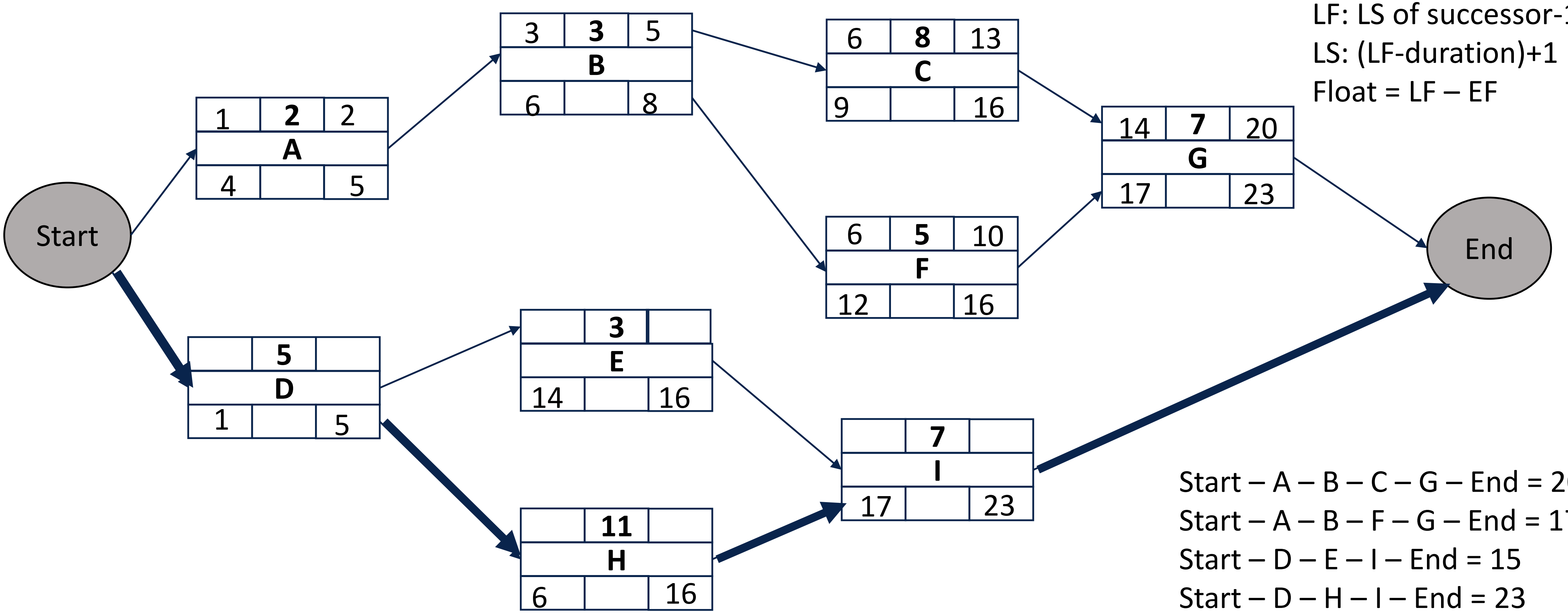

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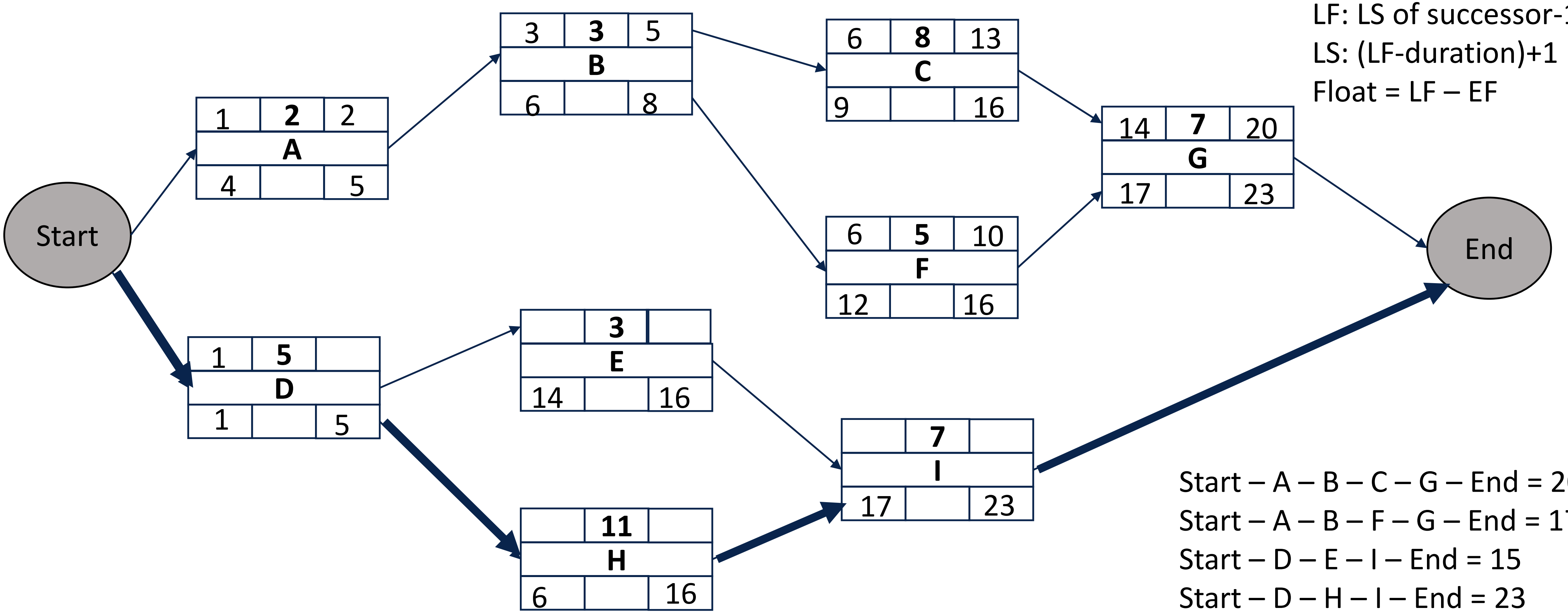

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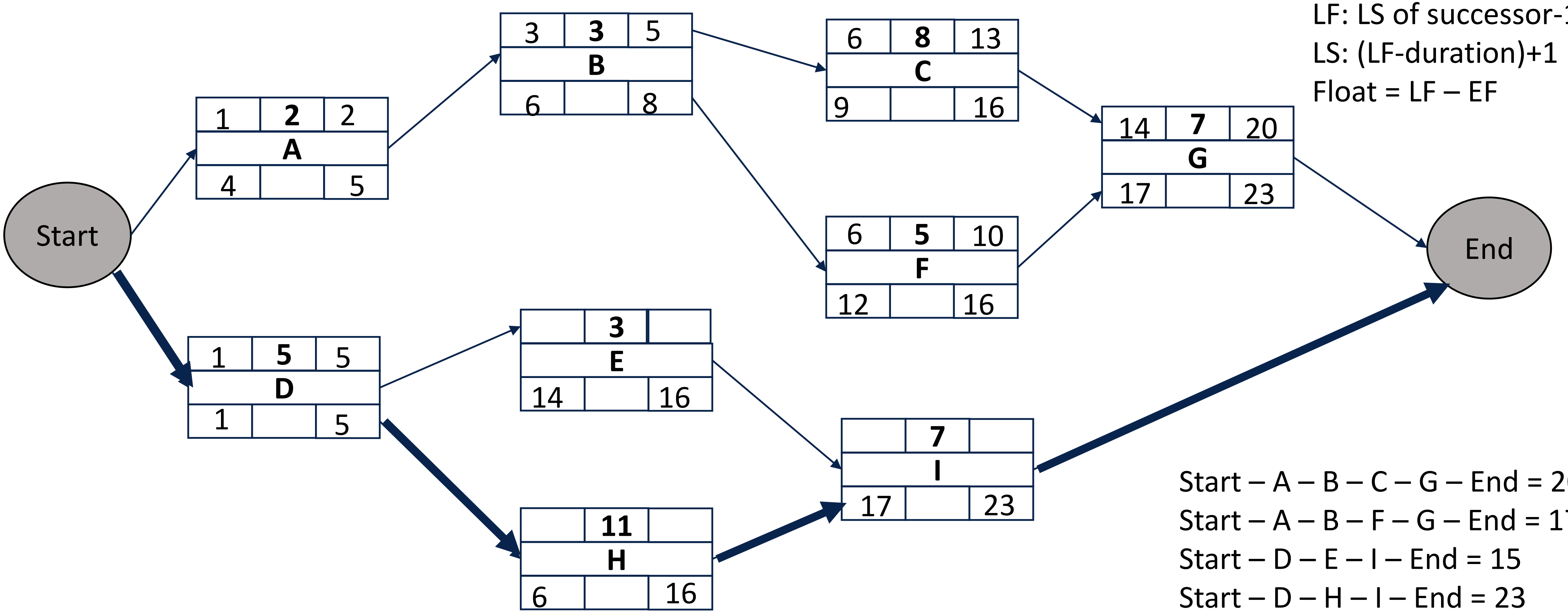

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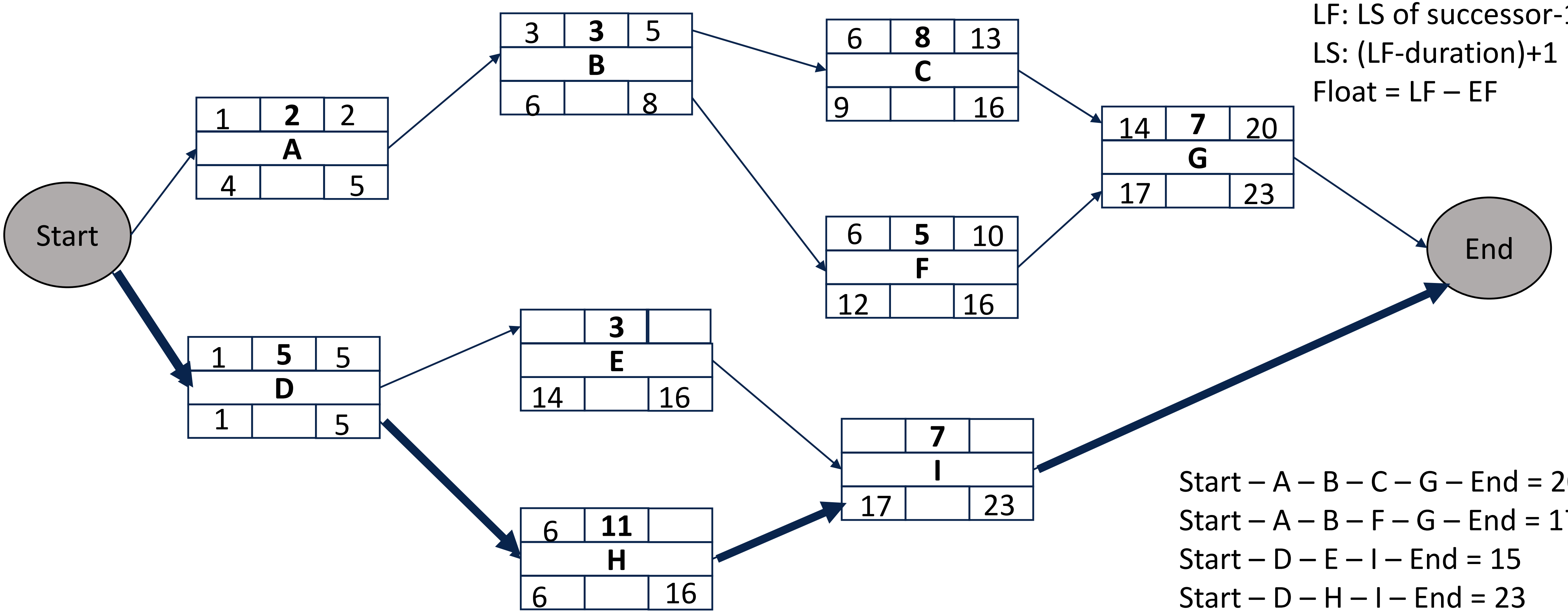

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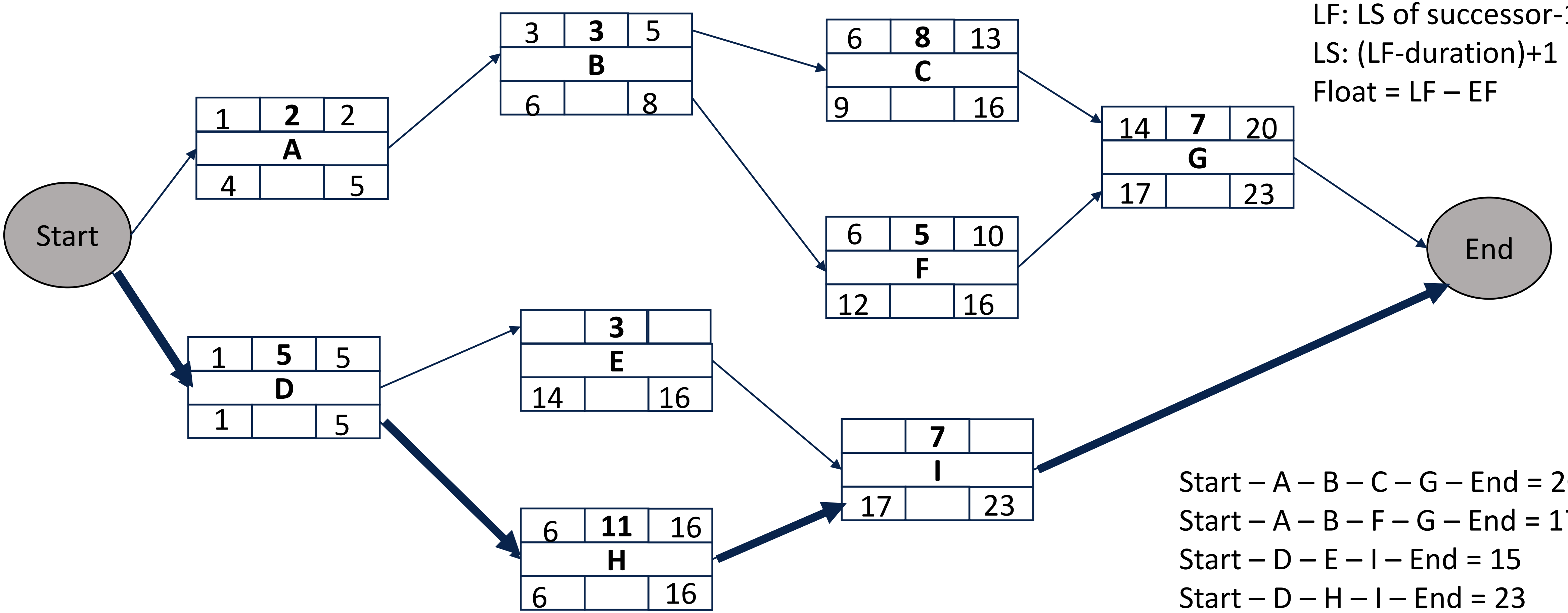

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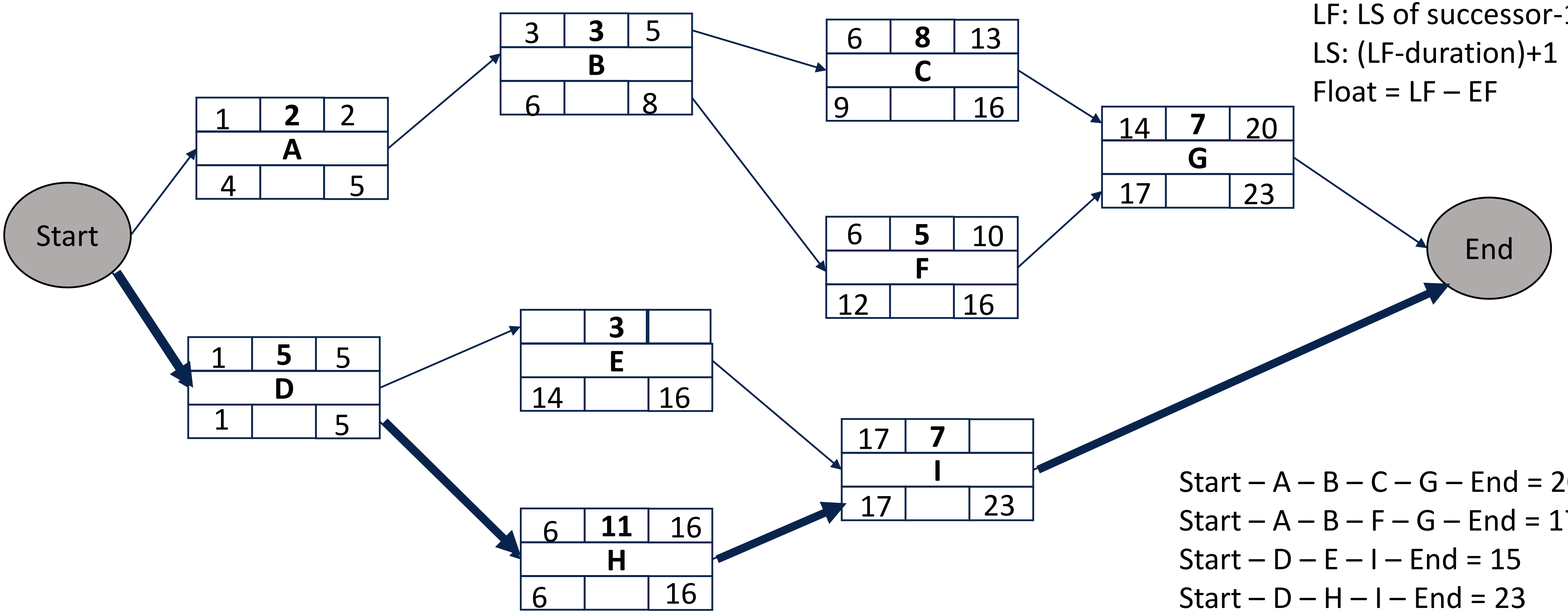

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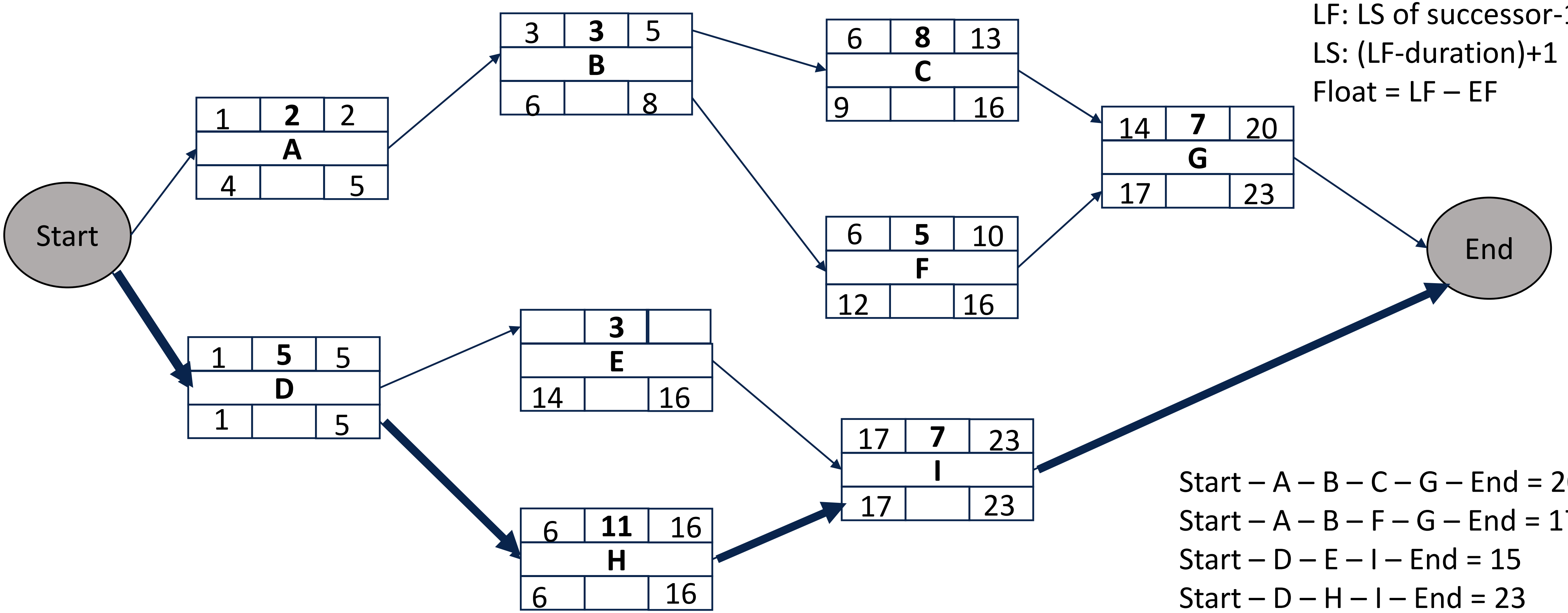

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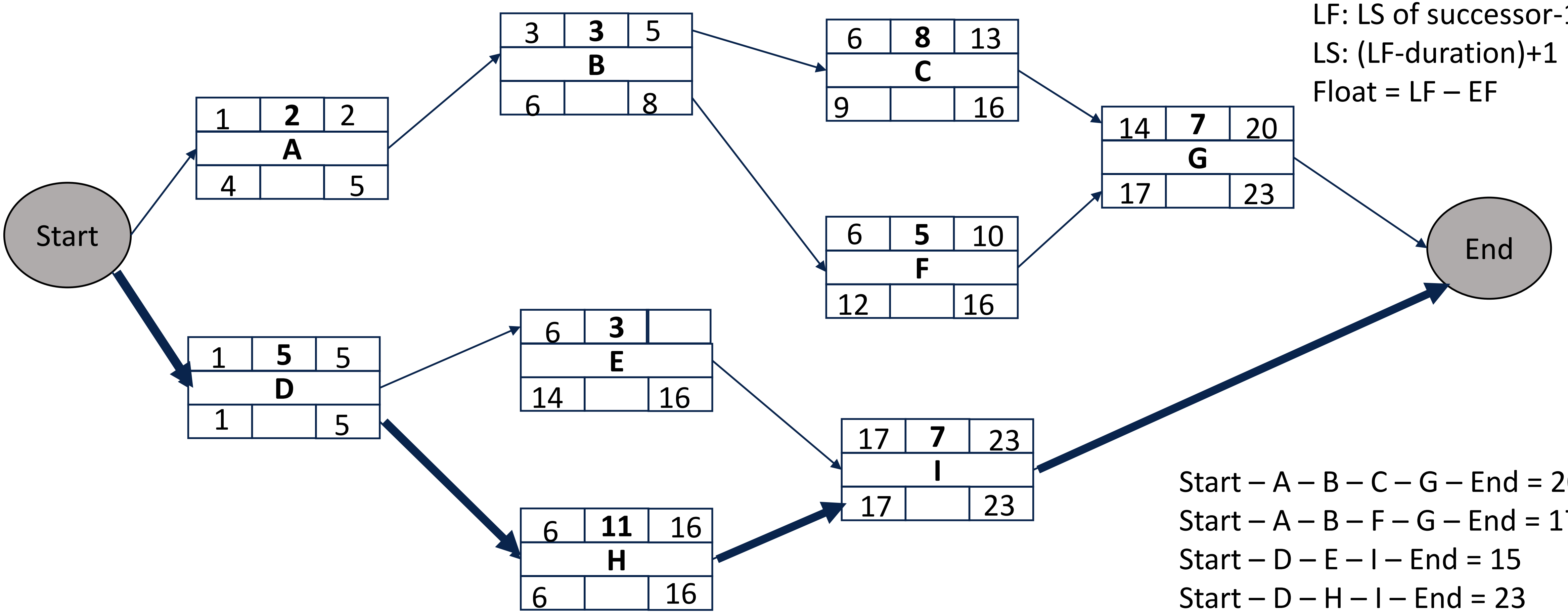

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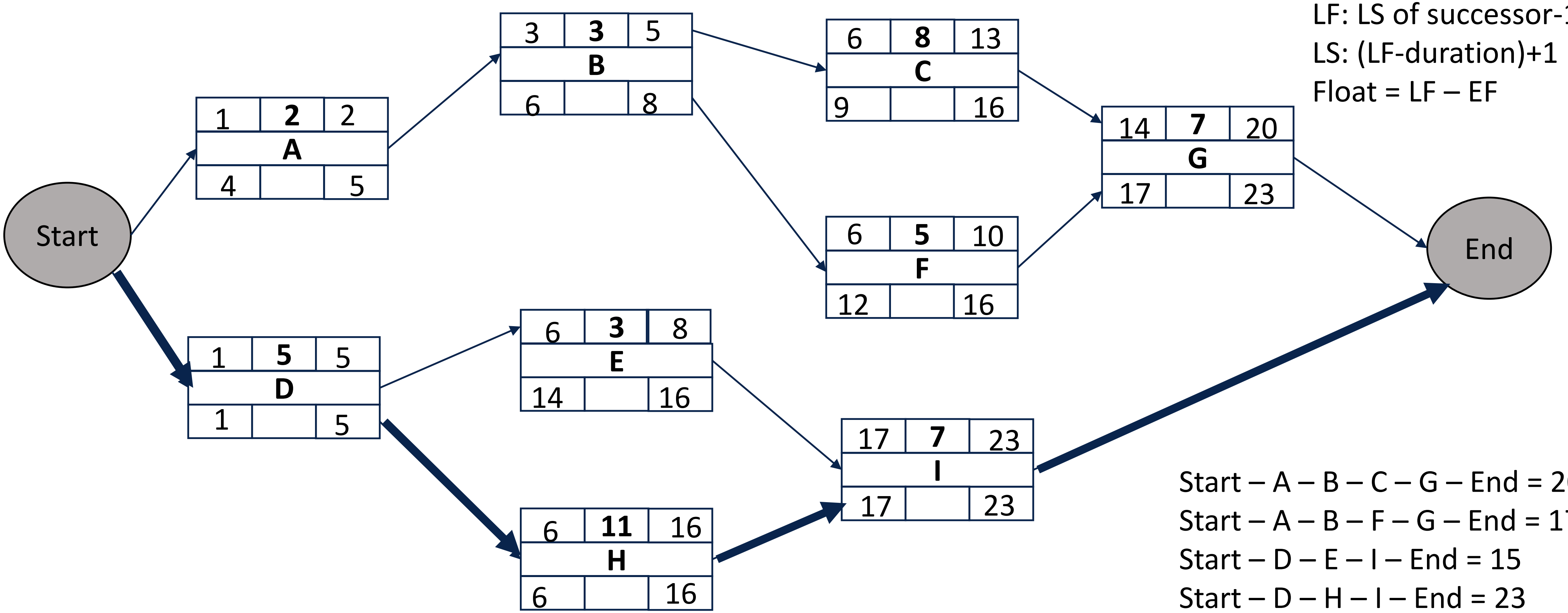

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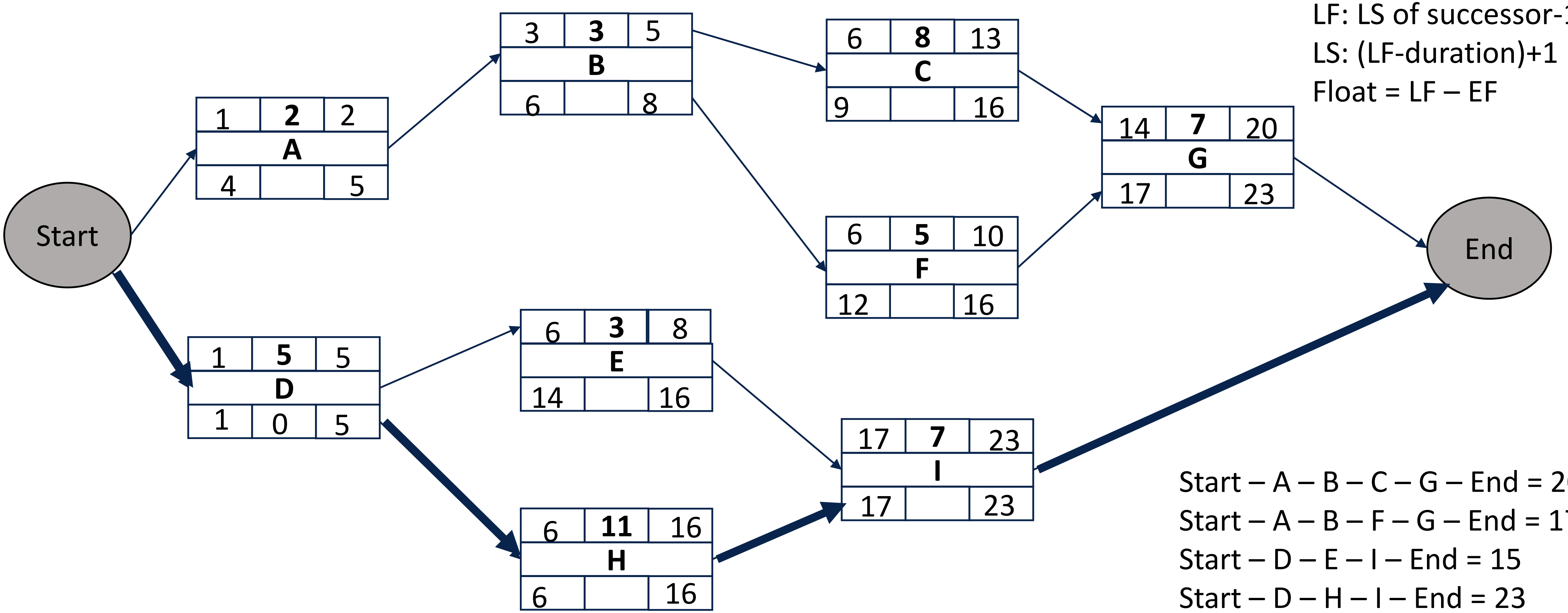

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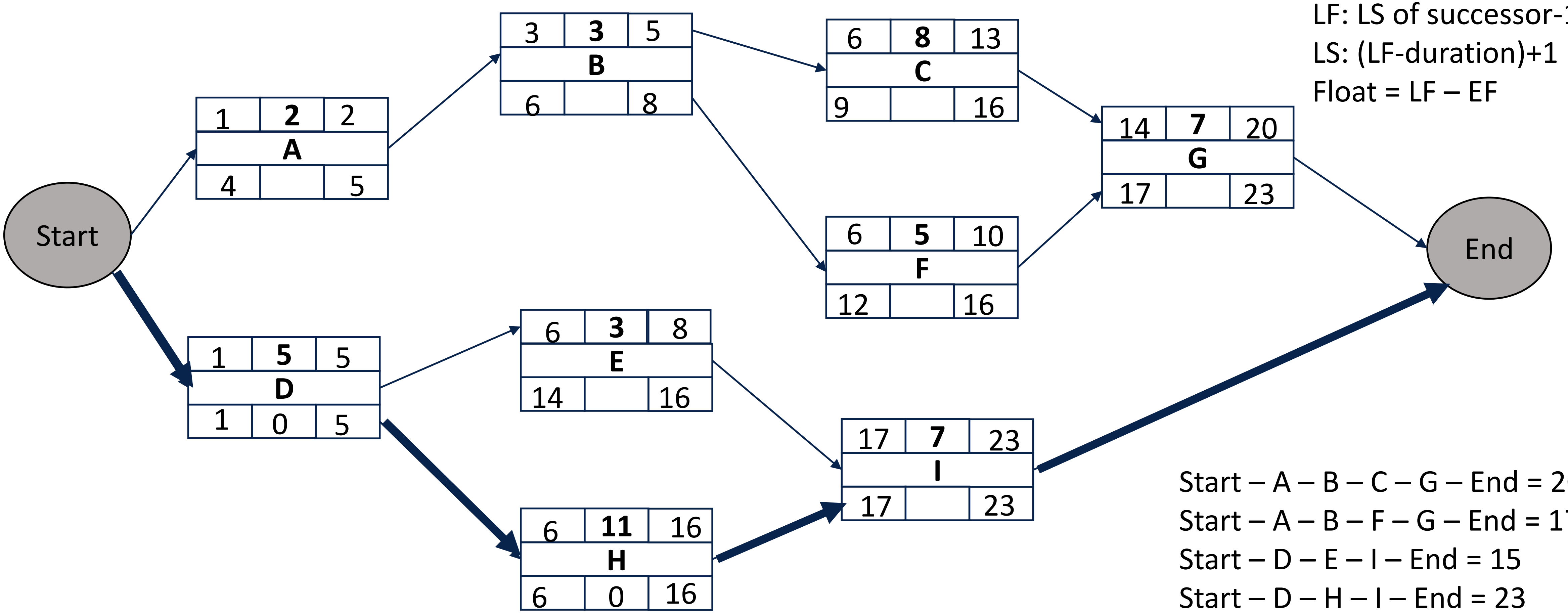

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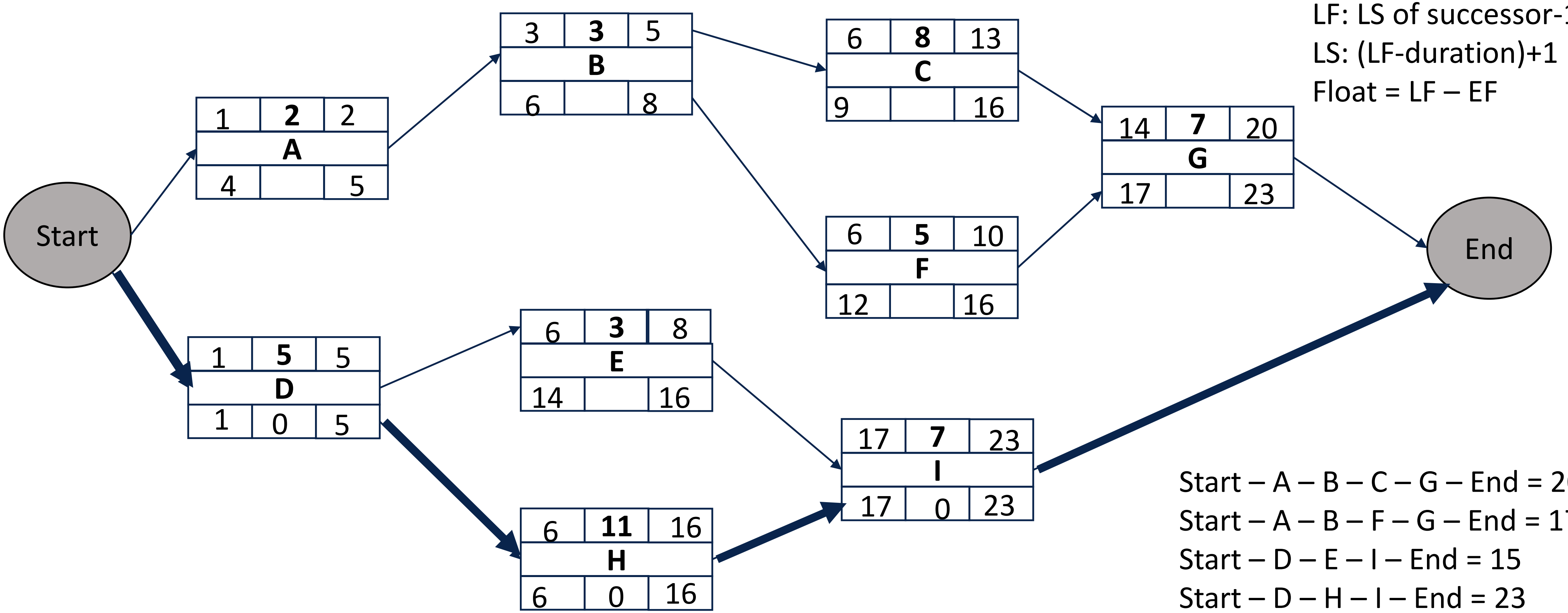

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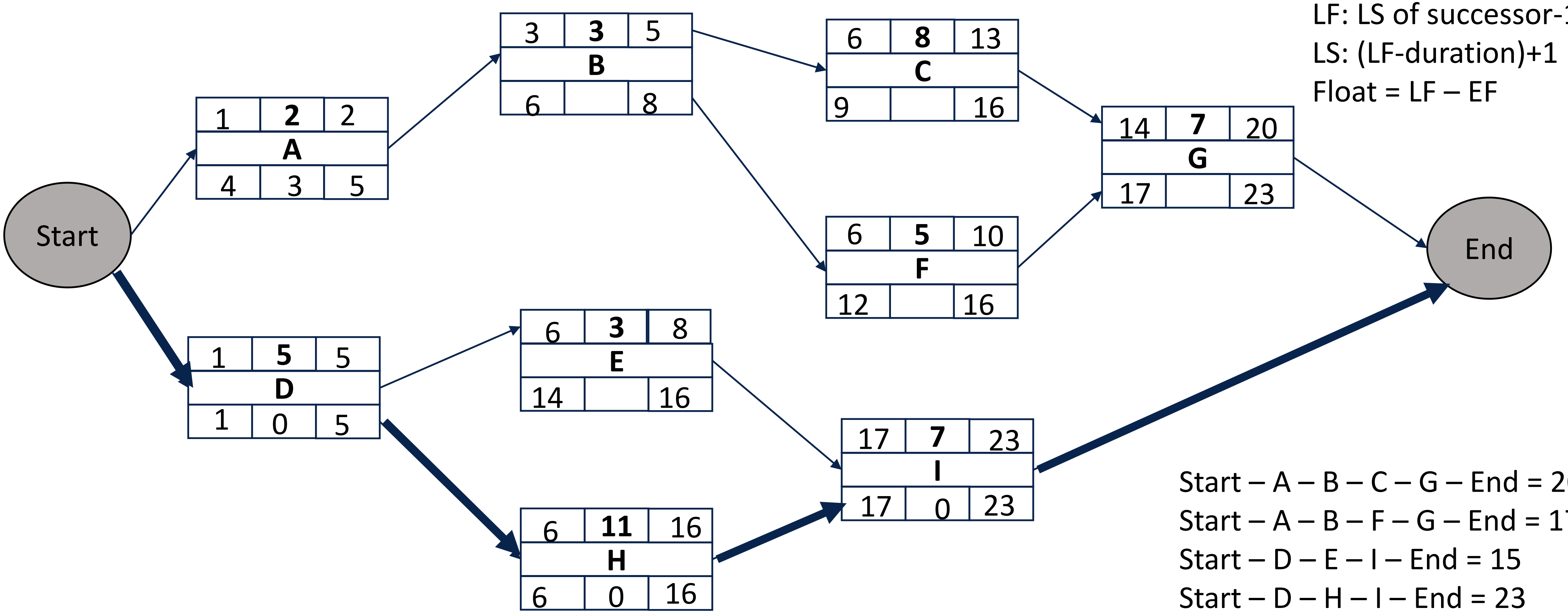

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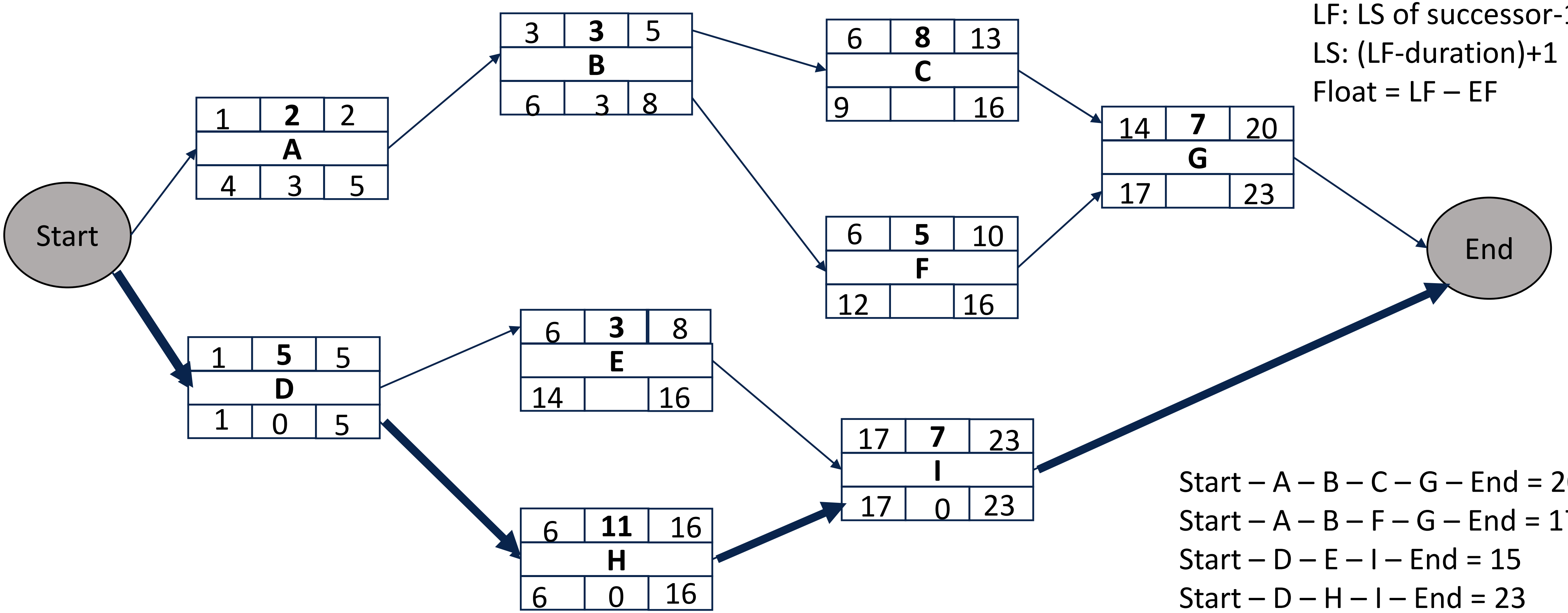

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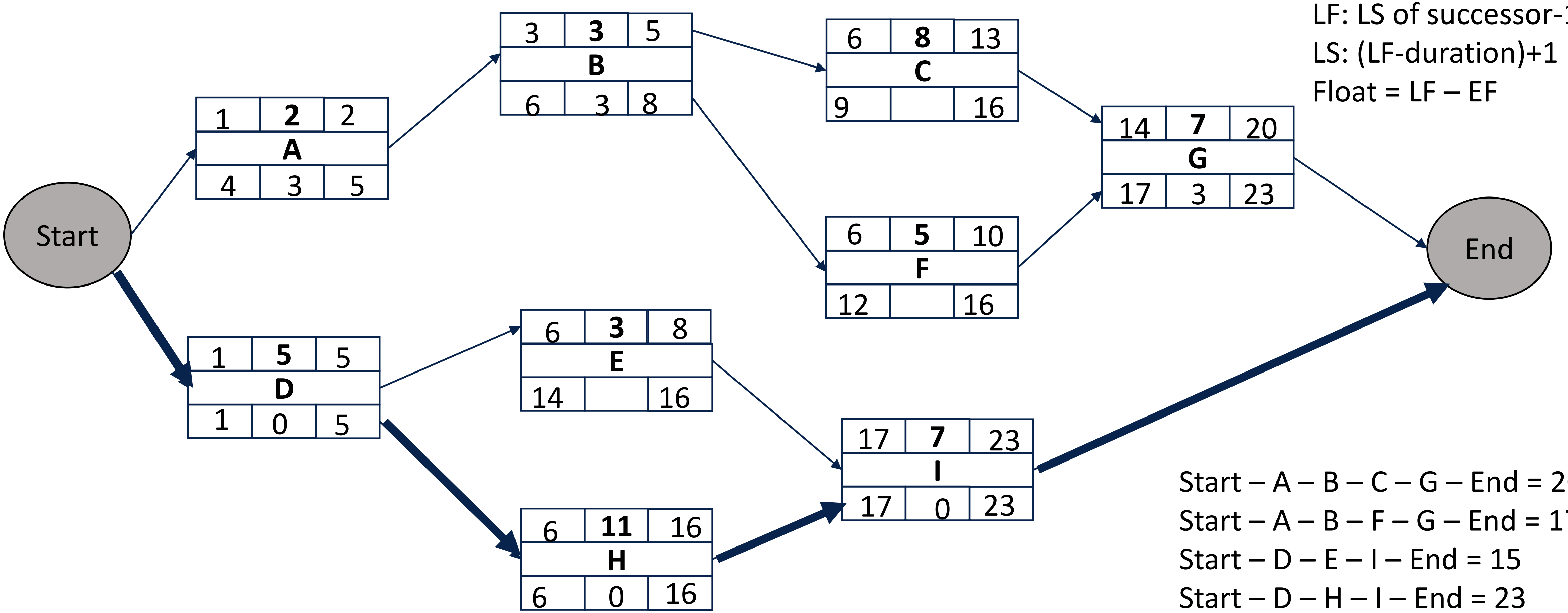

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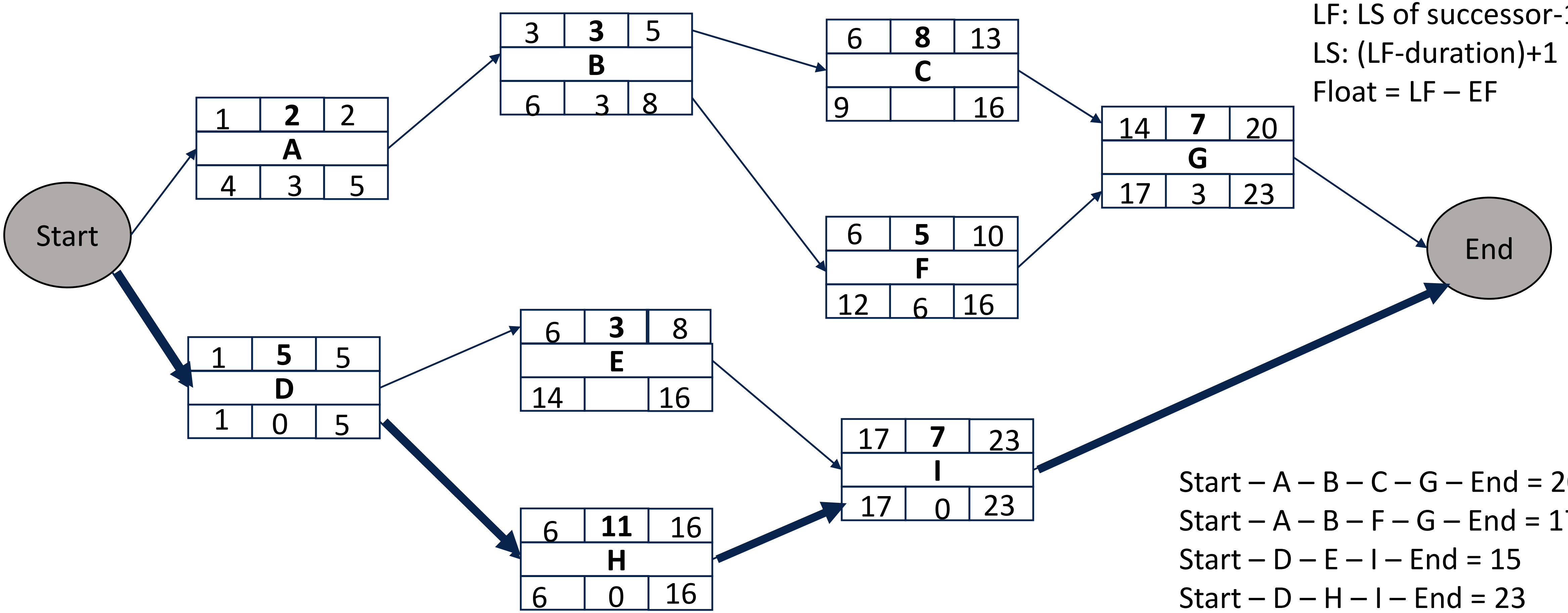

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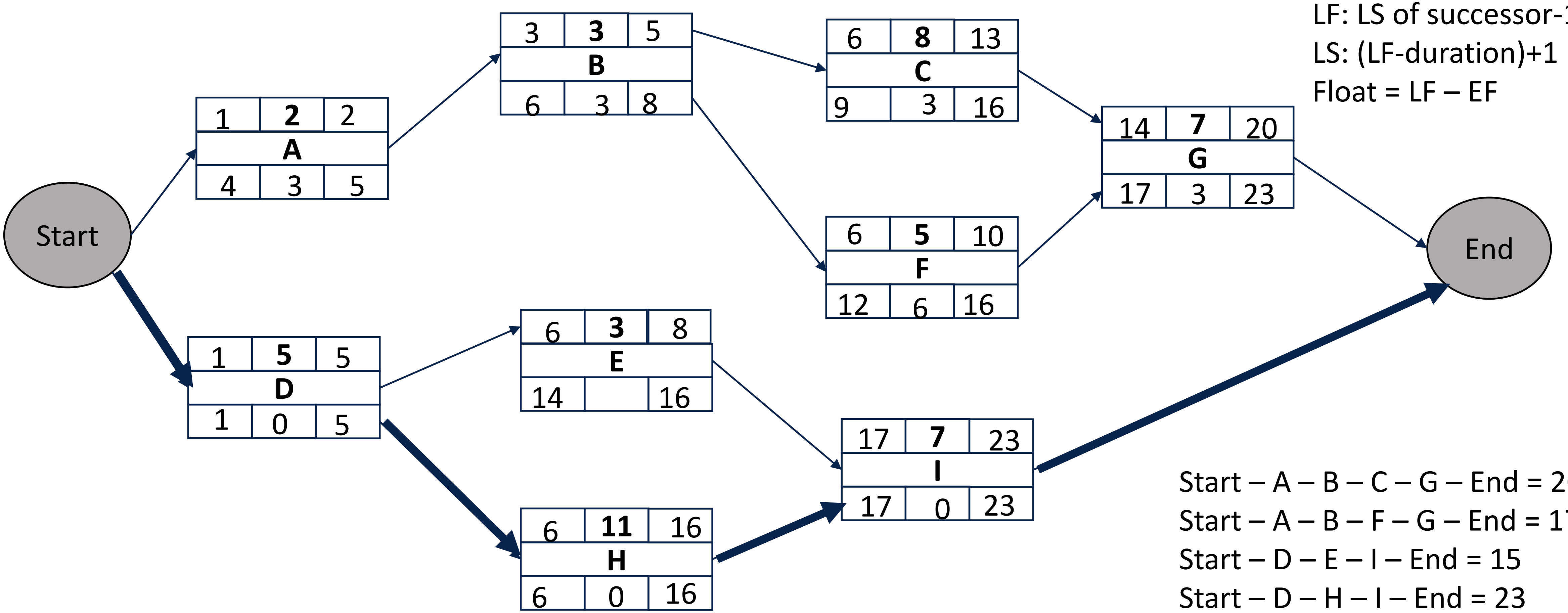

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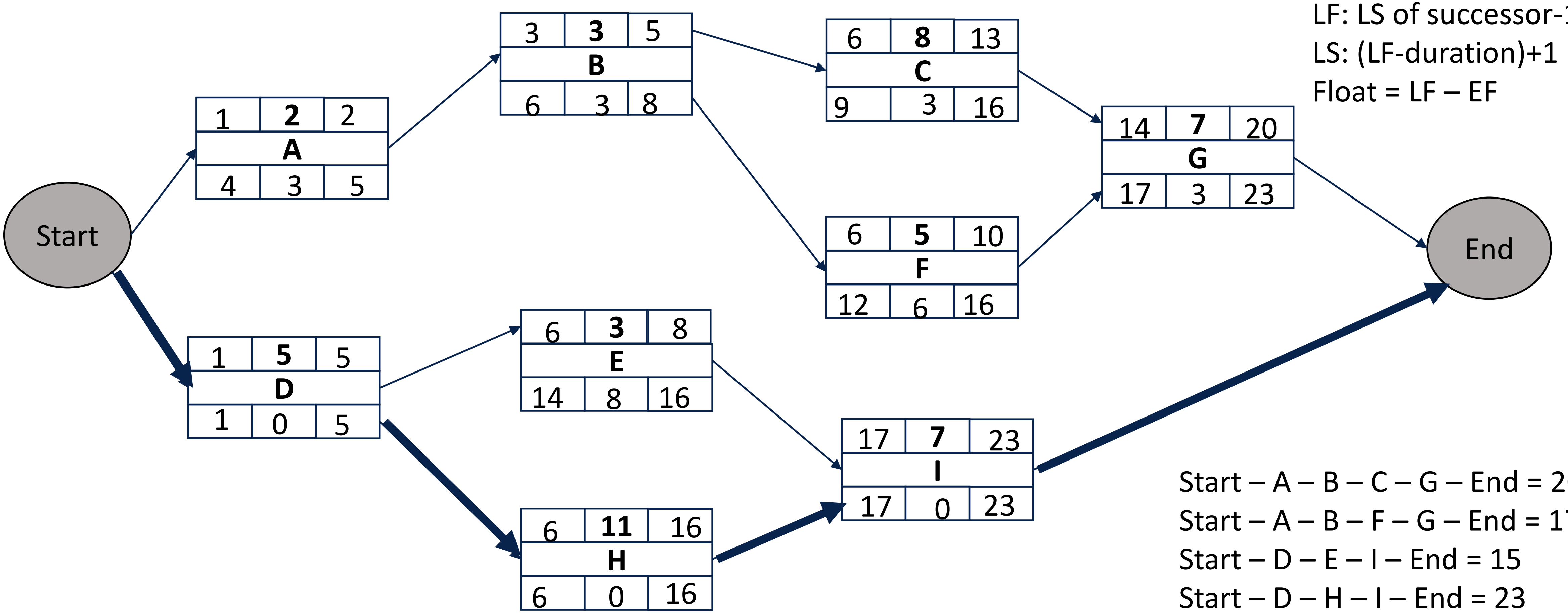

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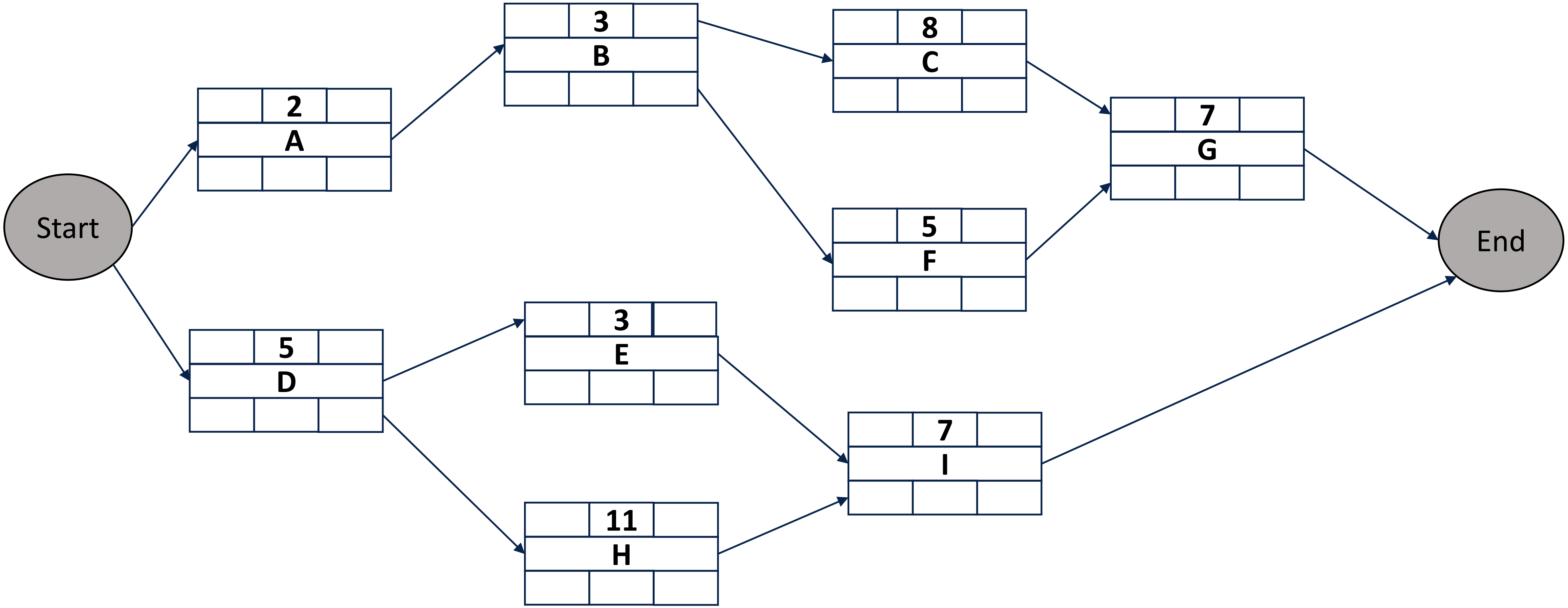

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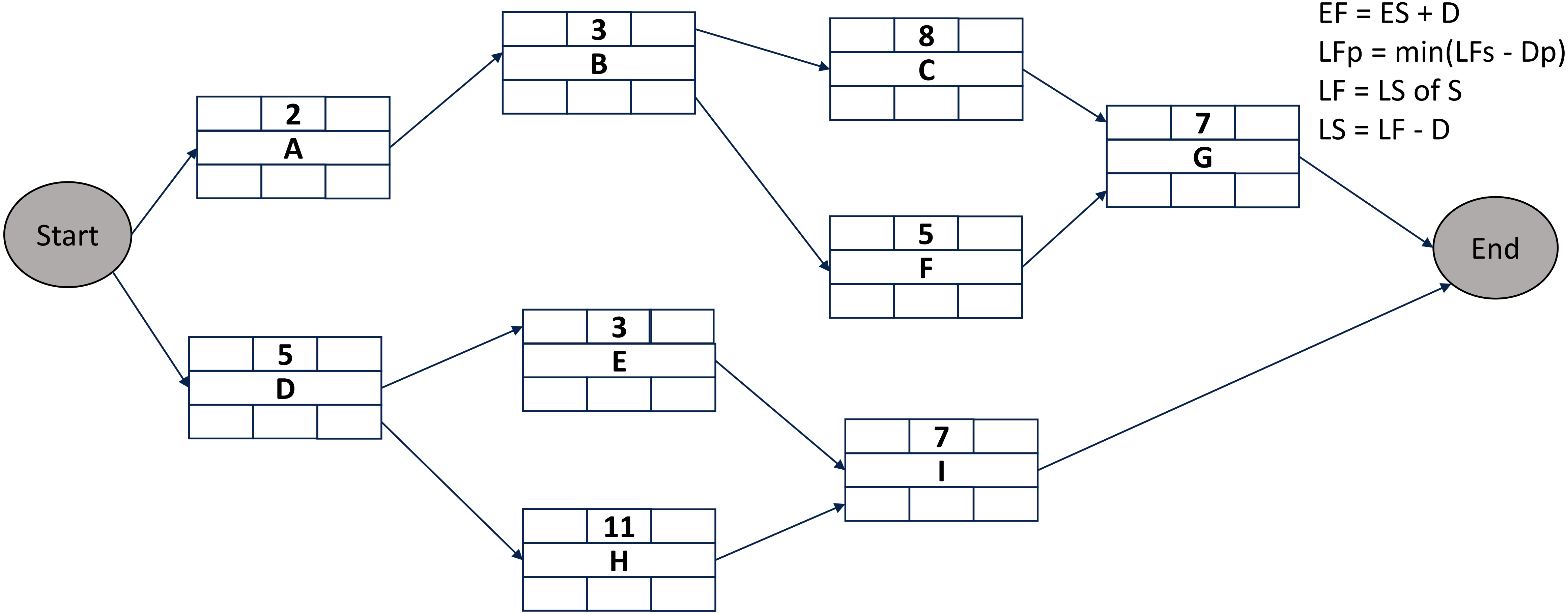

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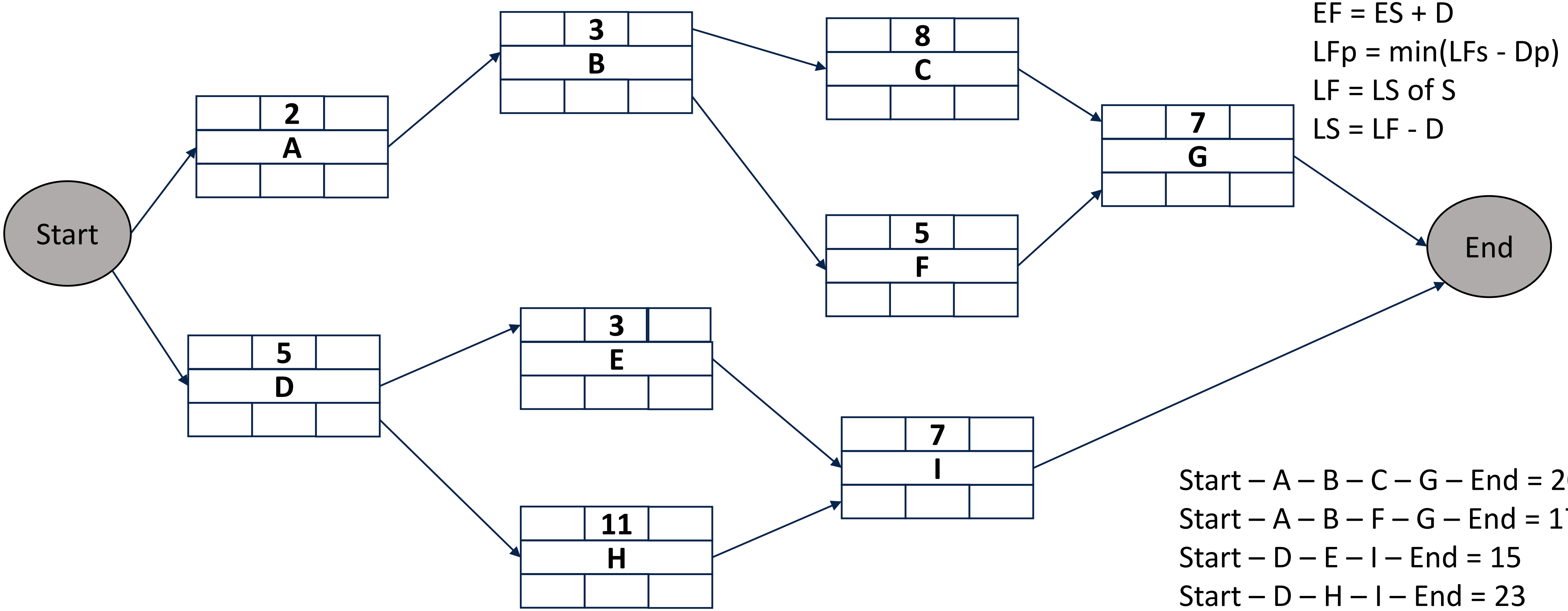

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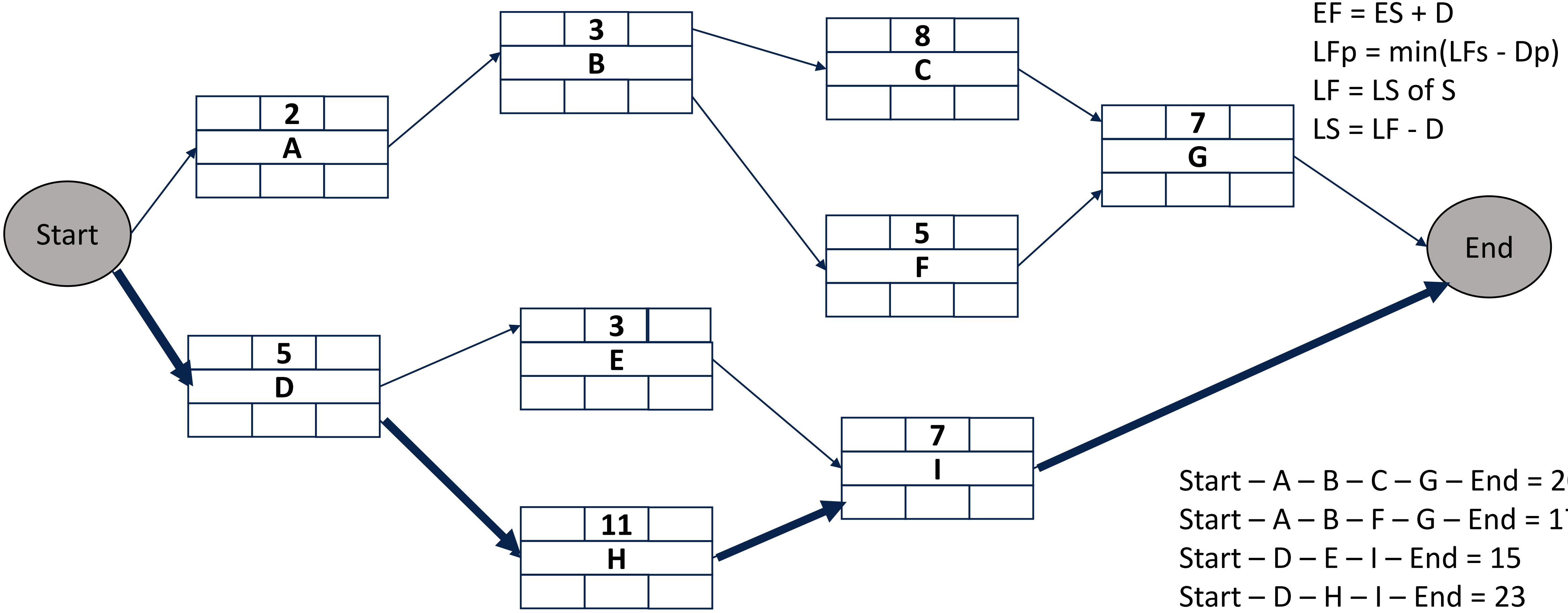

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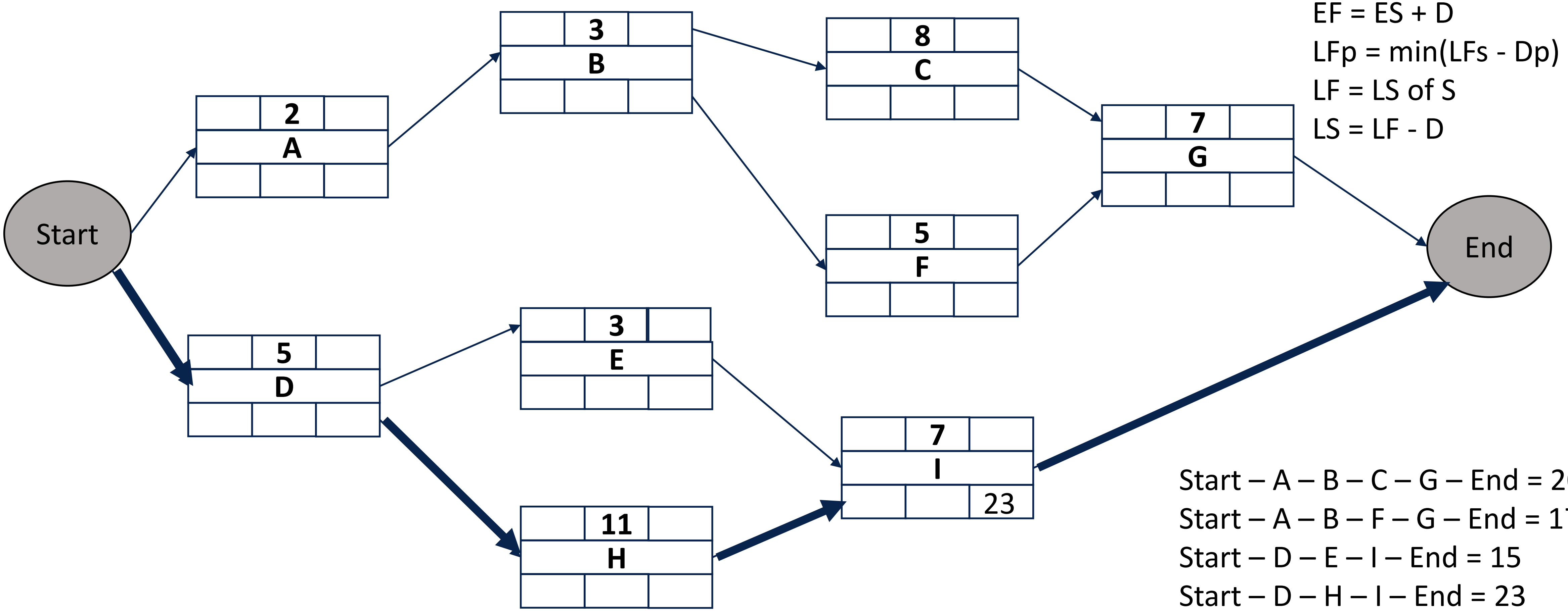

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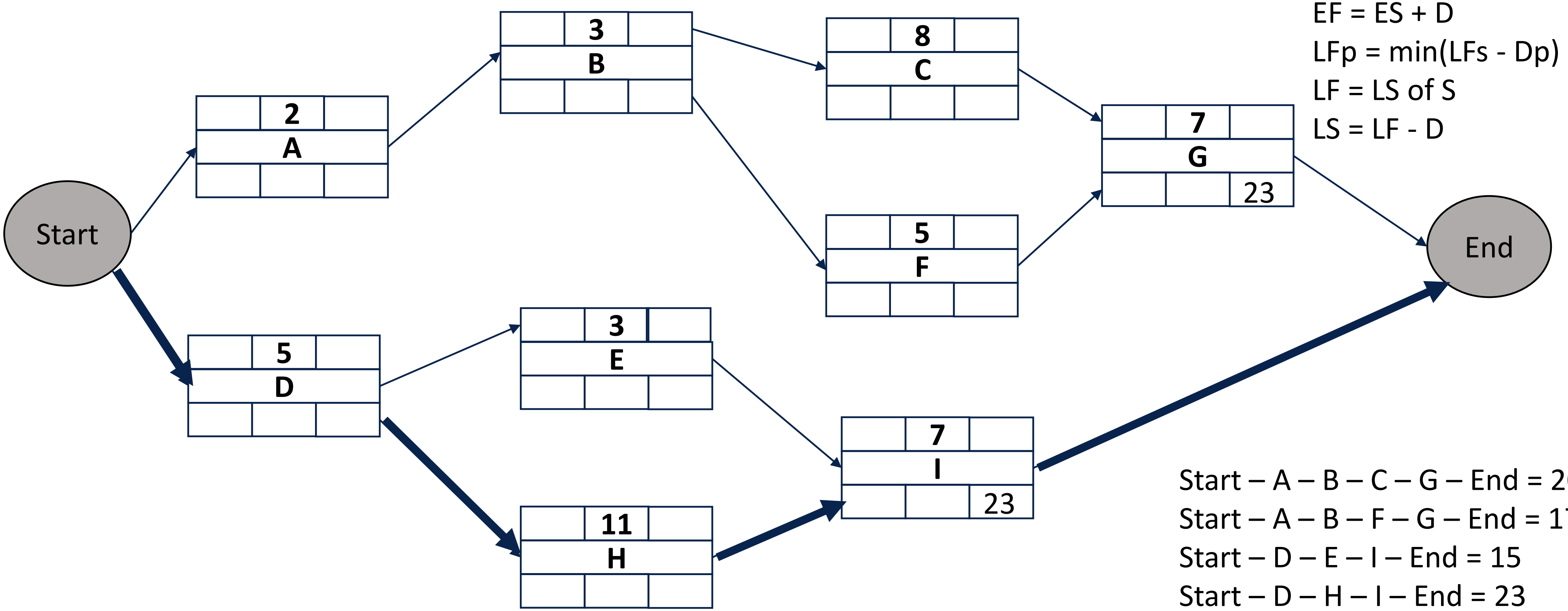

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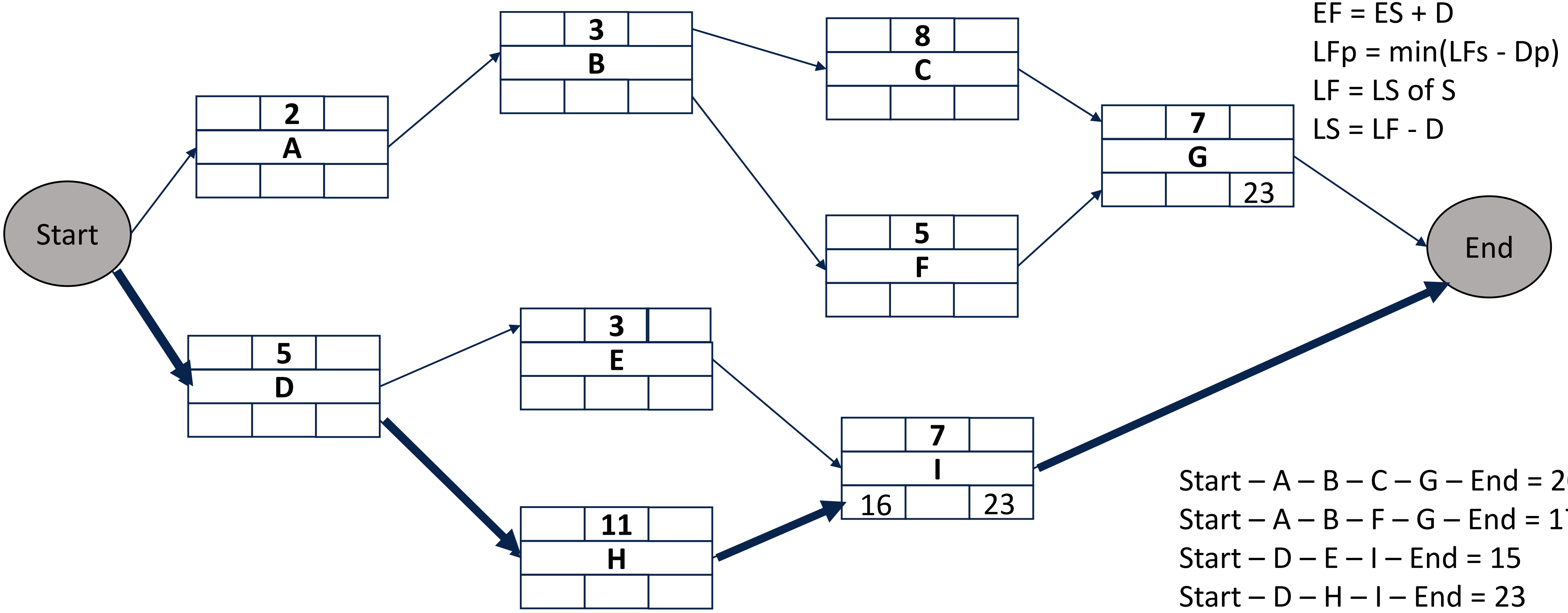

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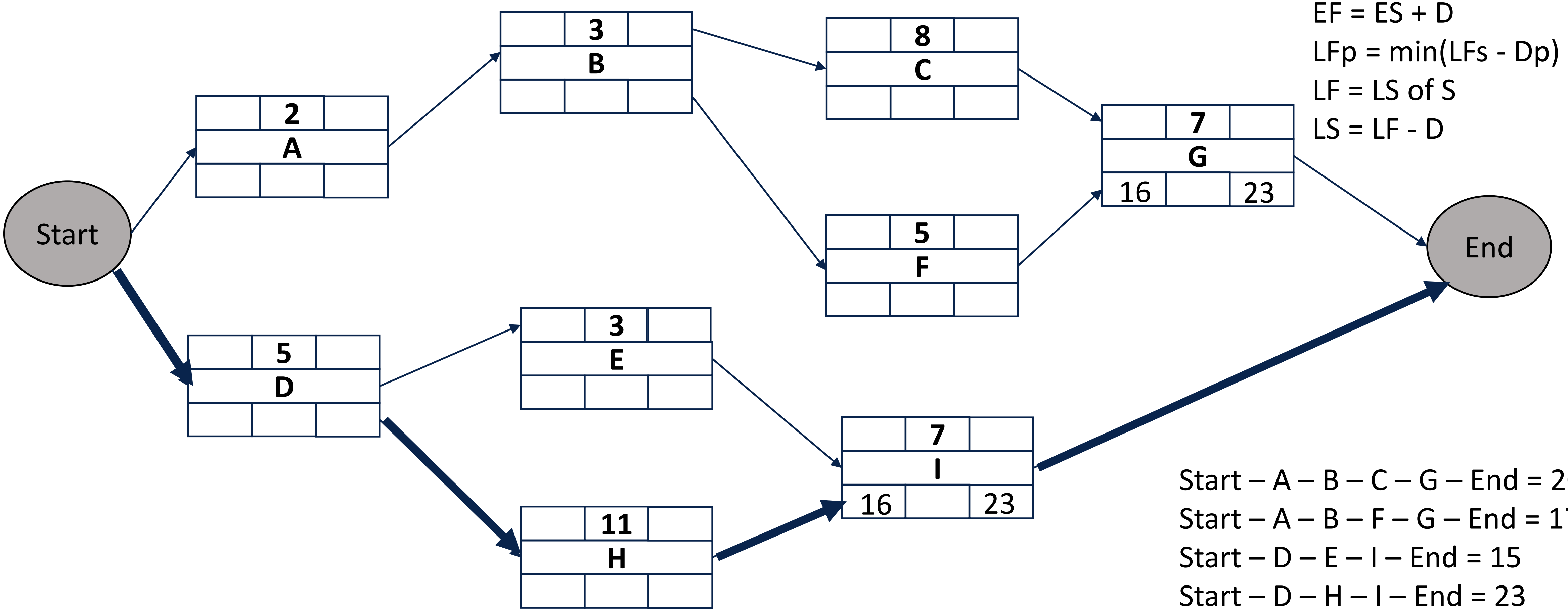

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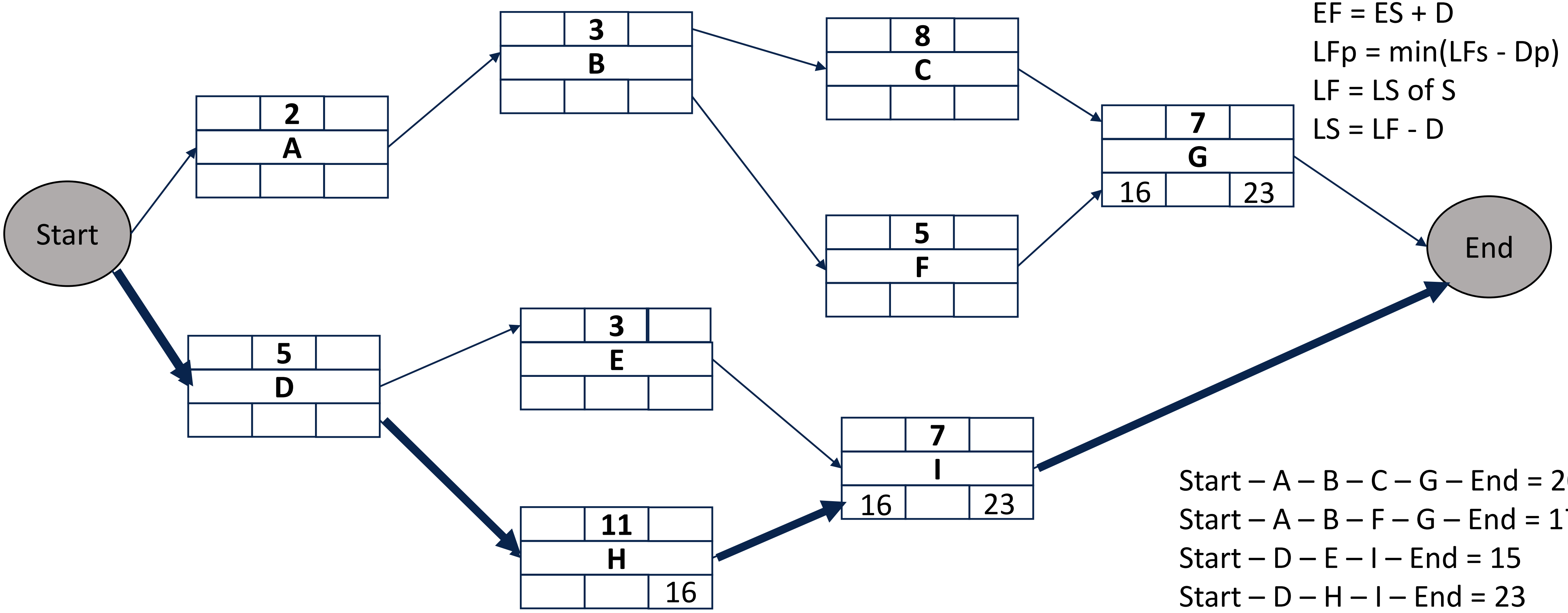

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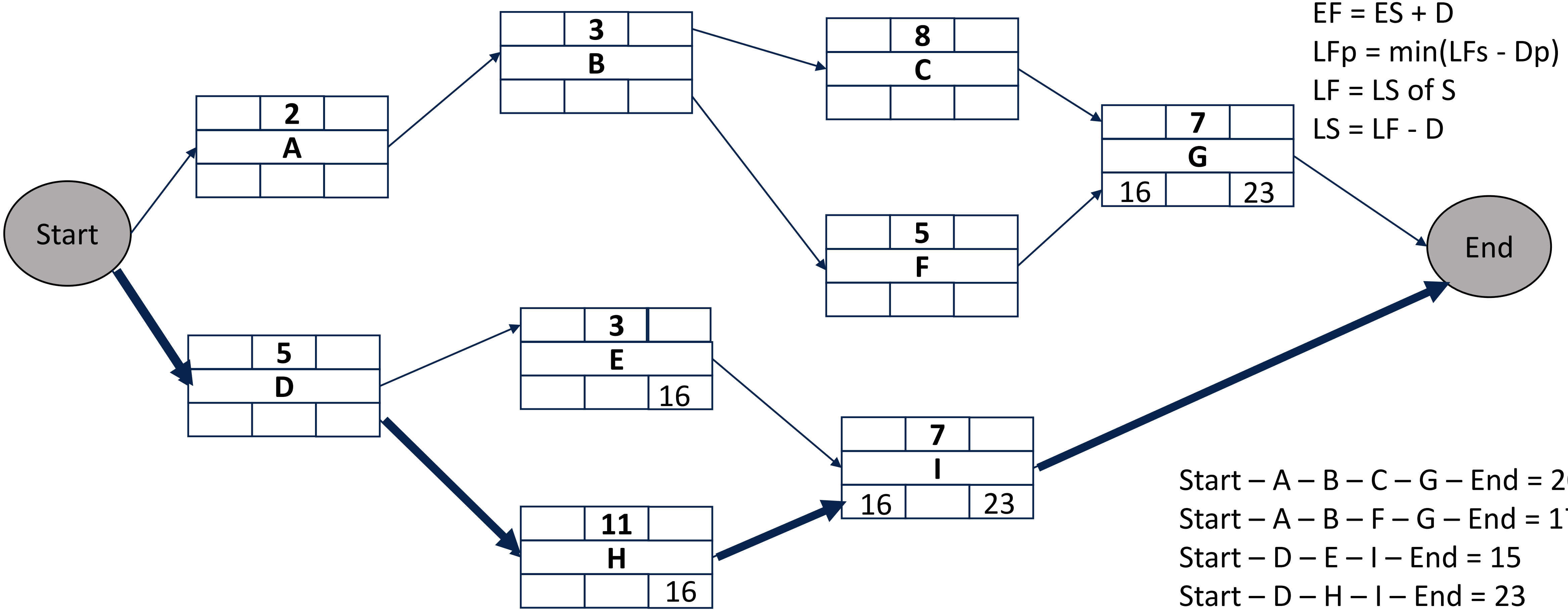

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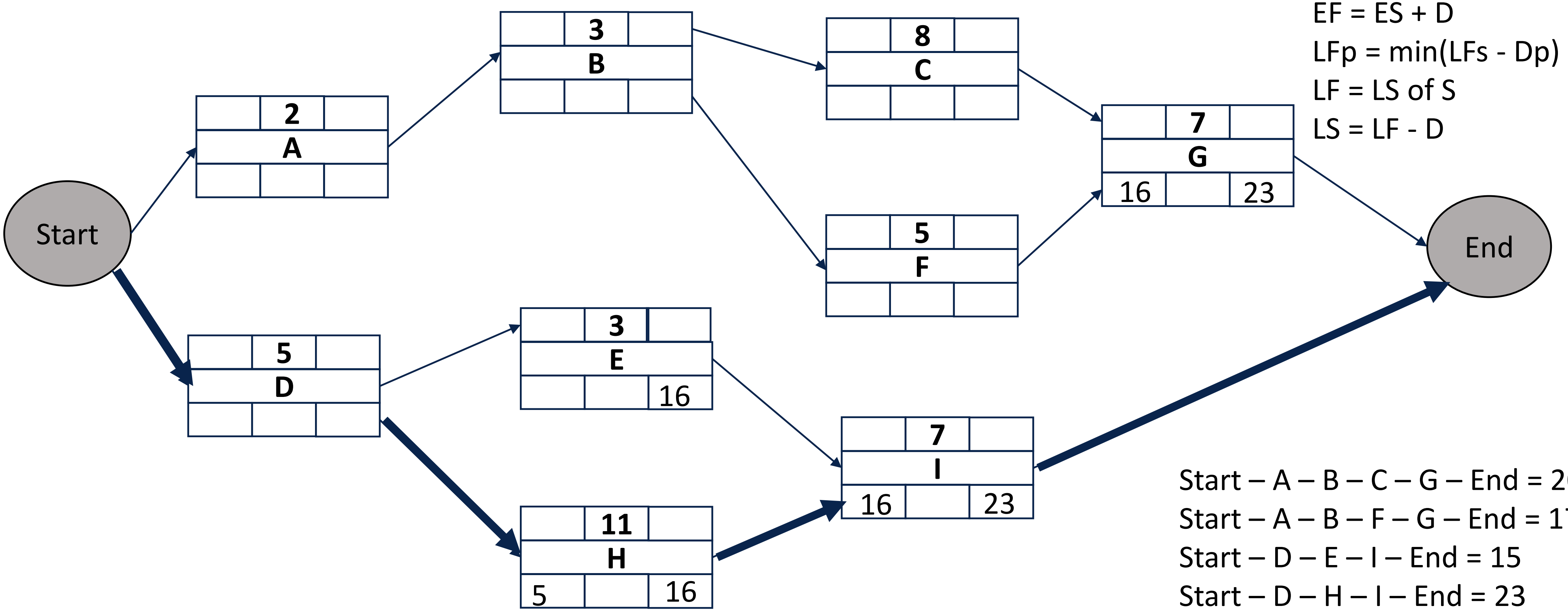

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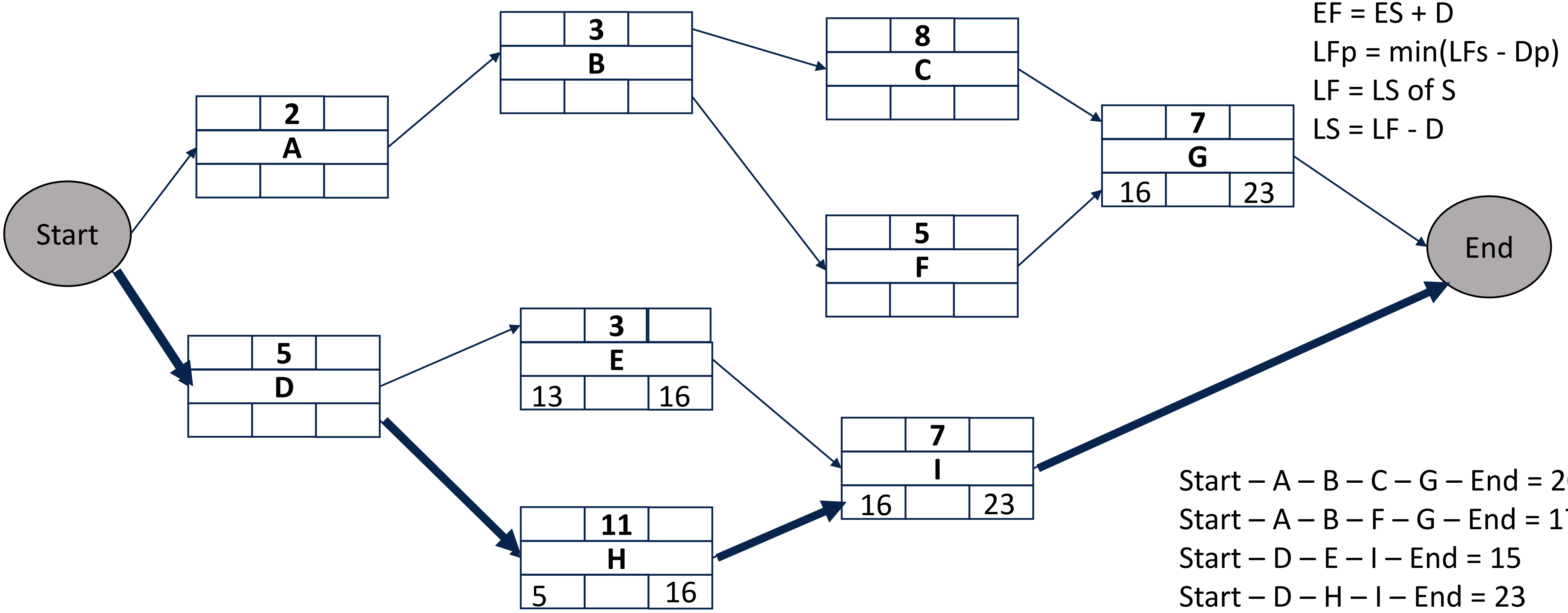

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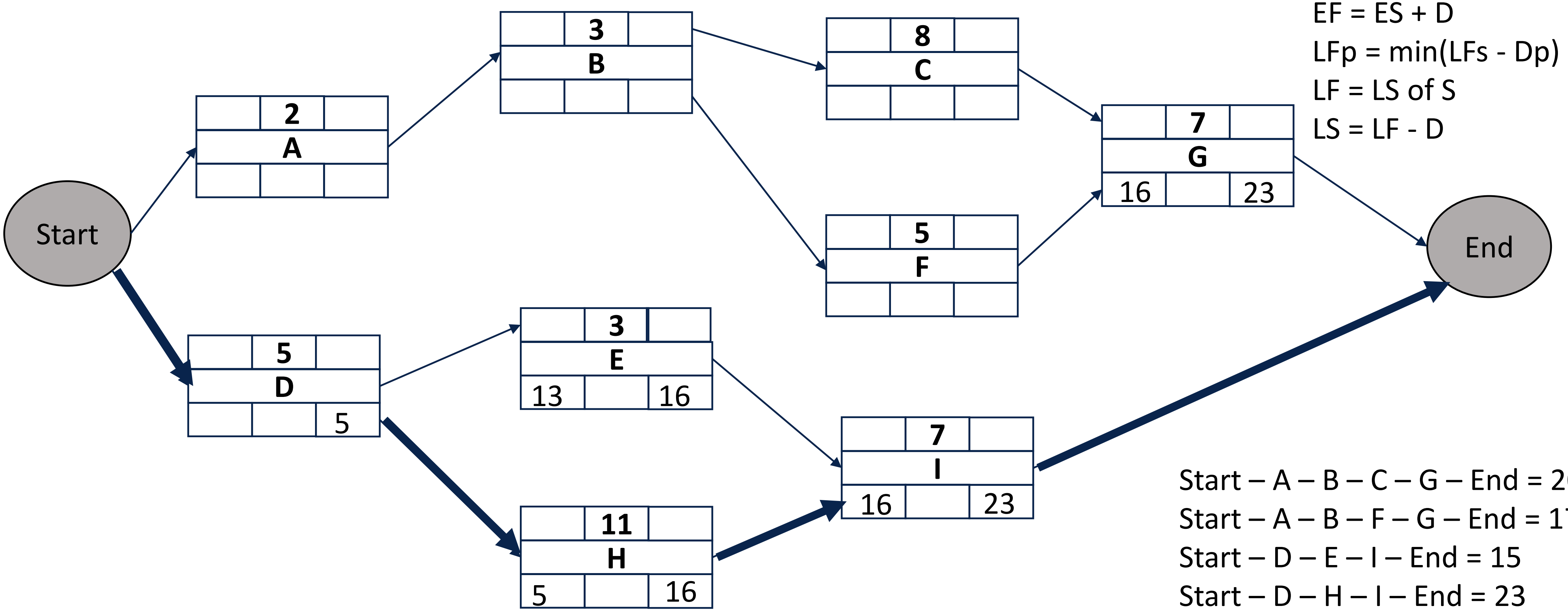

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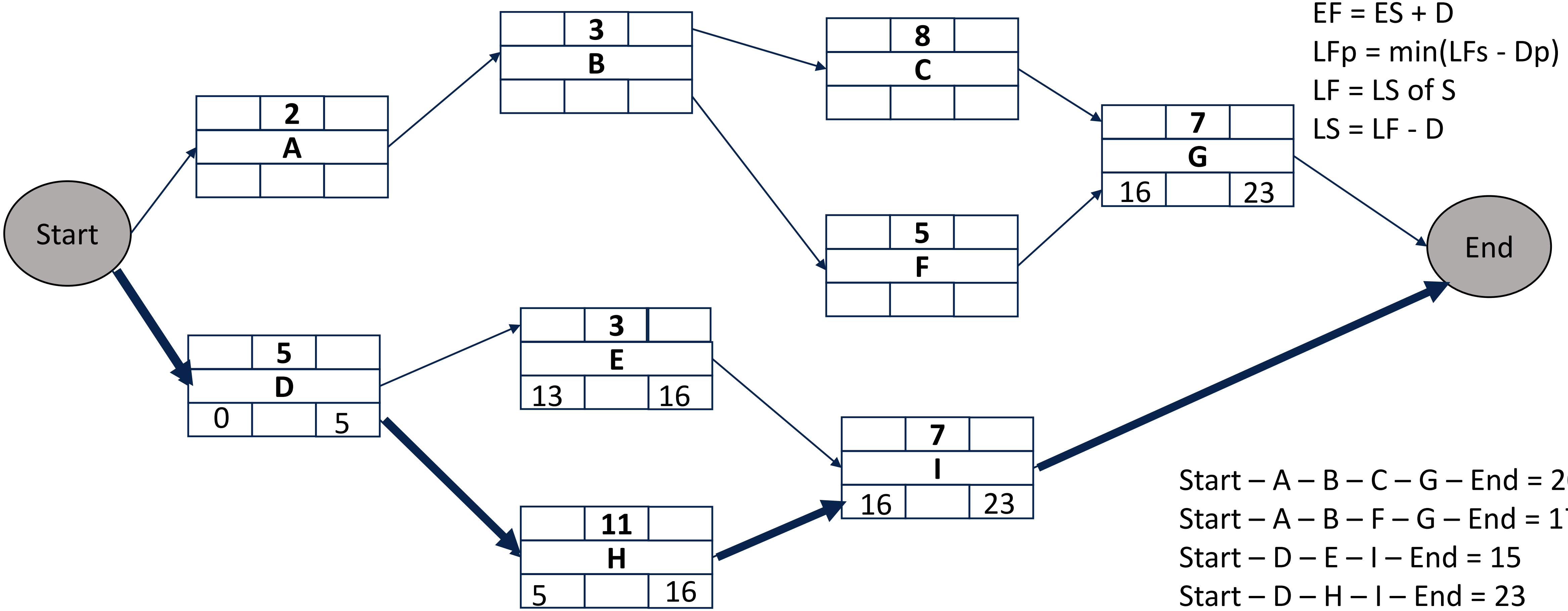

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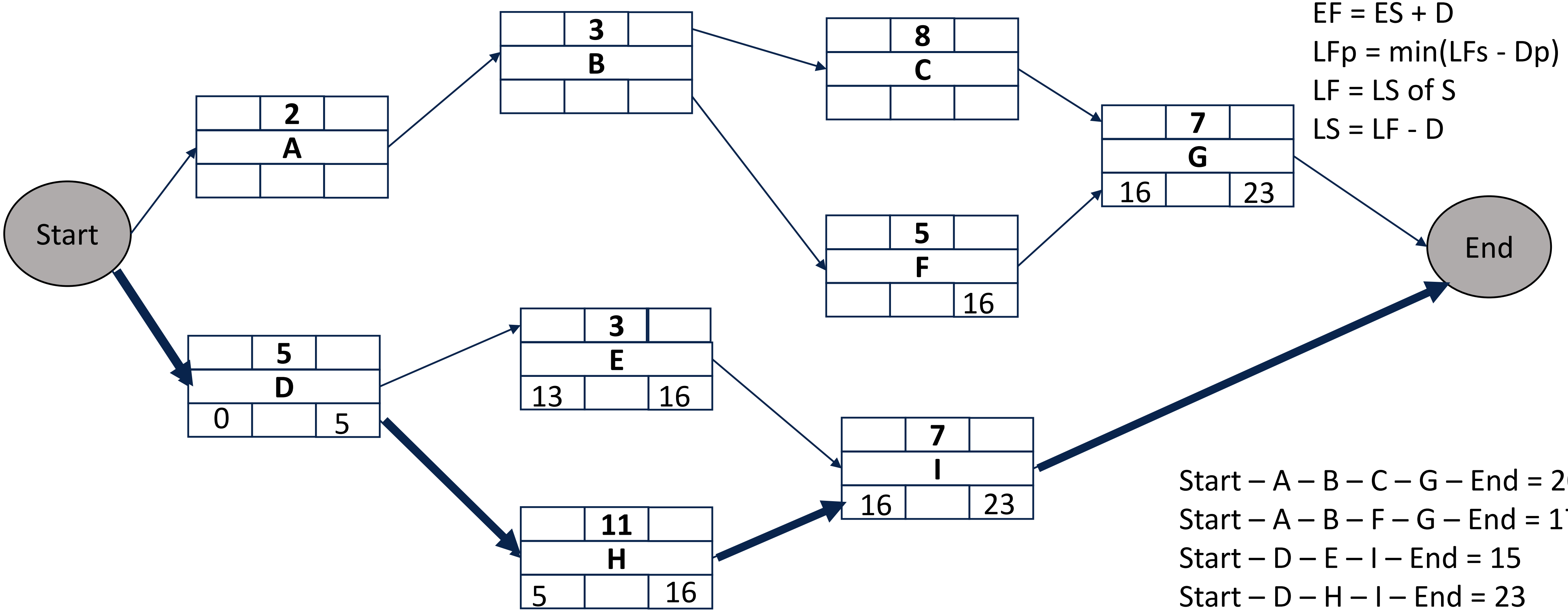

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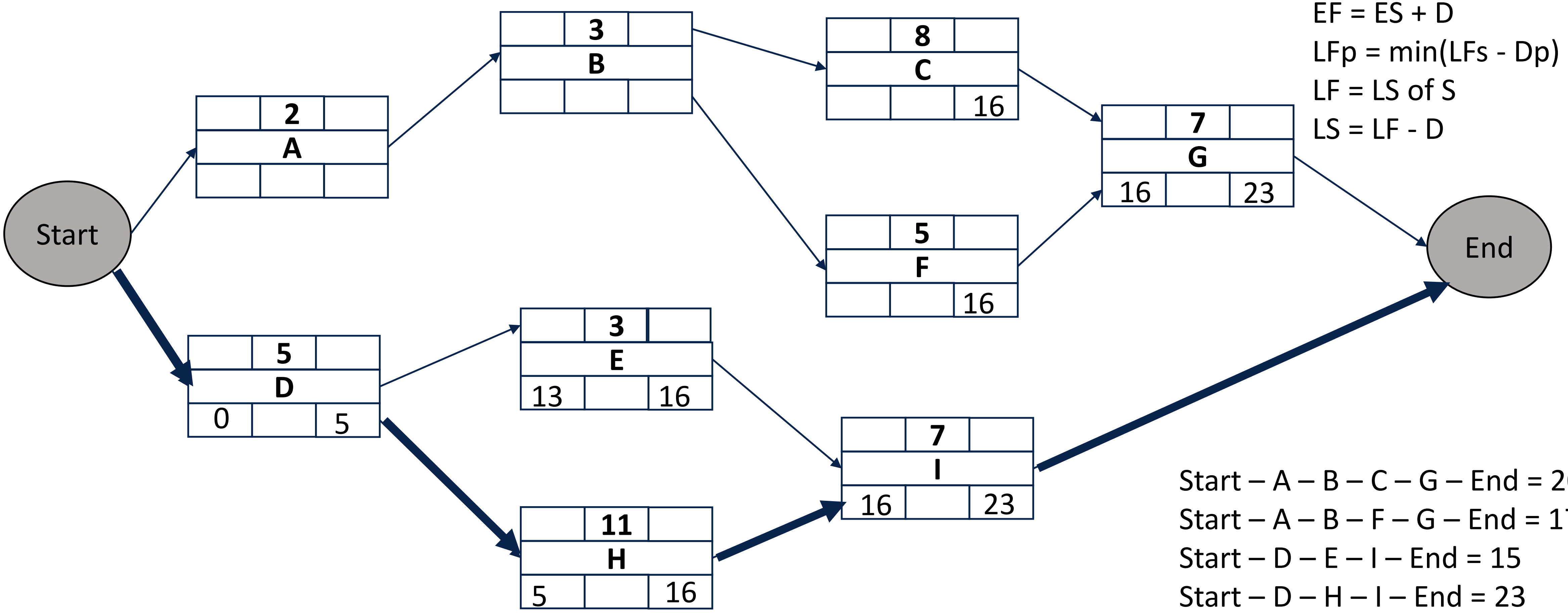

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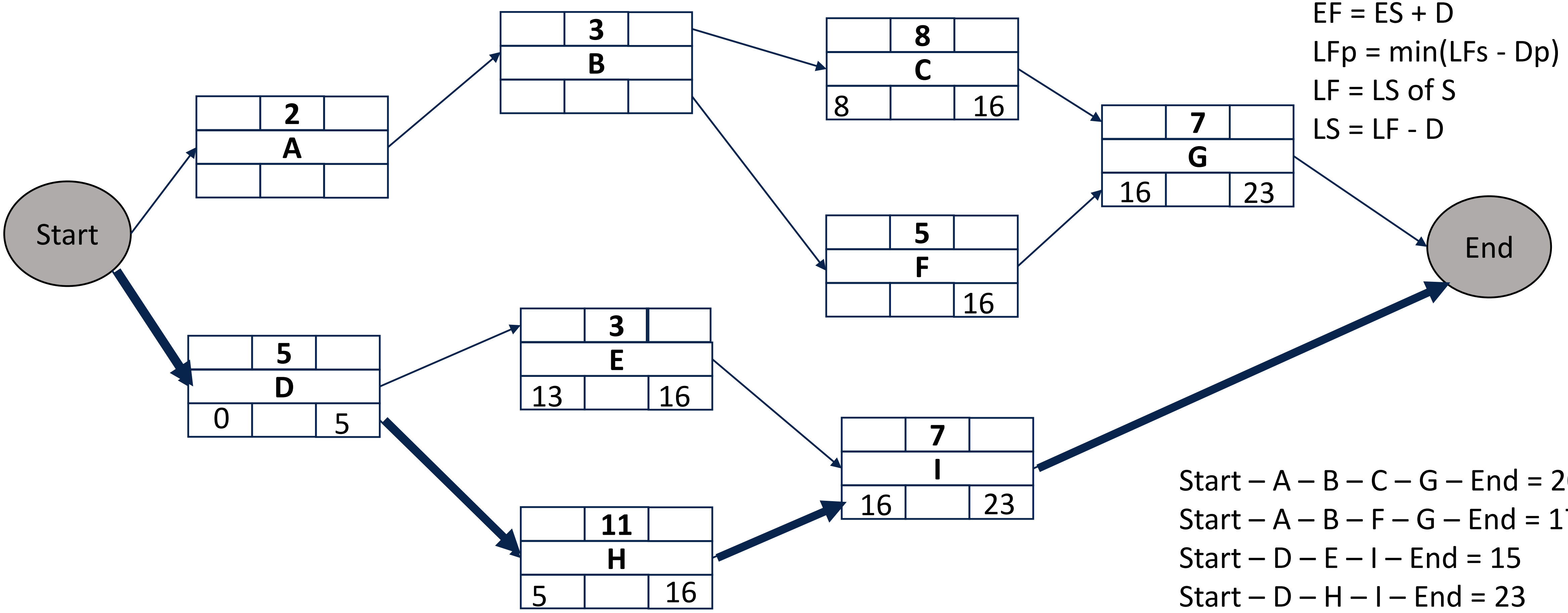

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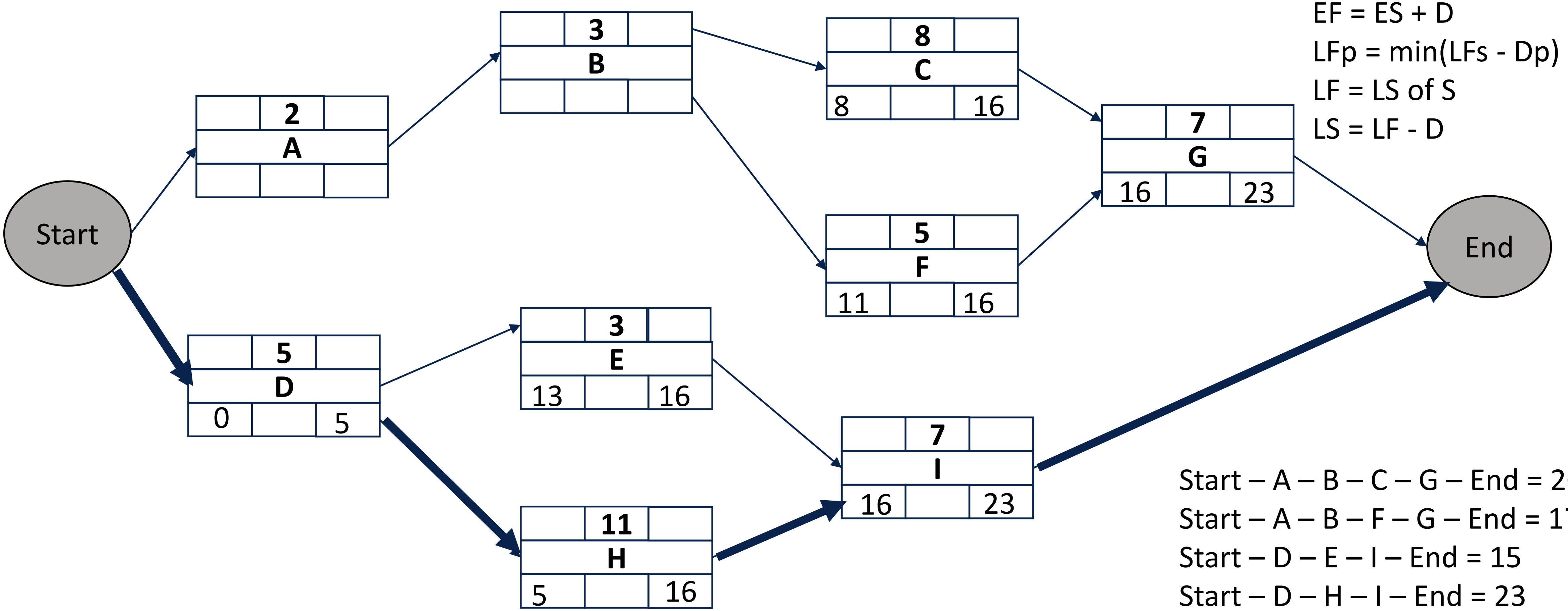

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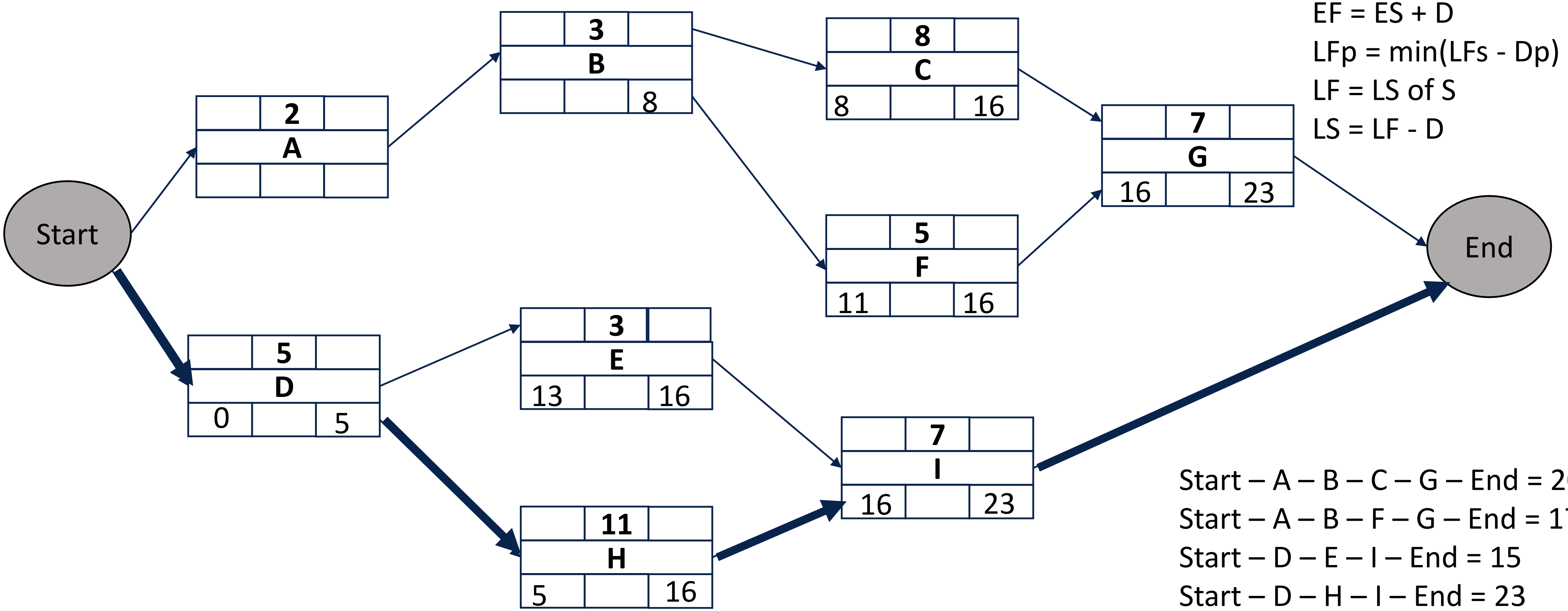

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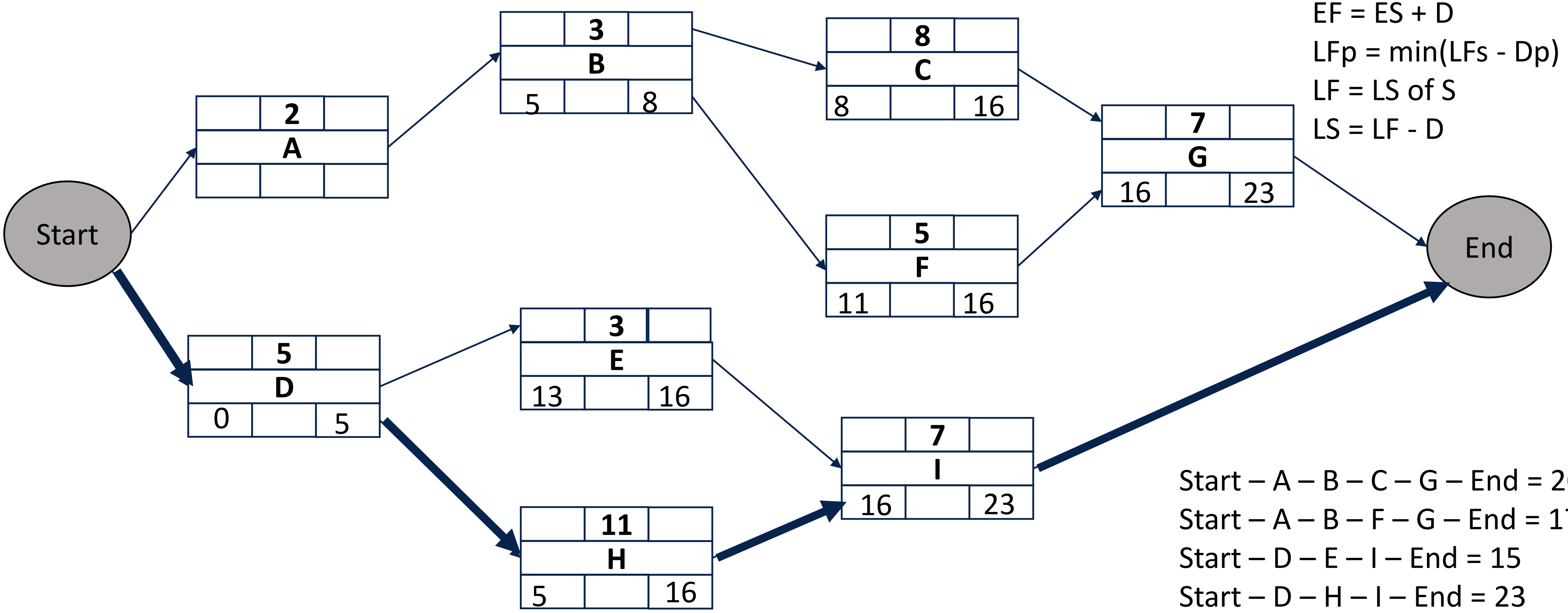

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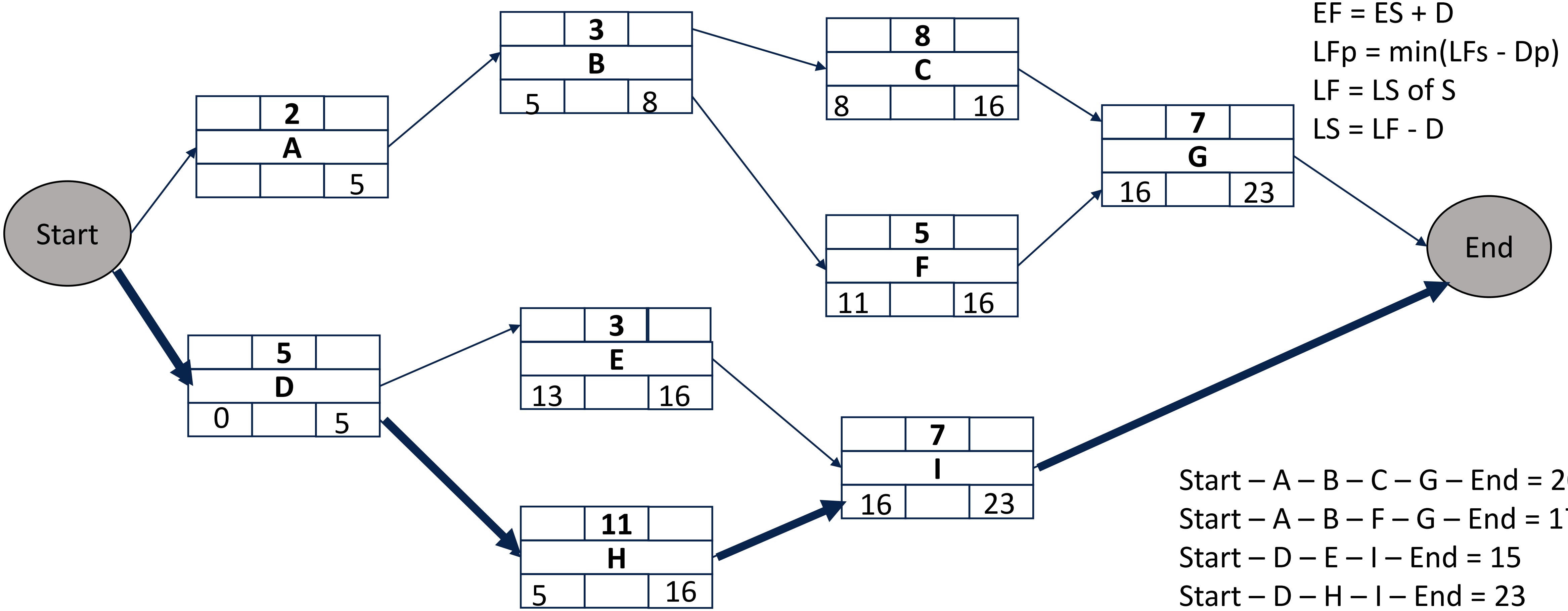

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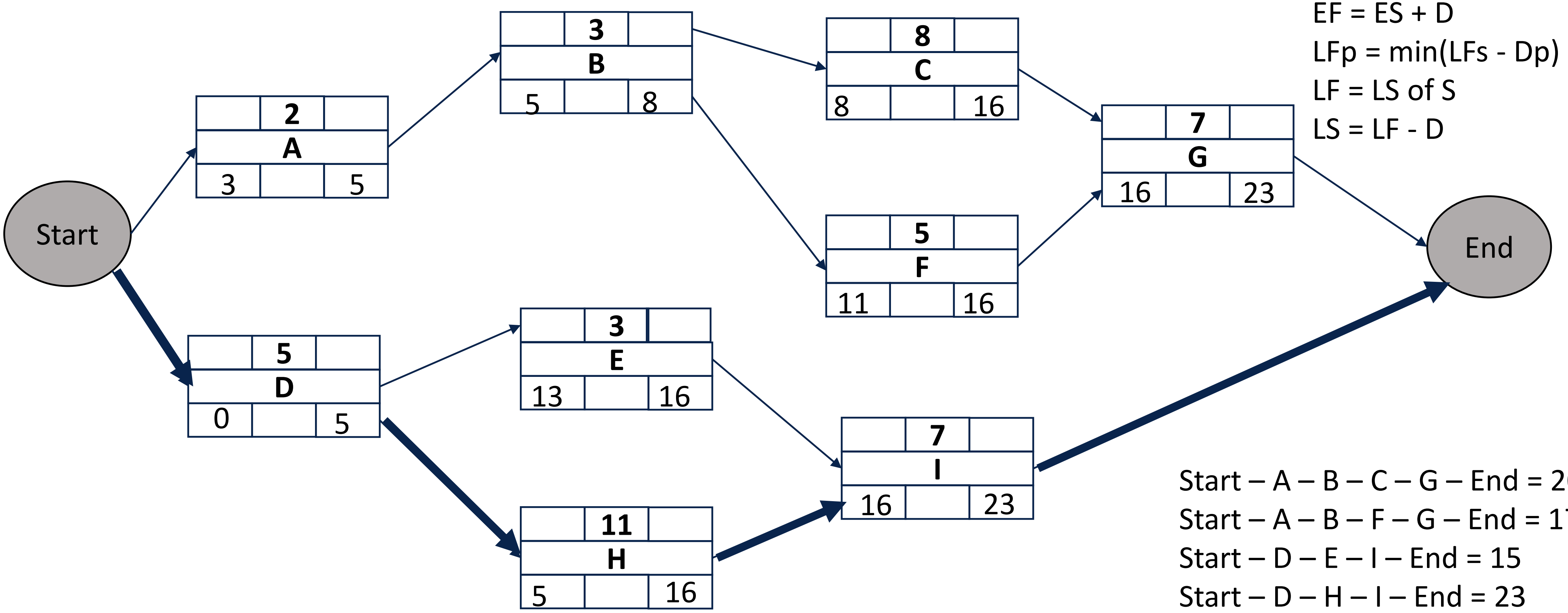

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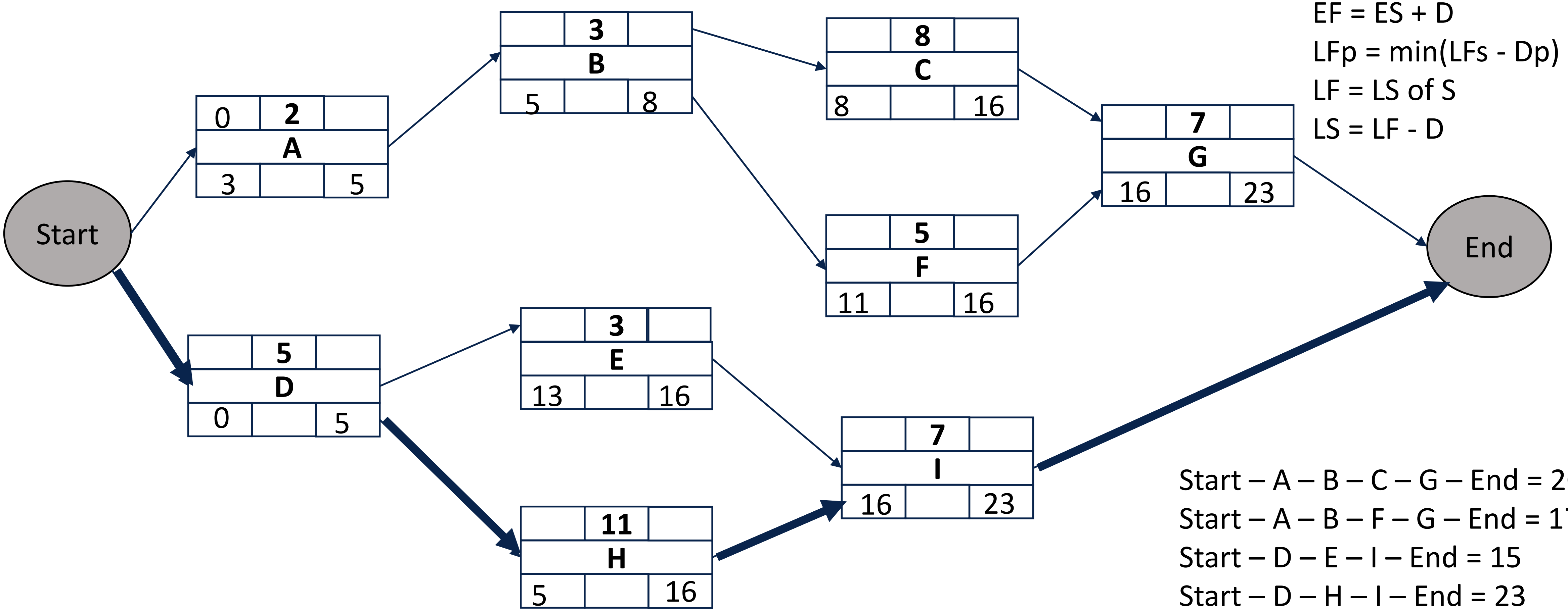

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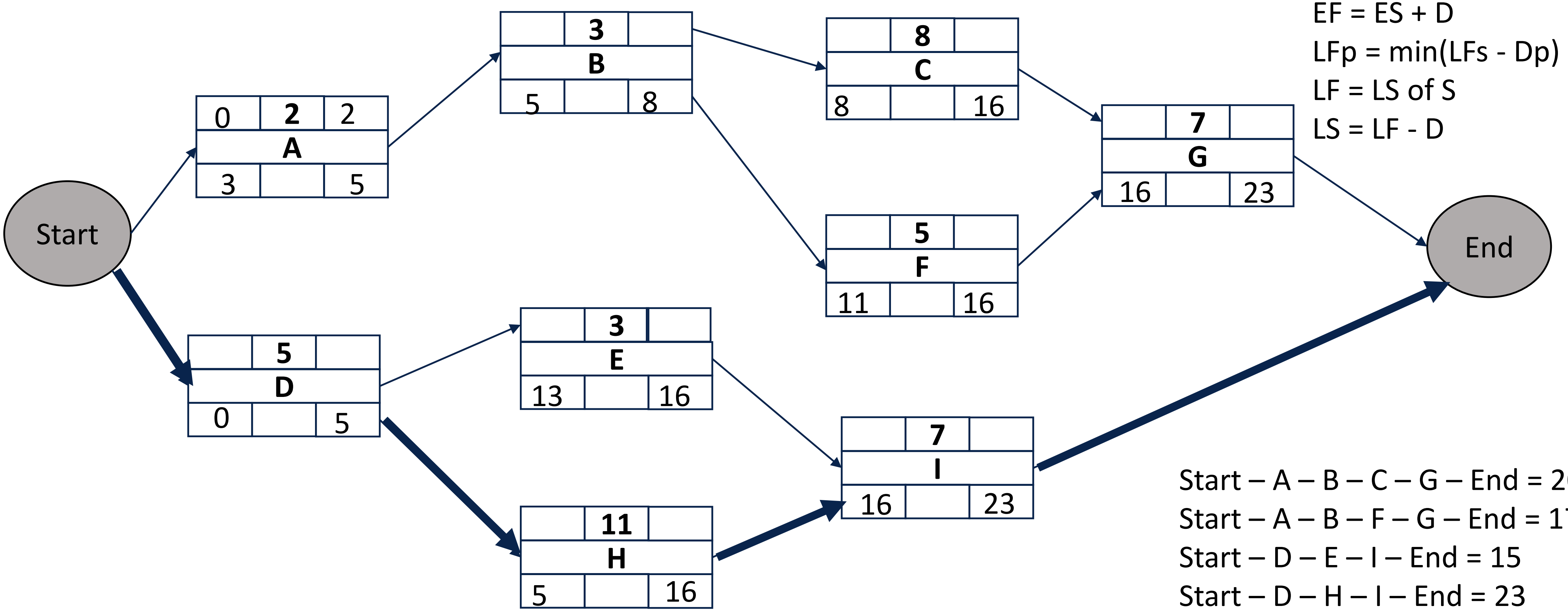

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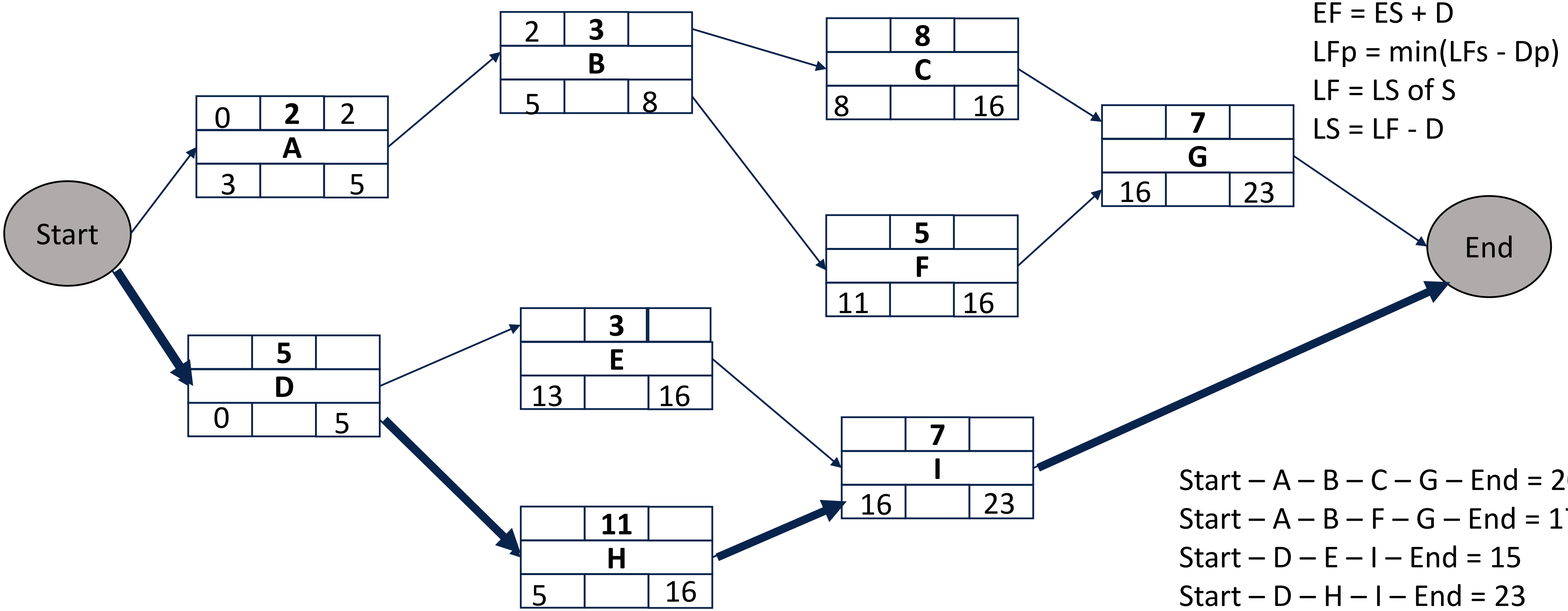

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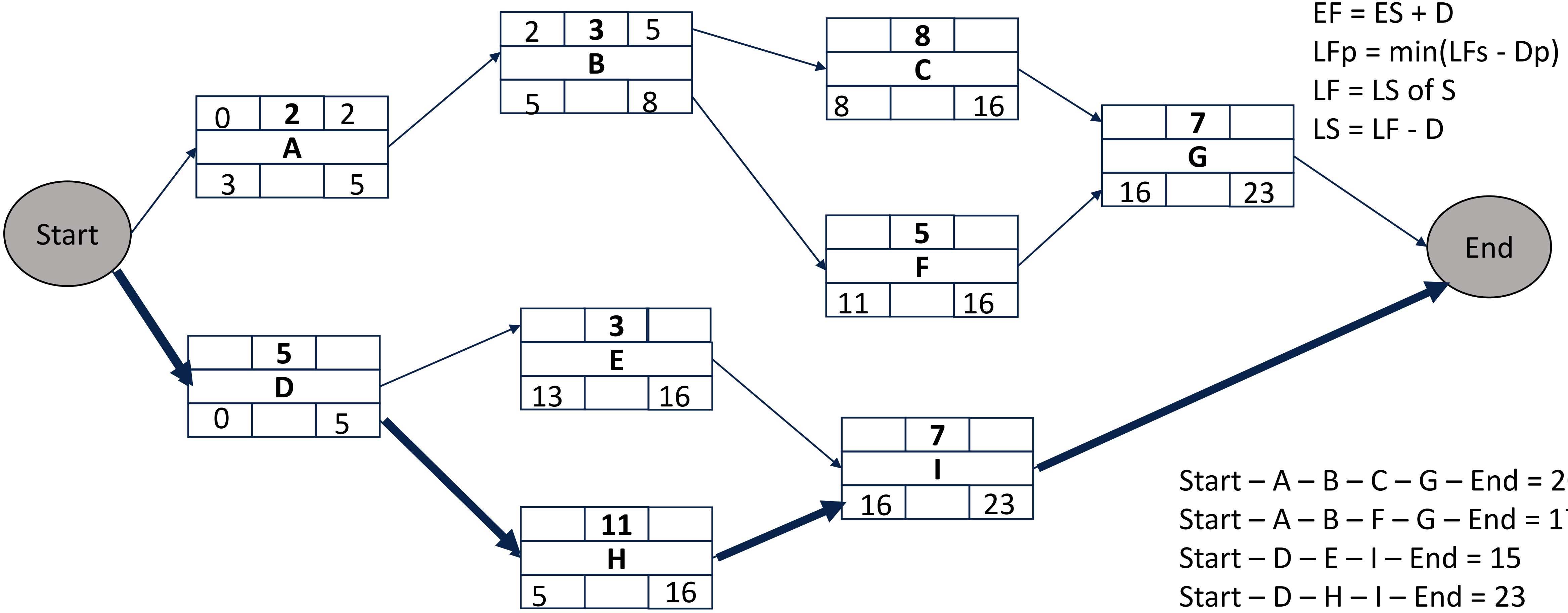

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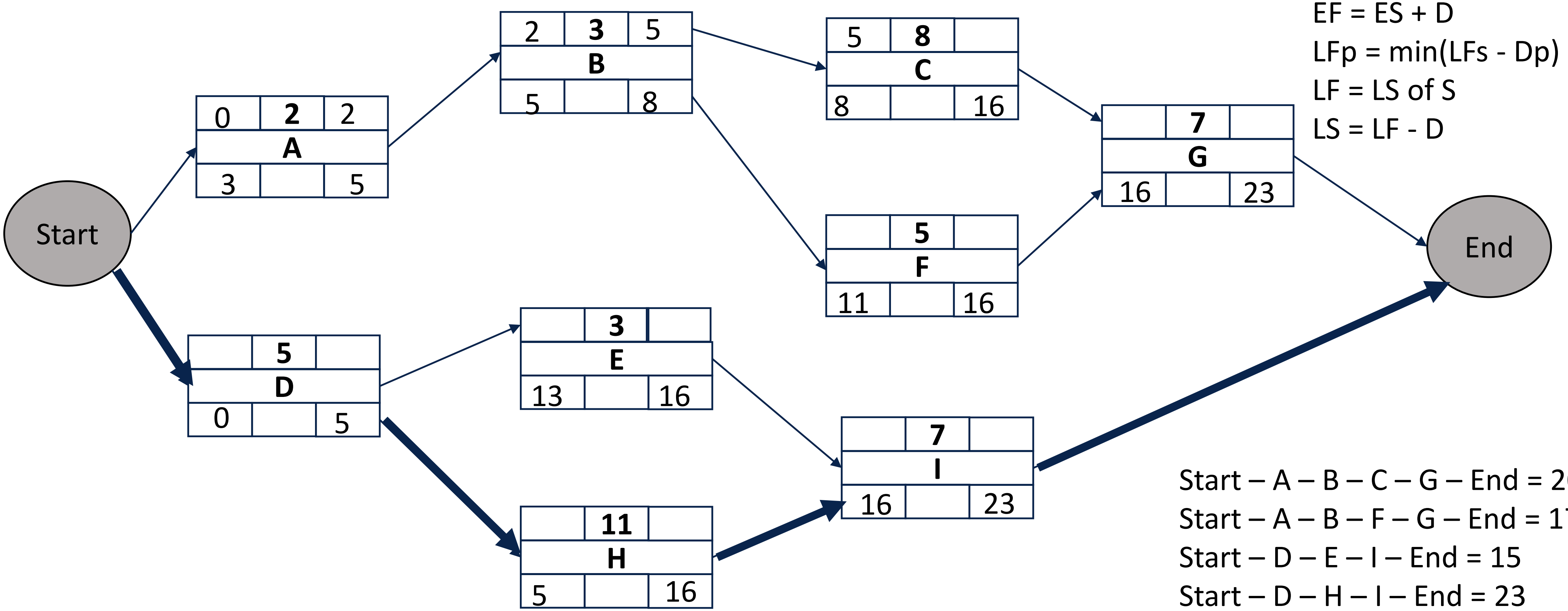

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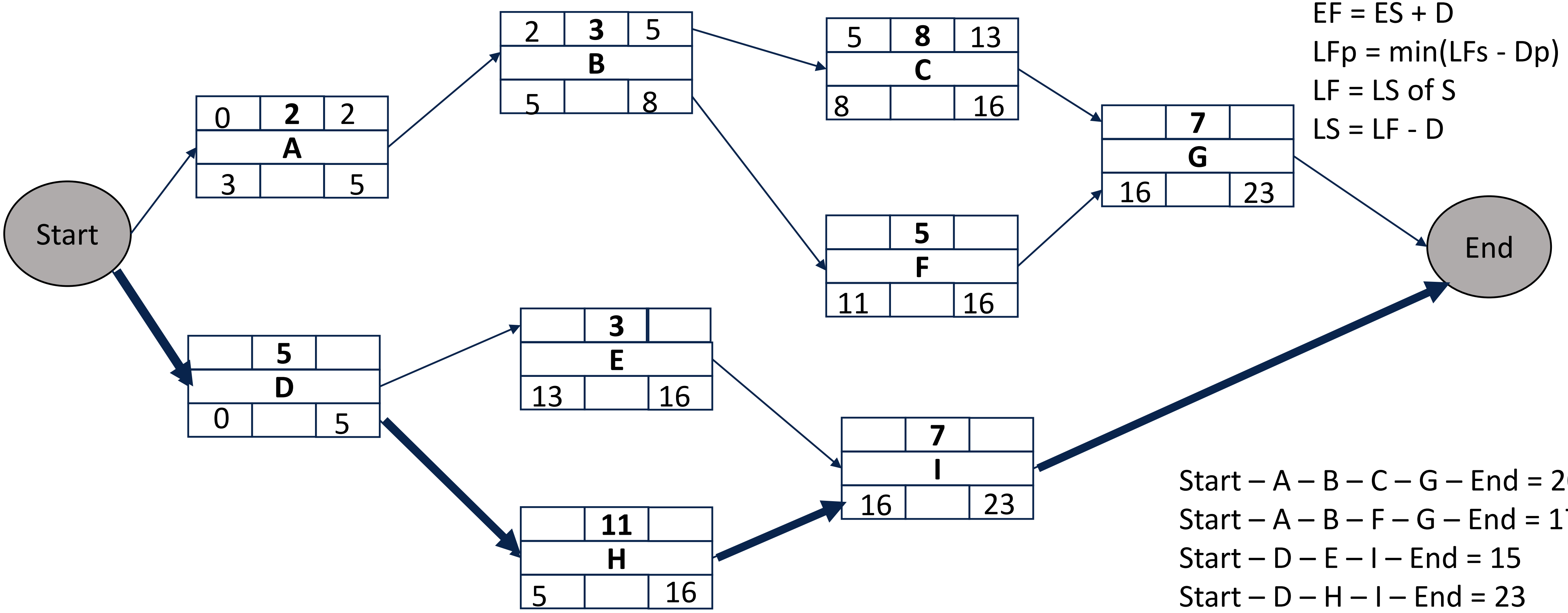

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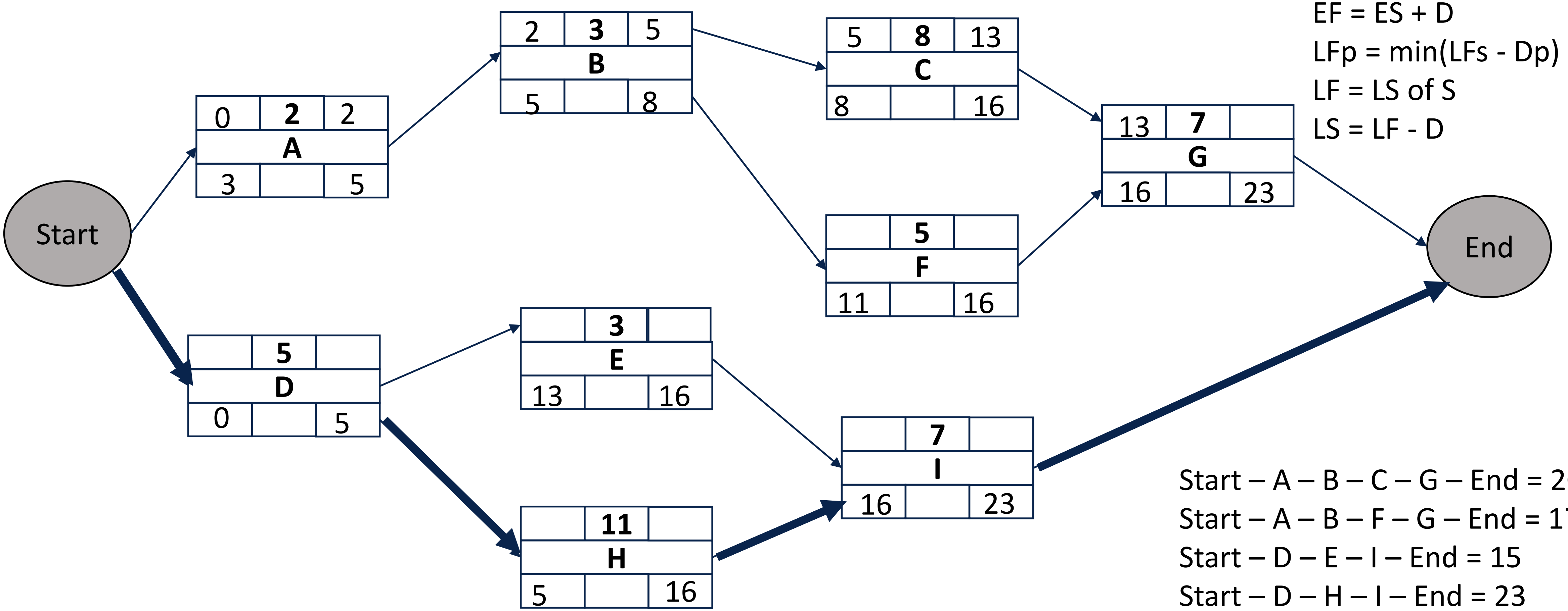

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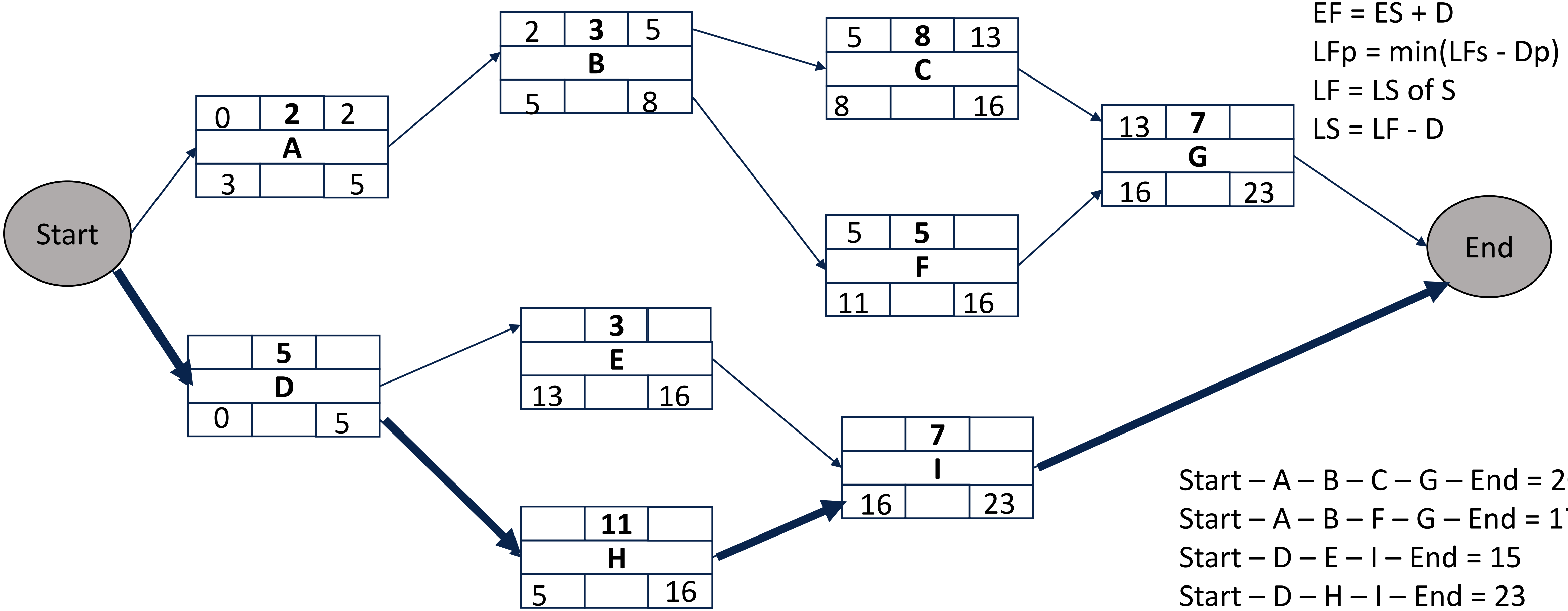

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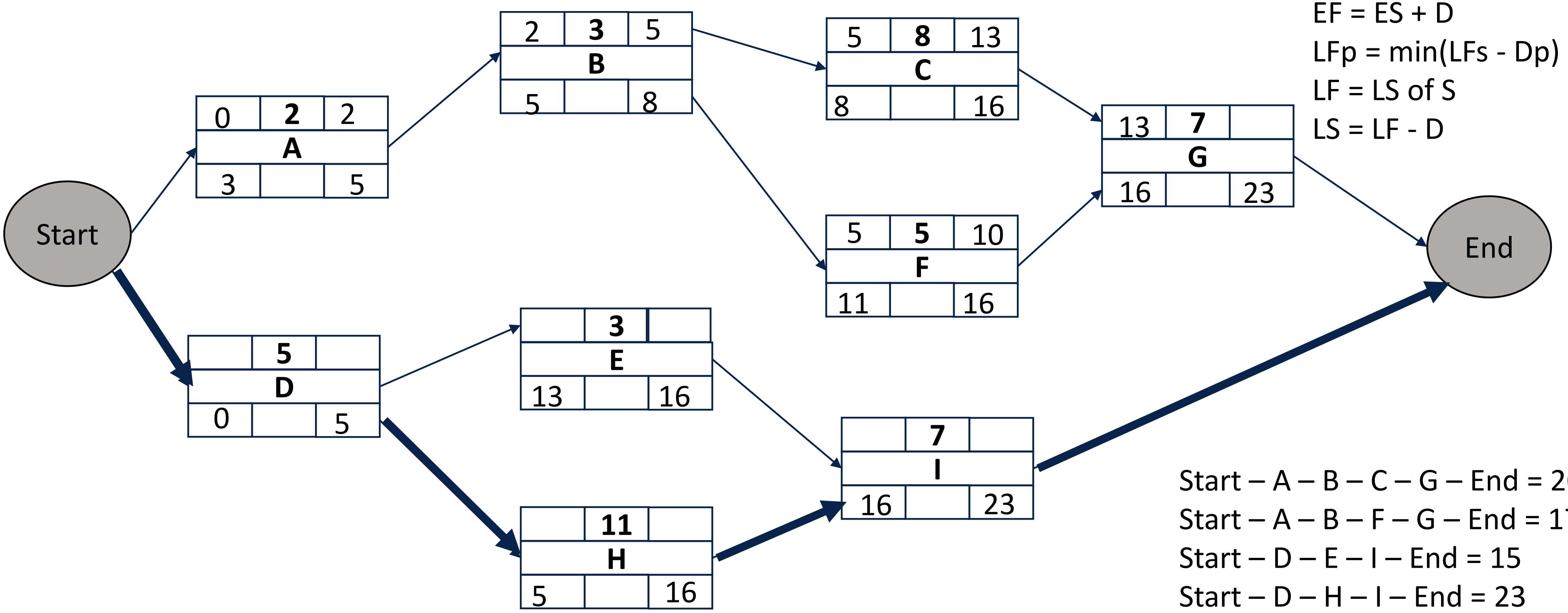

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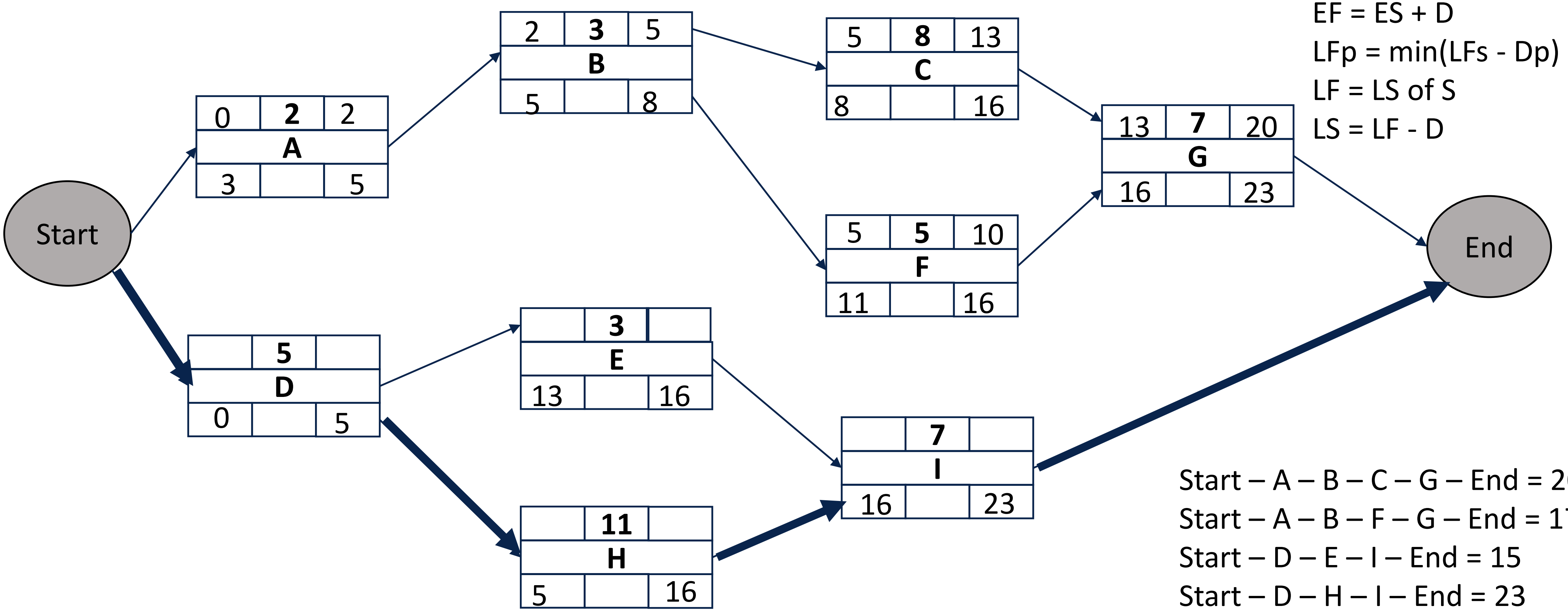

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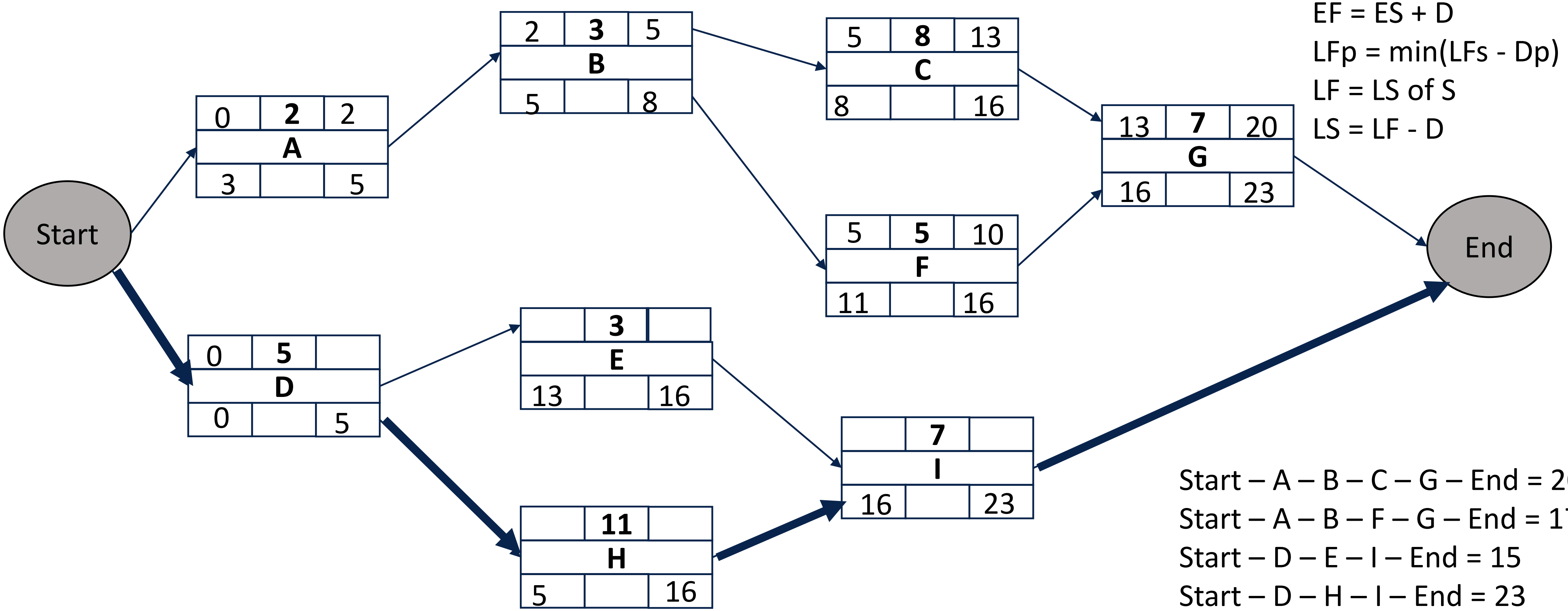

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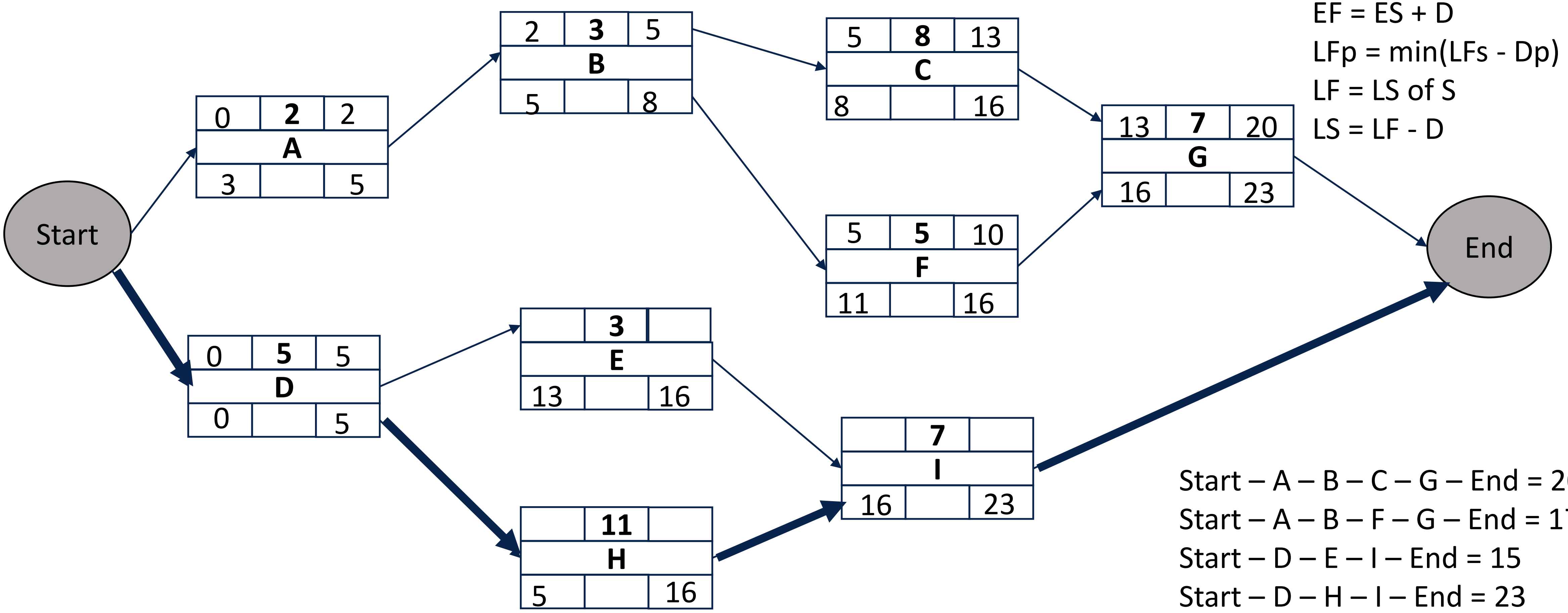

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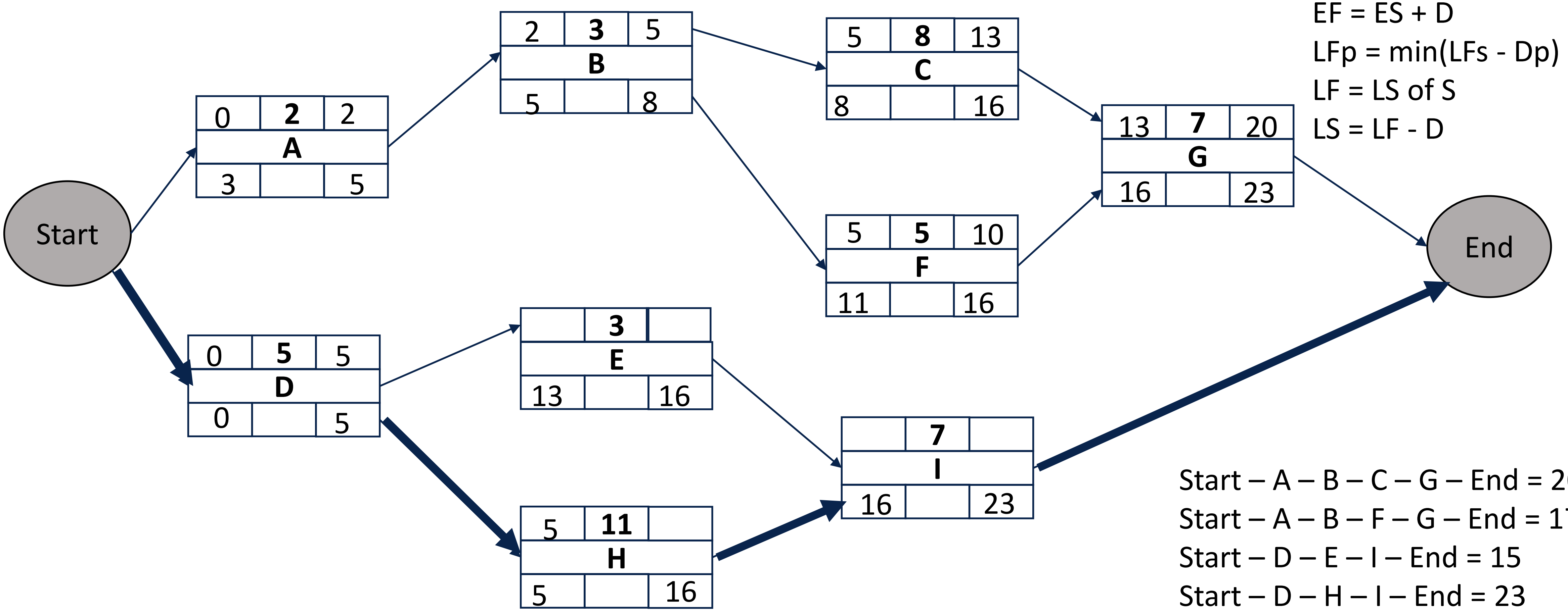

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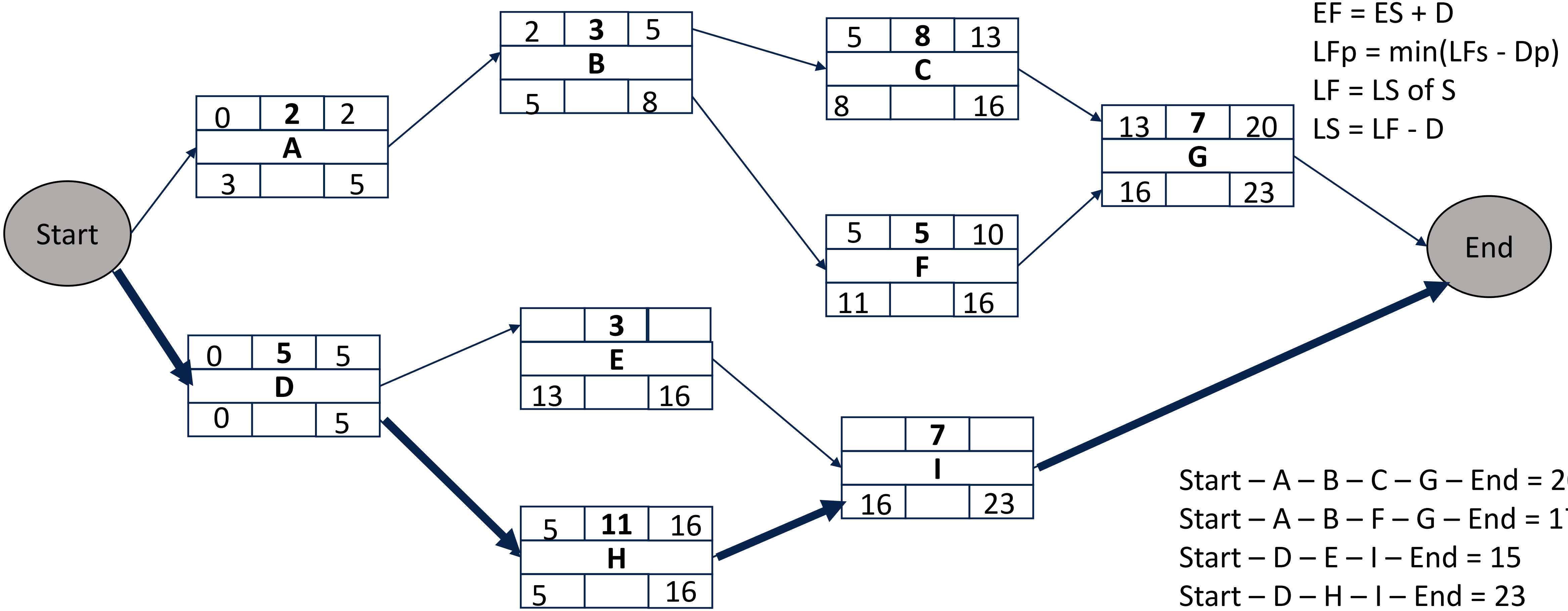

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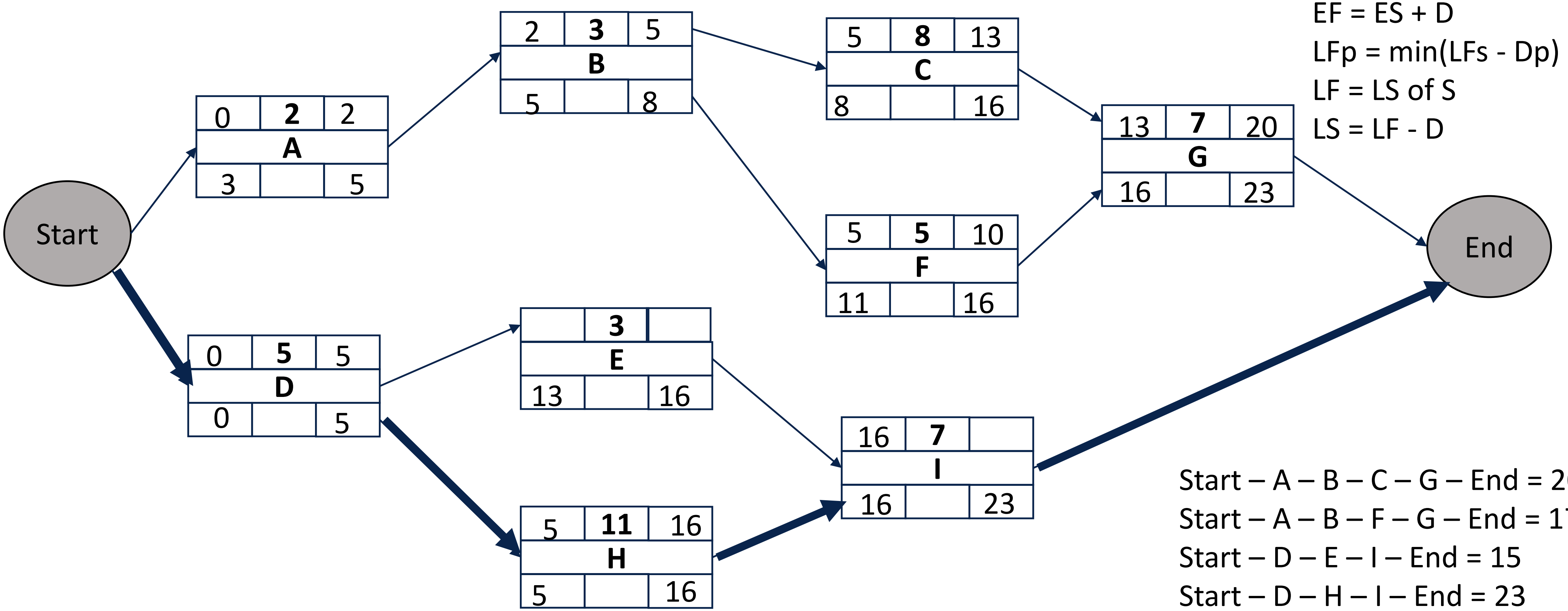

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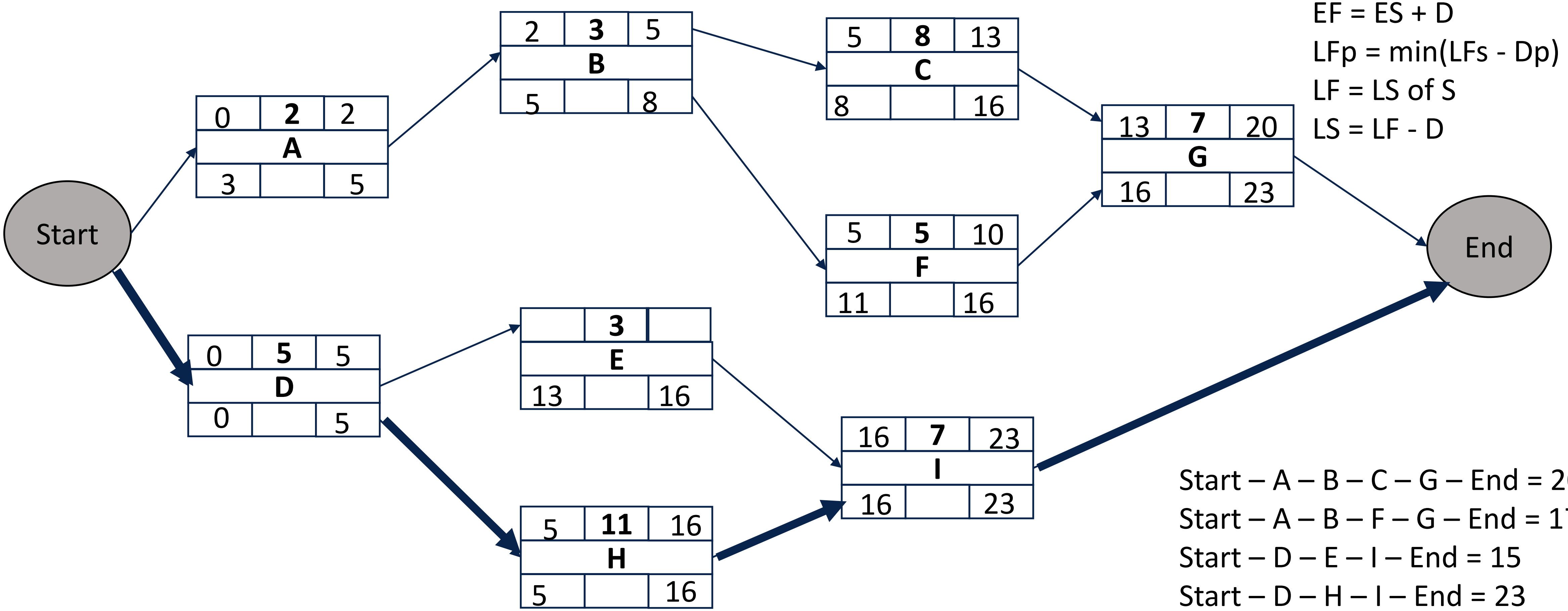

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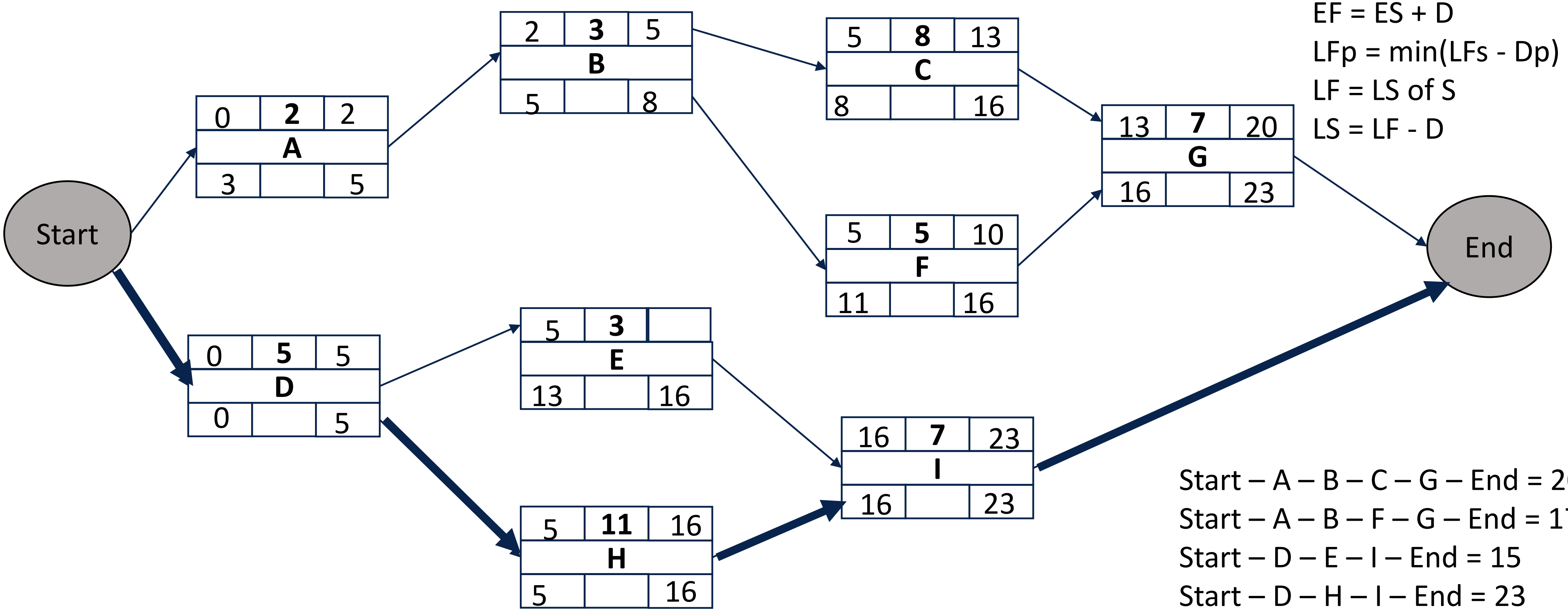

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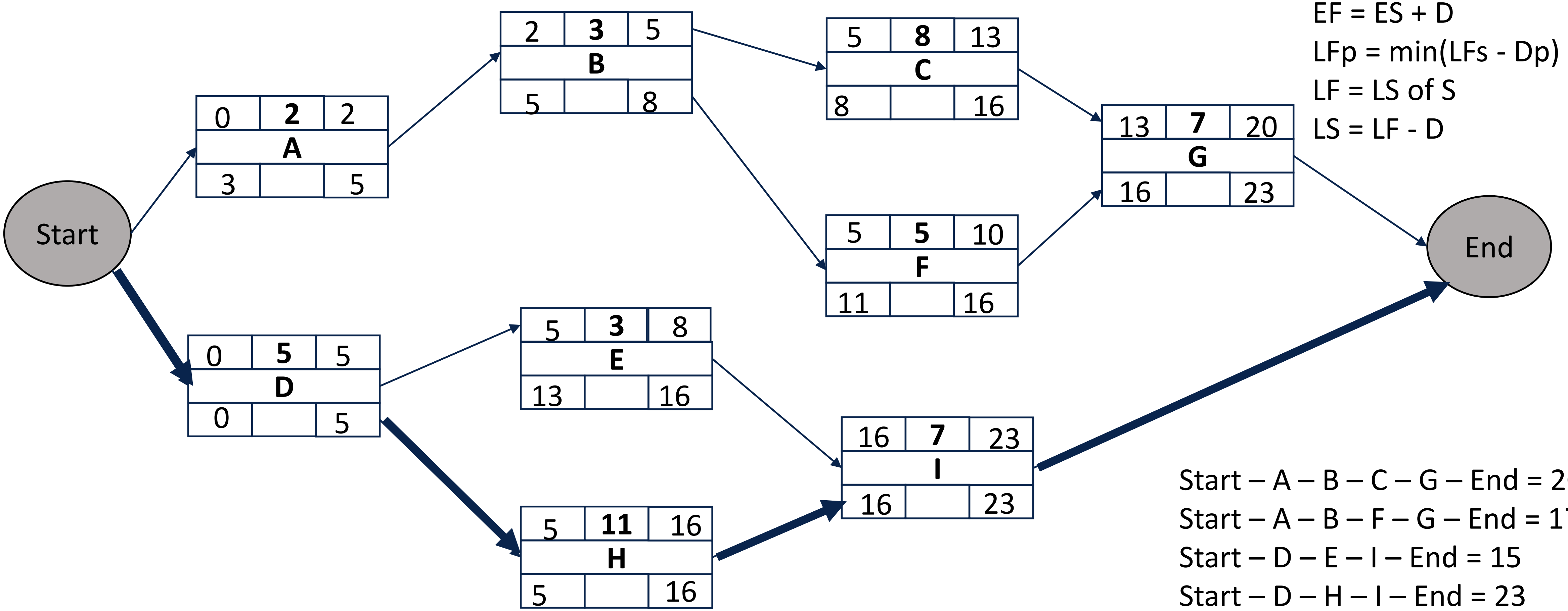

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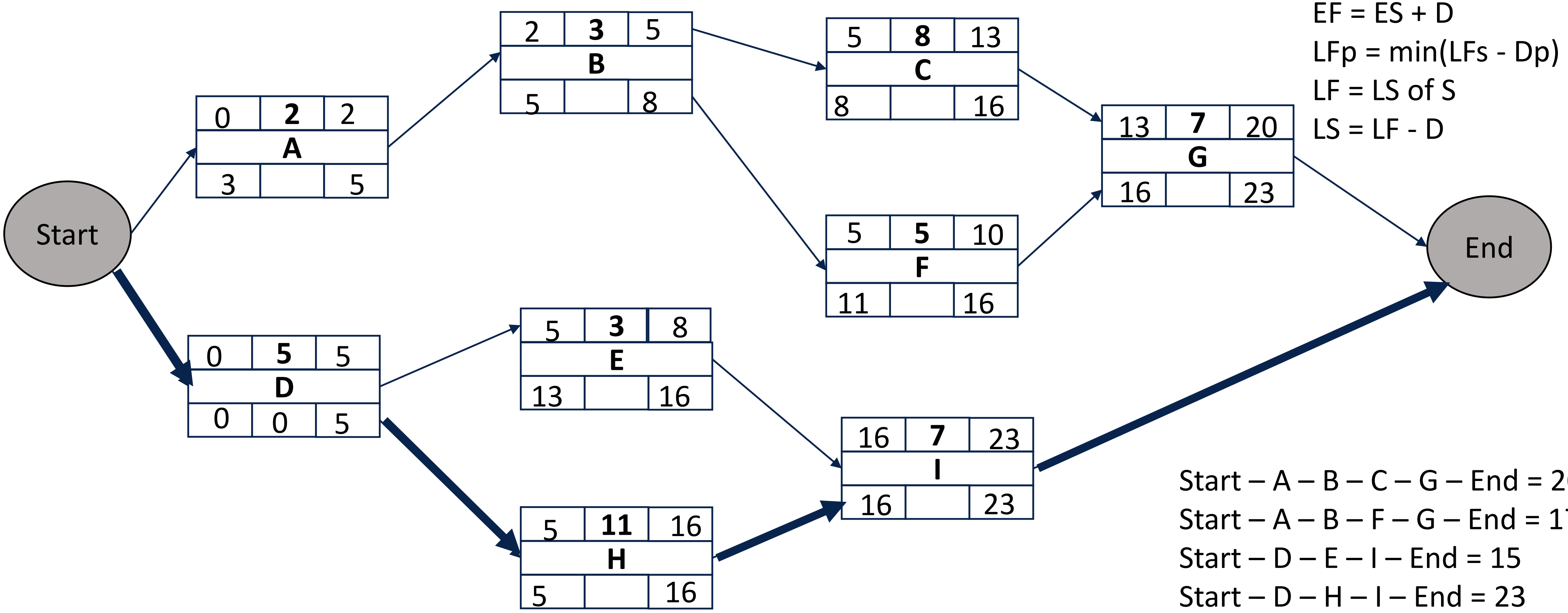

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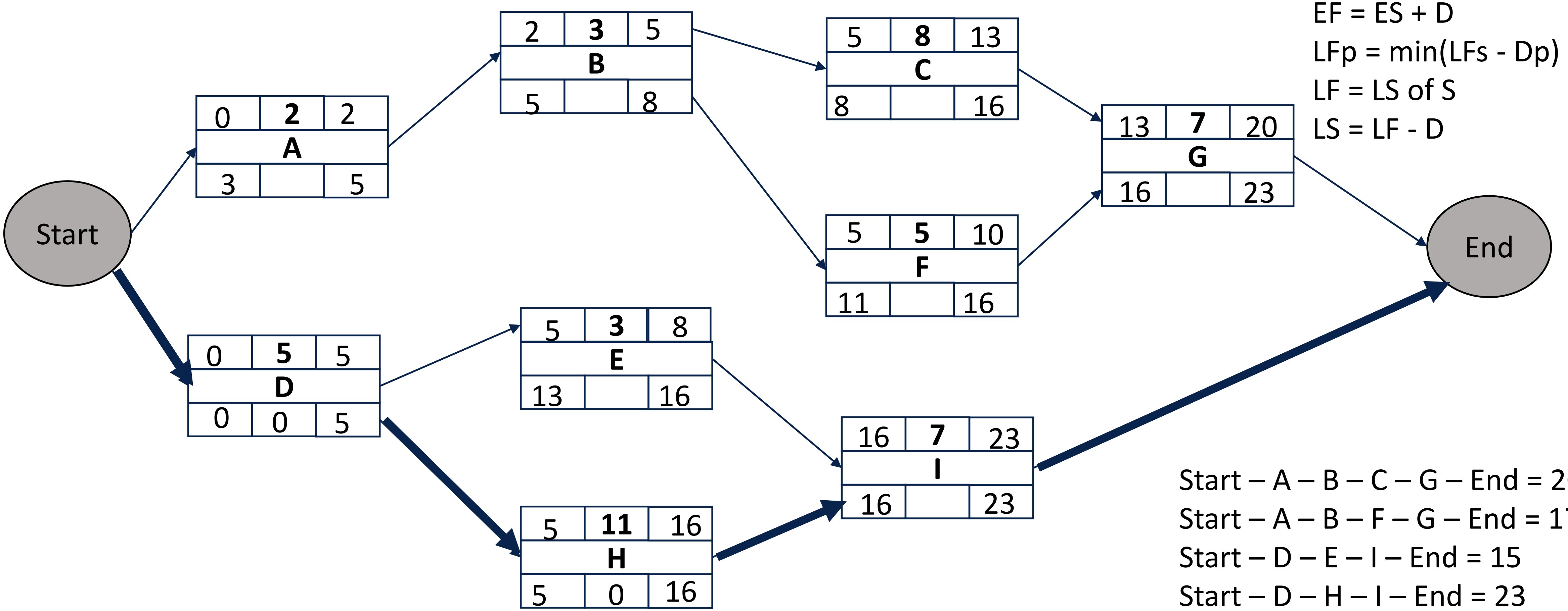

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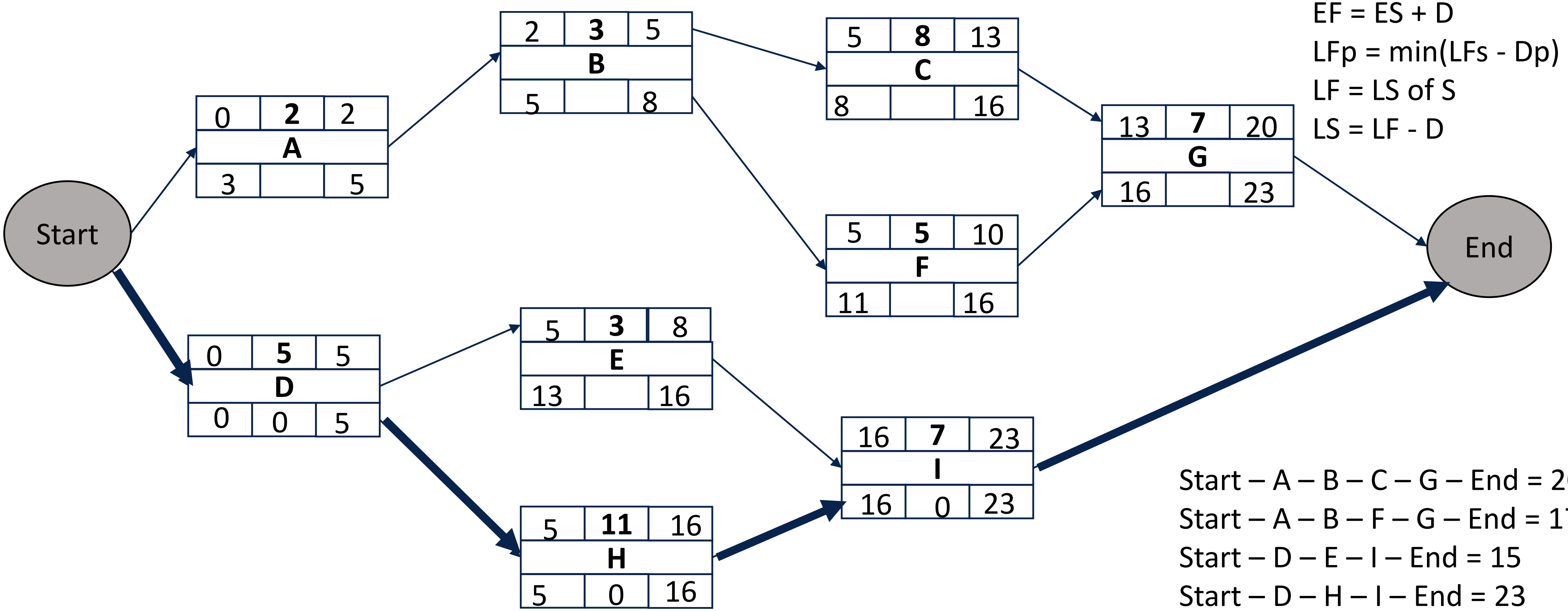

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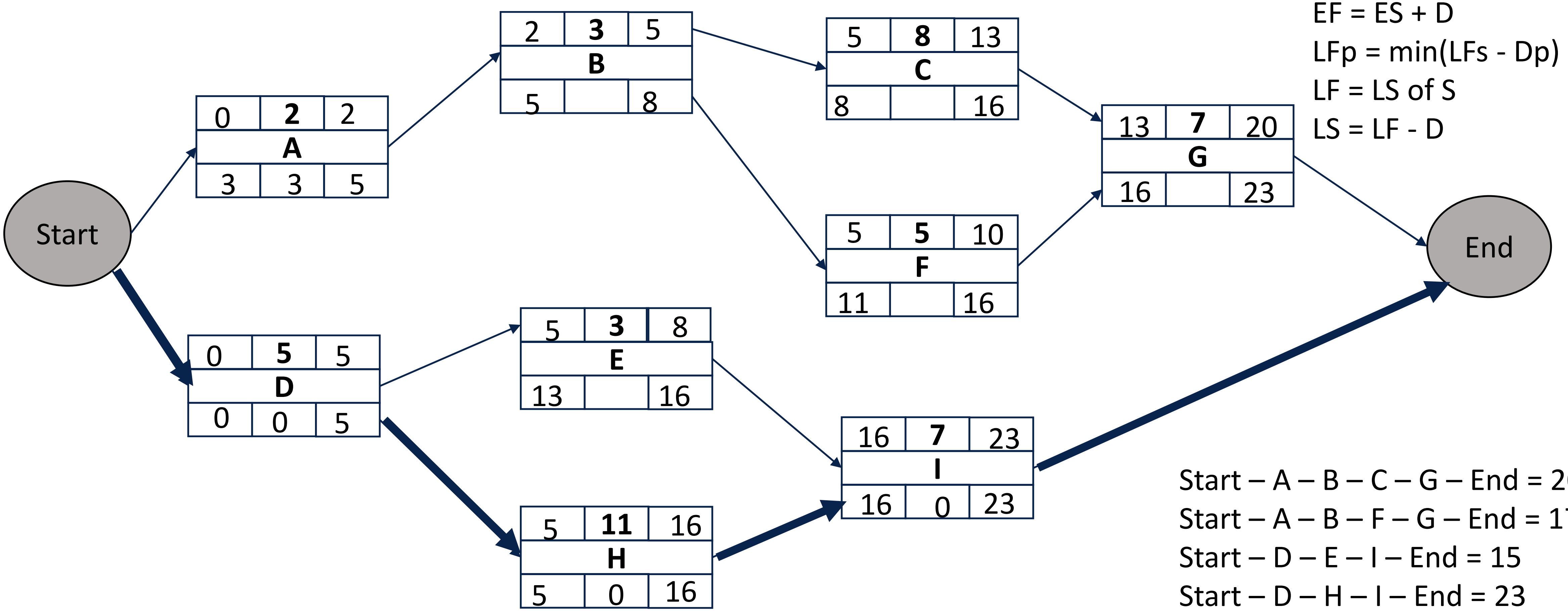

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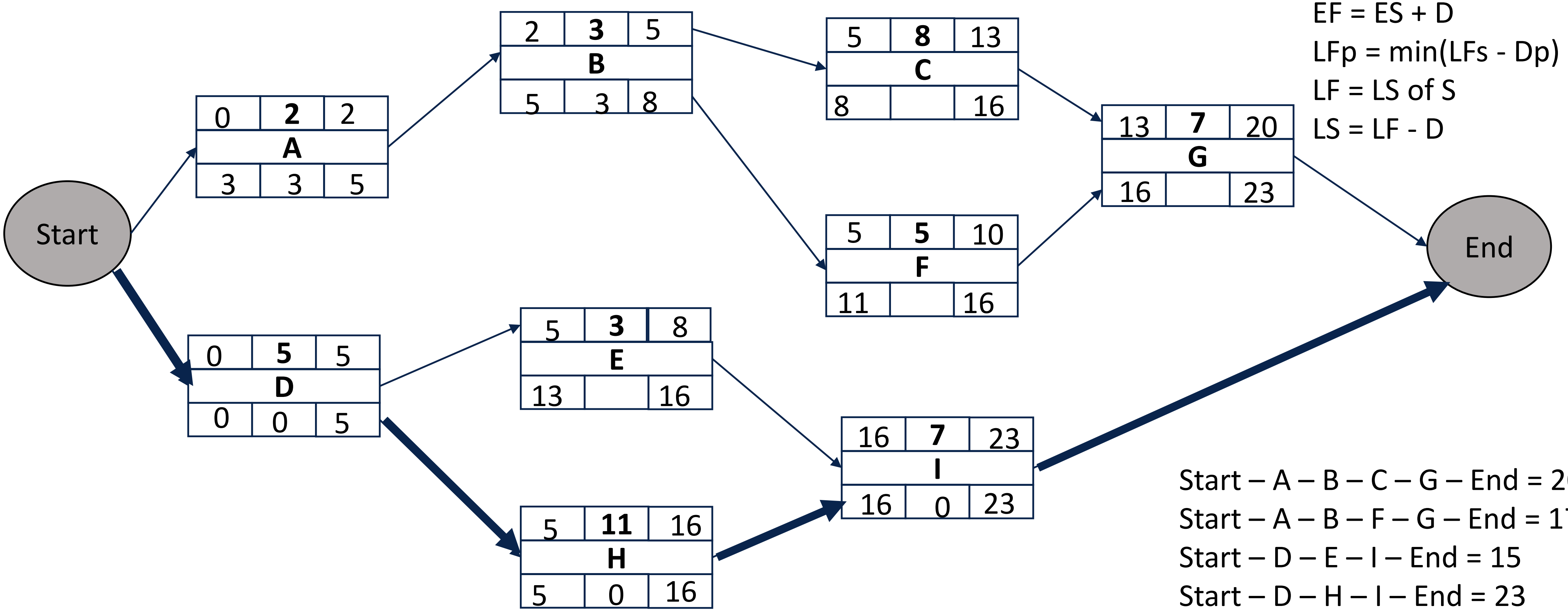

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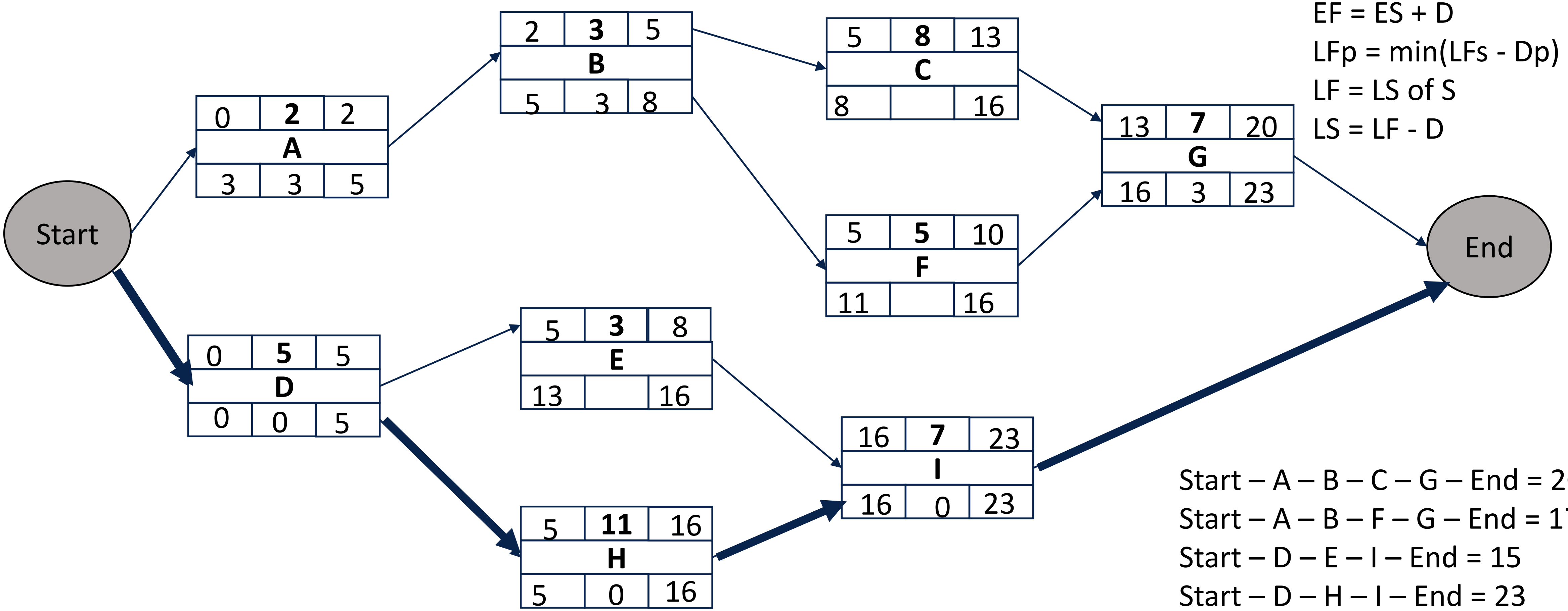

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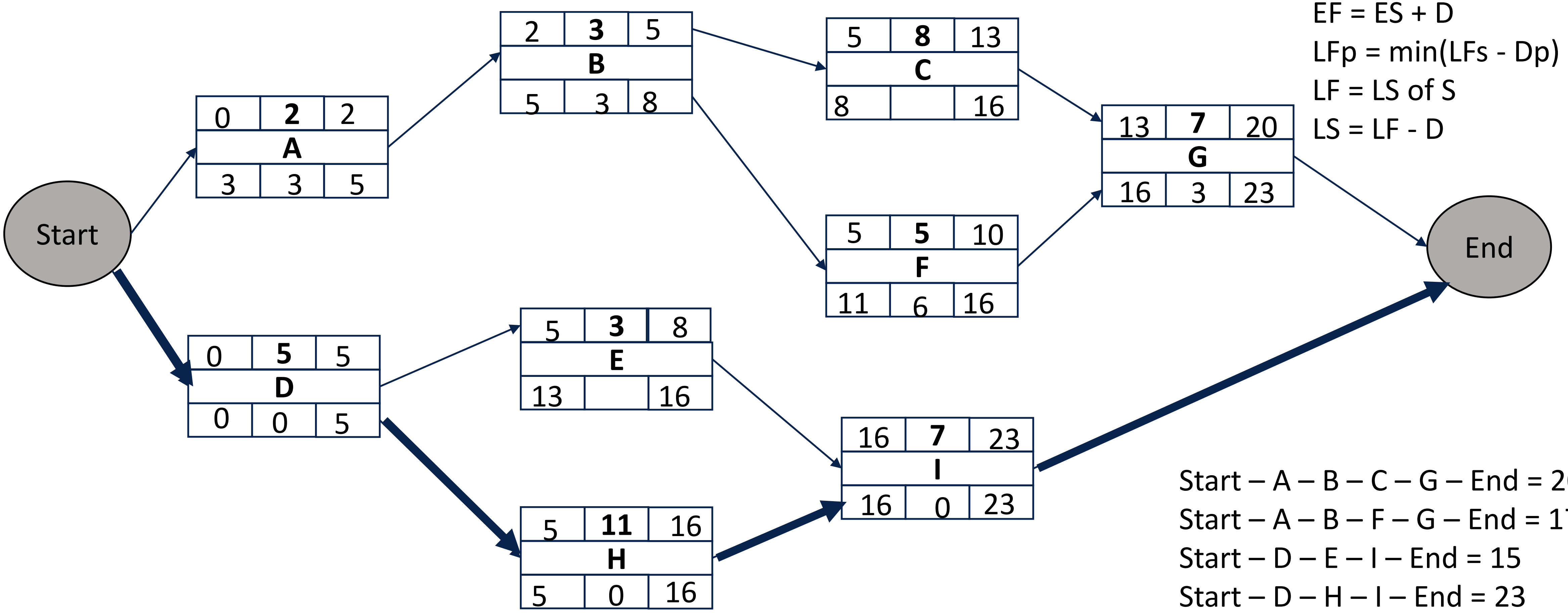

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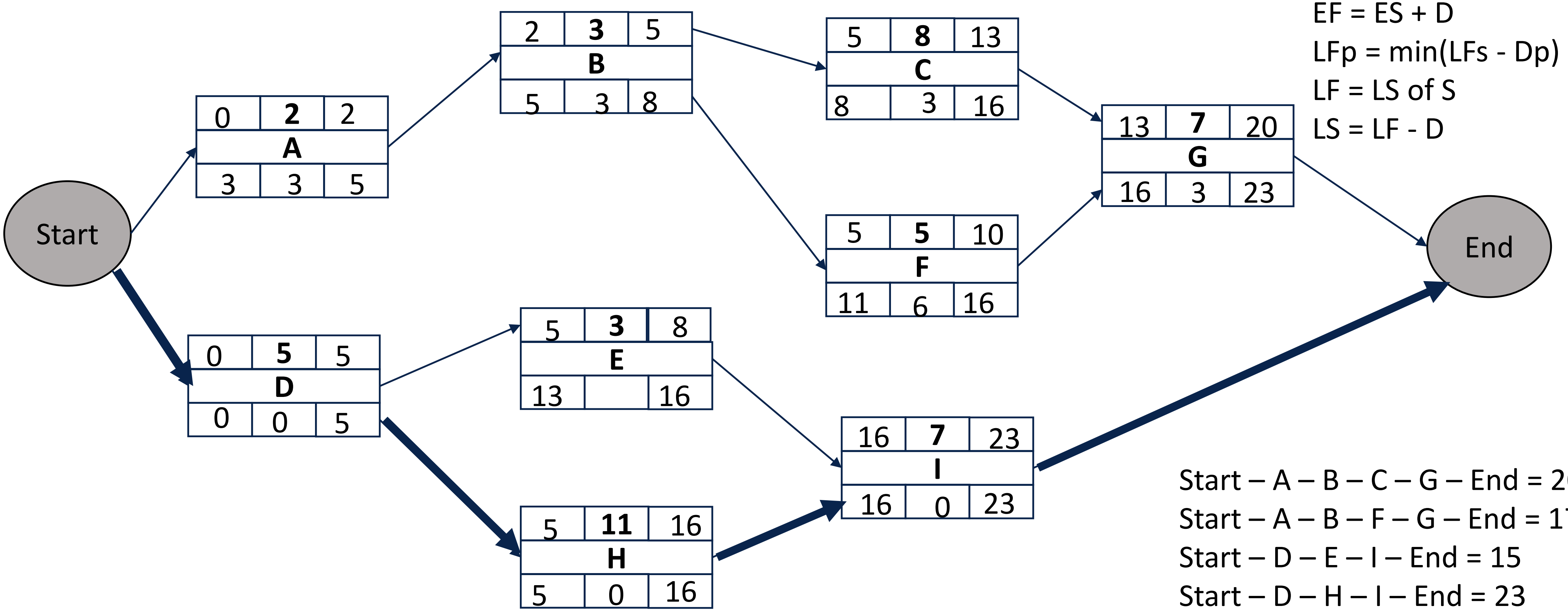

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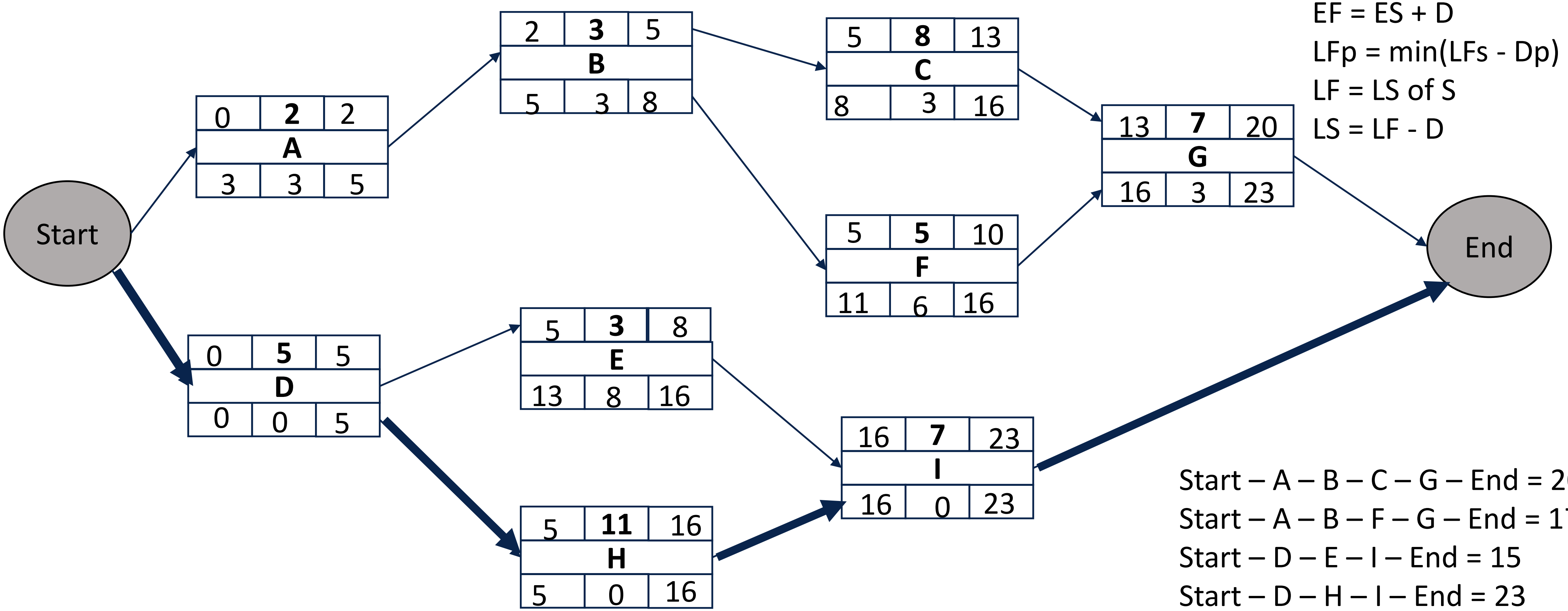

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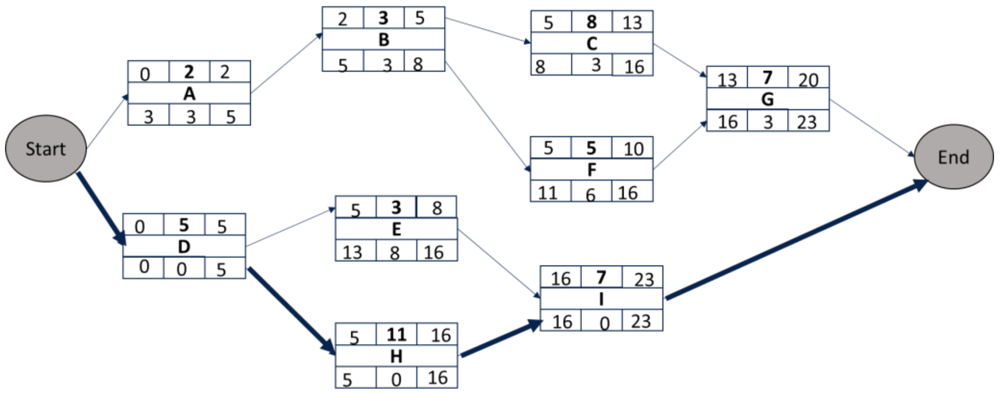
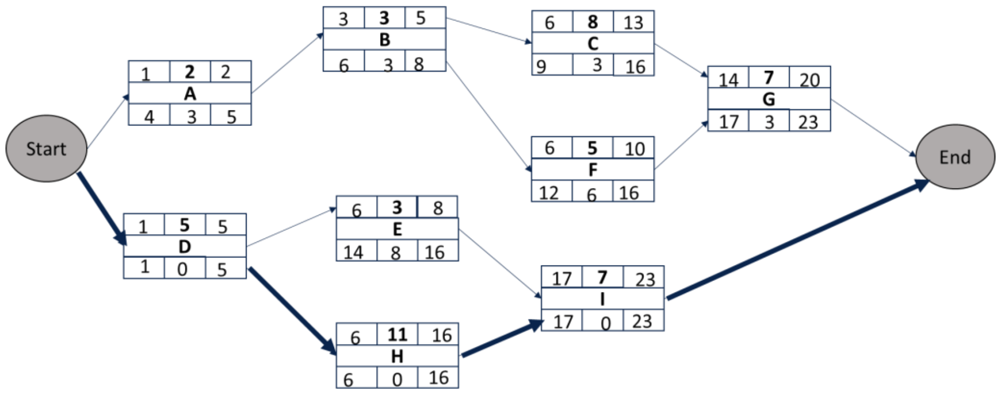


Differences:

- ✓ First activity starts from "zero"
- ✓ EF = ES + Duration
- ✓ ES (Successor) = EF (Predecessor)
- ✓ LF (Predecessor) = LS(Successor)

Similarities:

- ✓ Project duration
- ✓ EF & LF of any activity
- ✓ Float in any activity



Differences:

- ✓ First activity starts from "One"
- ✓ EF = ES + Duration -1
- ✓ ES (Successor) = EF (Predecessor) +1
- ✓ LF (Predecessor) = LS(Successor) -1

Similarities:

- ✓ Project duration
- ✓ EF & LF of any activity
- ✓ Float in any activity

Develop Schedule

Tools & Techniques: Critical Path Method

- ✓ the minimum amount of time needed for a project to be completed.
- ✓ the longest continuous path through a network diagram of interdependent tasks
- ✓ delay in the tasks on the critical path will directly impact the overall project timeline.
- ✓ Tasks on the critical path have zero slack or float, meaning there is no flexibility in their scheduling without affecting the project's completion date.
- ✓ Identifying and managing the critical path is essential for project managers to ensure timely project delivery and efficient resource allocation.

Develop Schedule

Activity	Preceding Activity	Estimate in Months
Start		0
D	Start	4
A	Start	6
F	D, A	7
E	D	8
G	F, E	5
B	F	5
H	G	7
C	H	8
End	C, B	0

Develop Schedule

Activity	Preceding Activity	Estimate in Months
Start		0
D	Start	4
A	Start	6
F	D, A	7
E	D	8
G	F, E	5
B	F	5
H	G	7
C	H	8
End	C, B	0

1. What is the duration of the critical path in months?
2. What is the float of activity B?
3. What is the float of activity E?
4. What is the float of activity D?

DEVELOP SCHEDULE

Activity	Preceding Activity	Estimate in Months
Start		0
D	Start	4
A	Start	6
F	D, A	7
E	D	8
G	F, E	5
B	F	5
H	G	7
C	H	8
End	C, B	0

1. What is the duration of the critical path in months?
2. What is the float of activity B?
3. What is the float of activity E?
4. What is the float of activity D?

Path	Duration
Start, D, E, G, H, C, End	32
Start, D, F, G, H, C, End	31
Start, D, F, B, End	16
Start, A, F, G, H, C, End	33
Start, A, F, B, End	18

Develop Schedule

Activity	Preceding Activity	Estimate in Months
Start		0
D	Start	4
A	Start	6
F	D, A	7
E	D	8
G	F, E	5
B	F	5
H	G	7
C	H	8
End	C, B	0

DEVELOP SCHEDULE

Activity	Preceding Activity	Estimate in Months
Start		0
D	Start	4
A	Start	6
F	D, A	7
E	D	8
G	F, E	5
B	F	5
H	G	7
C	H	8
End	C, B	0

1. What is the duration of the critical path in months?
2. What is the float of activity B?
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DEVELOP SCHEDULE

Activity	Preceding Activity	Estimate in Months
Start		0
D	Start	4
A	Start	6
F	D, A	7
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G	F, E	5
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1. What is the duration of the critical path in months?
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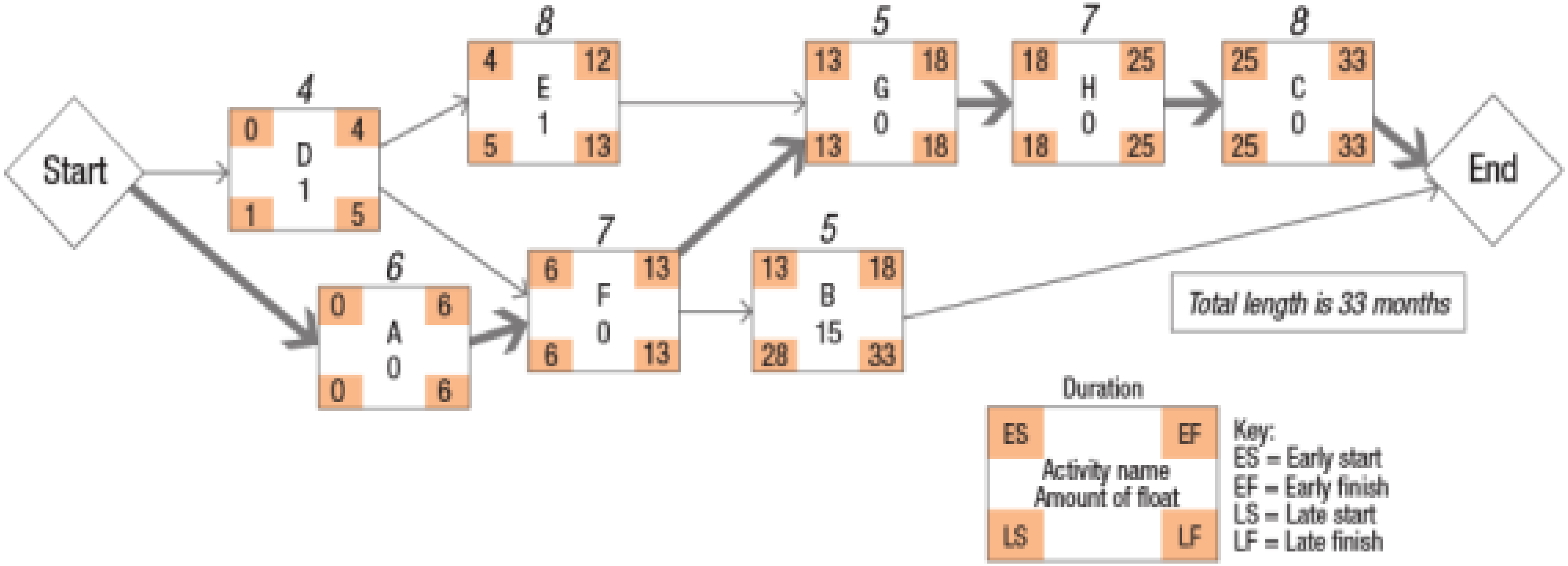

Develop Schedule

Activity	Preceding Activity	Estimate in Months
Start		0
D	Start	4
A	Start	6
F	D, A	7
E	D	8
G	F, E	5
B	F	5
H	G	7
C	H	8
End	C, B	0

Develop Schedule

Activity	Preceding Activity	Estimate in Months
Start		0
D	Start	4
A	Start	6
F	D, A	7
E	D	8
G	F, E	5
B	F	5
H	G	7
C	H	8
End	C, B	0

1. To shorten the length of the project, the sponsor has offered to remove the work of activity E from the project, making activity D the predecessor to activities G and F. What will be the effect?

DEVELOP SCHEDULE

Activity	Preceding Activity	Estimate in Months
Start		0
D	Start	4
A	Start	6
F	D, A	7
~~E~~	~~D~~	~~8~~
G	F, ~~E~~ D	5
B	F	5
H	G	7
C	H	8
End	C, B	0

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Develop Schedule

Activity	Preceding Activity	Estimate in Months
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B	F	5
H	G	7
C	H	8
End	C, B	0

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Path	
Start, D, G, H, C, End	24
Start, D, F, G, H, C, End	31
Start, D, F, B, End	16
Start, A, F, G, H, C, End	33
Start, A, F, B, End	18

DEVELOP SCHEDULE

Tools & Techniques: Resource Optimization

Resource Optimization is used to **adjust the start and finish dates** of activities to adjust **planned resource** use to **be equal to or less than resource availability**

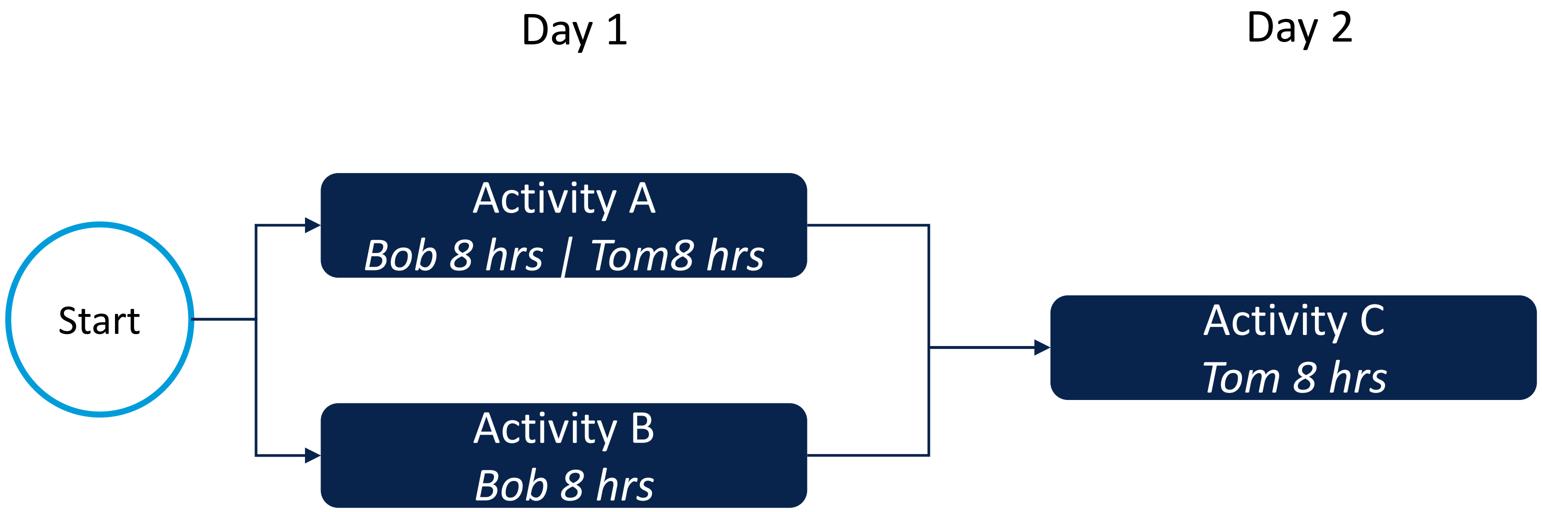
Resource leveling.

- A technique in which start, and finish dates are adjusted based on resource constraints to balance the demand for resources with the available supply.
- Resource leveling can often cause the original critical path to change. Available float is used for leveling resources. Consequently, the critical path through the project schedule may change.

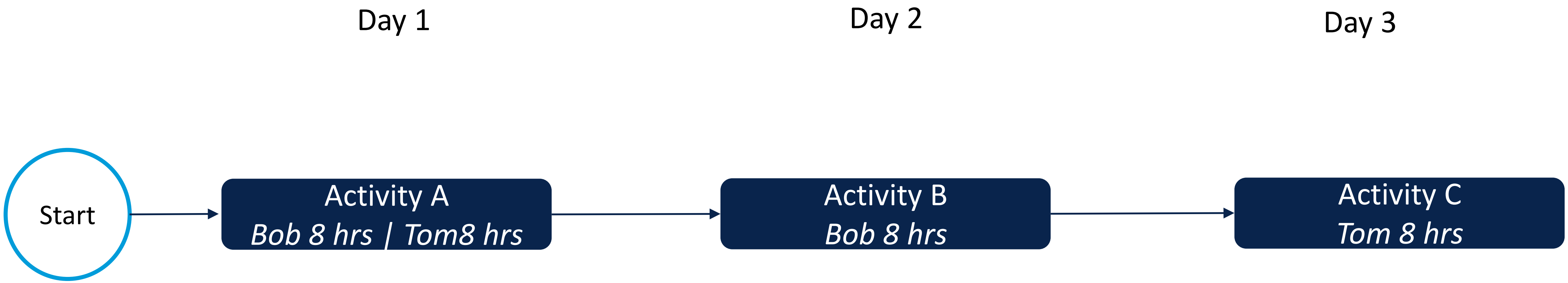
- **Resource smoothing.**
  - A technique that adjusts the activities of a schedule model such that the requirements for resources on the project do not exceed certain predefined resource limits.
  - In resource smoothing, as opposed to resource leveling, the project's critical path is not changed, and the completion date may not be delayed.
  - In other words, activities may only be delayed within their free and total float. Resource smoothing may not be able to optimize all resources.

RESOURCE LEVELING

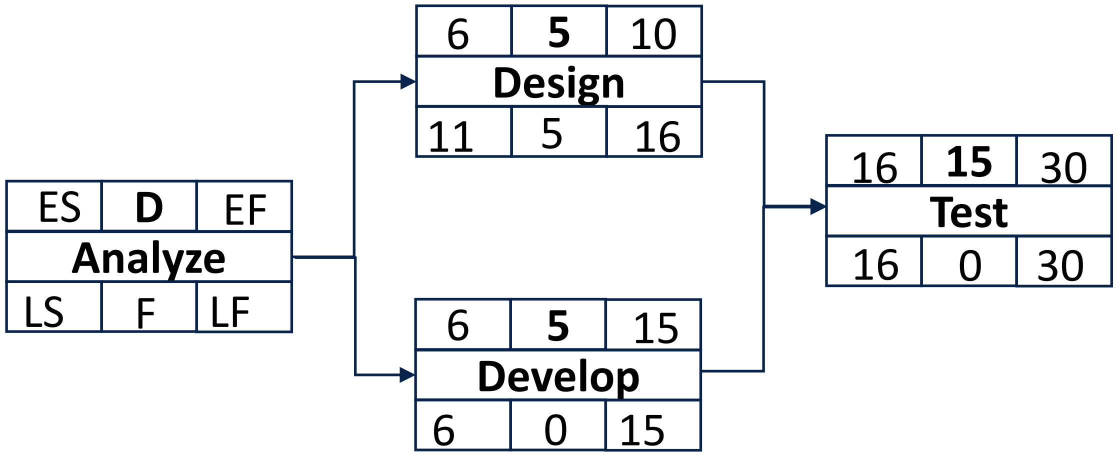
Resource Leveling



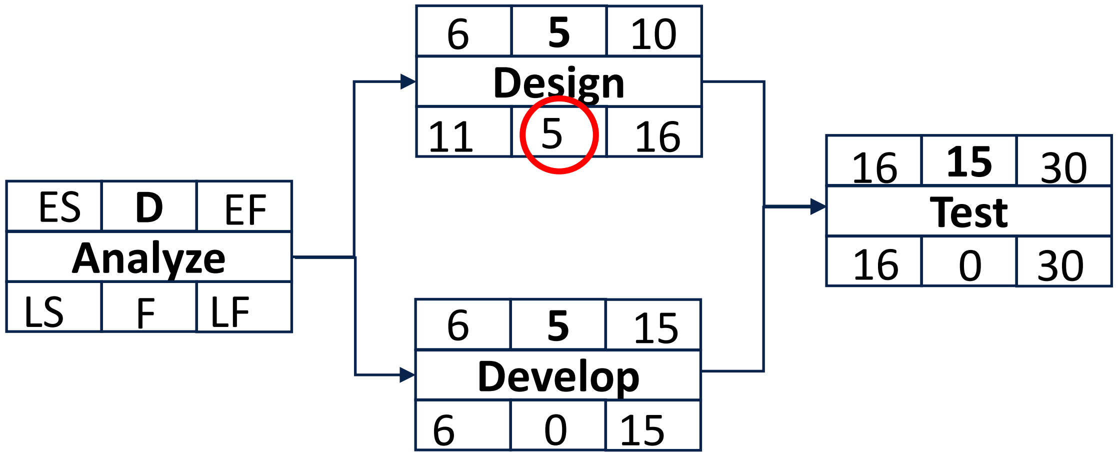
Resource Leveling



Resource Smoothing



Resource Smoothing



DEVELOP SCHEDULE

Tools & Techniques: Resource Optimization

Activity	Duration (days)	No. of Server Required	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
A	3	6																							
B	2	1																							
C	5	5																							
E	9	4																							
G	1	6																							
D	4	2																							
F	2	4																							

Develop Schedule

Tools & Techniques: Resource Optimization

Activity	Duration (days)	No. of Server Required	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
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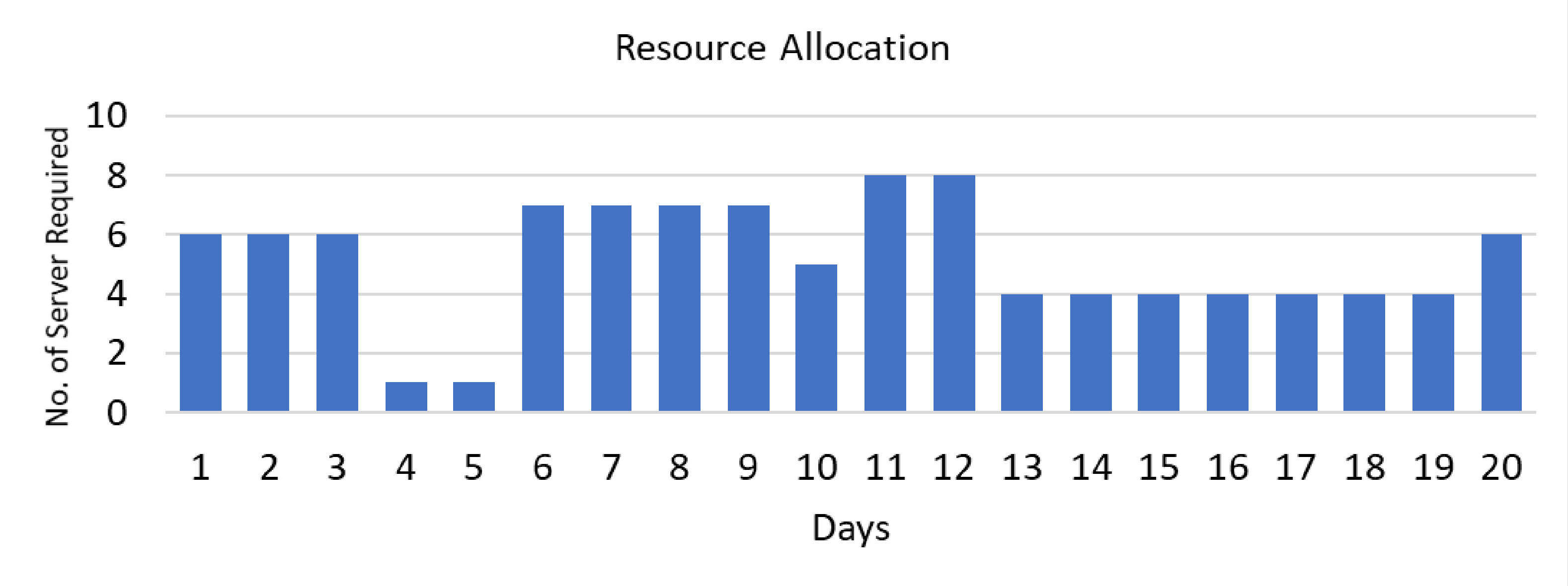

DEVELOP SCHEDULE

Tools & Techniques: Resource Optimization

Activity	Duration (days)	No. of Server Required	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
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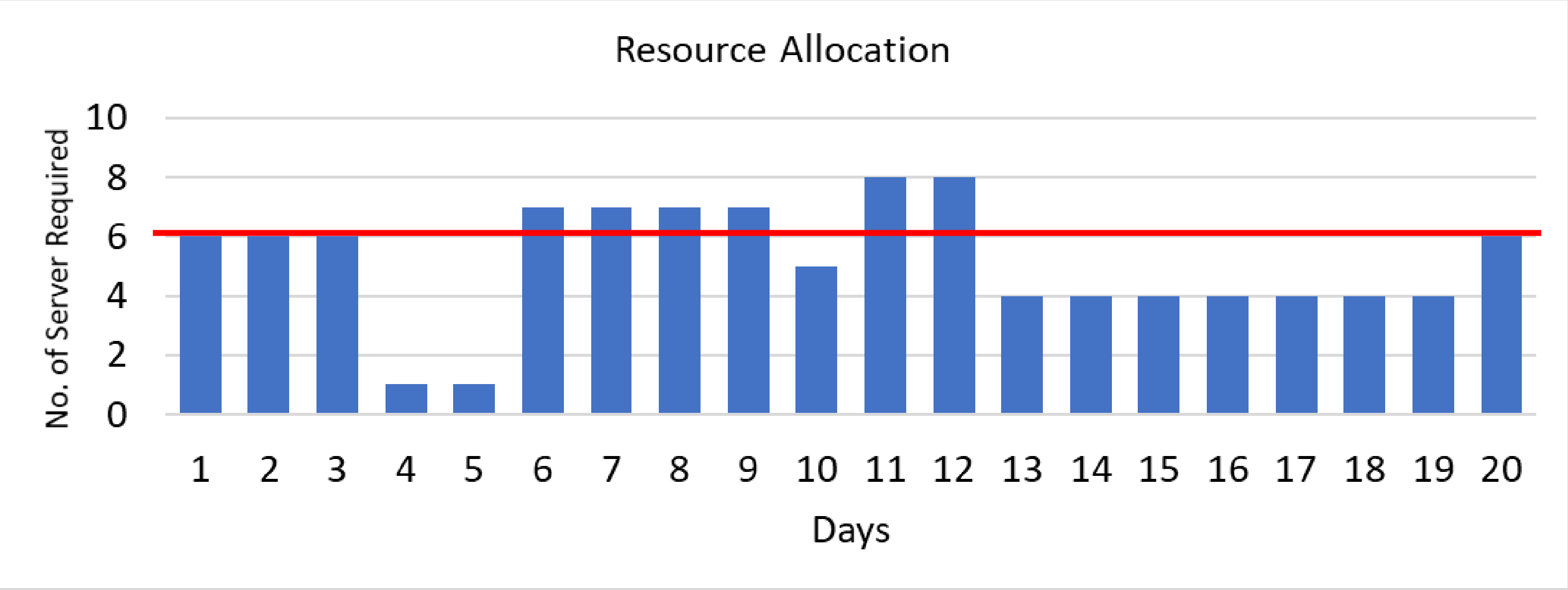

Available No. of Server

Develop Schedule

Tools & Techniques: Resource Optimization

Activity	Duration (days)	No. of Server Required	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
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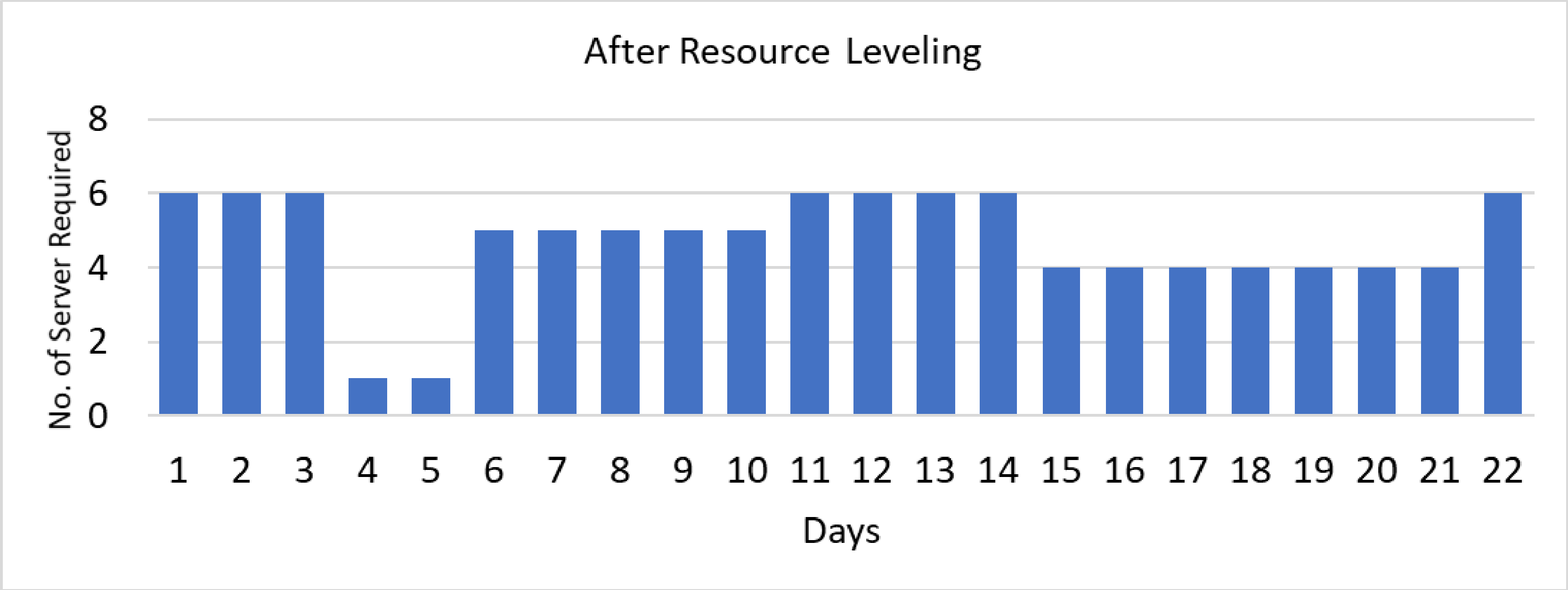

DEVELOP SCHEDULE

Tools & Techniques: Resource Optimization

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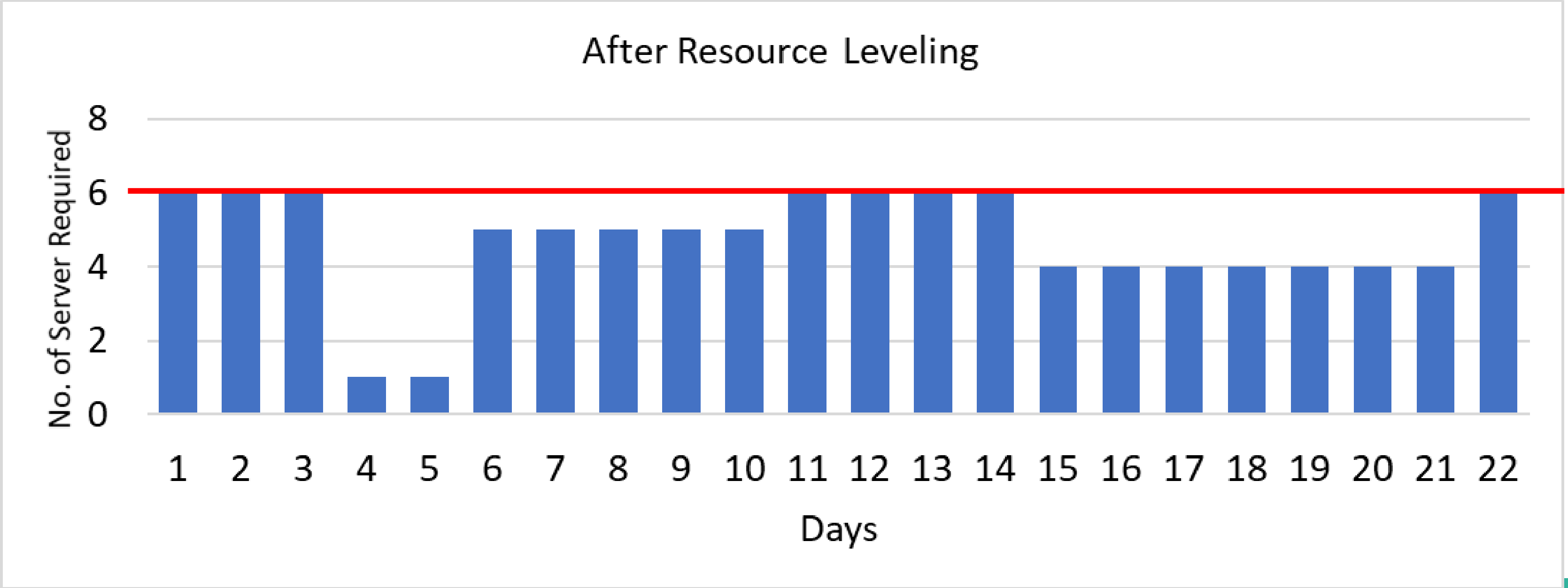

Develop Schedule

Tools & Techniques: Resource Optimization

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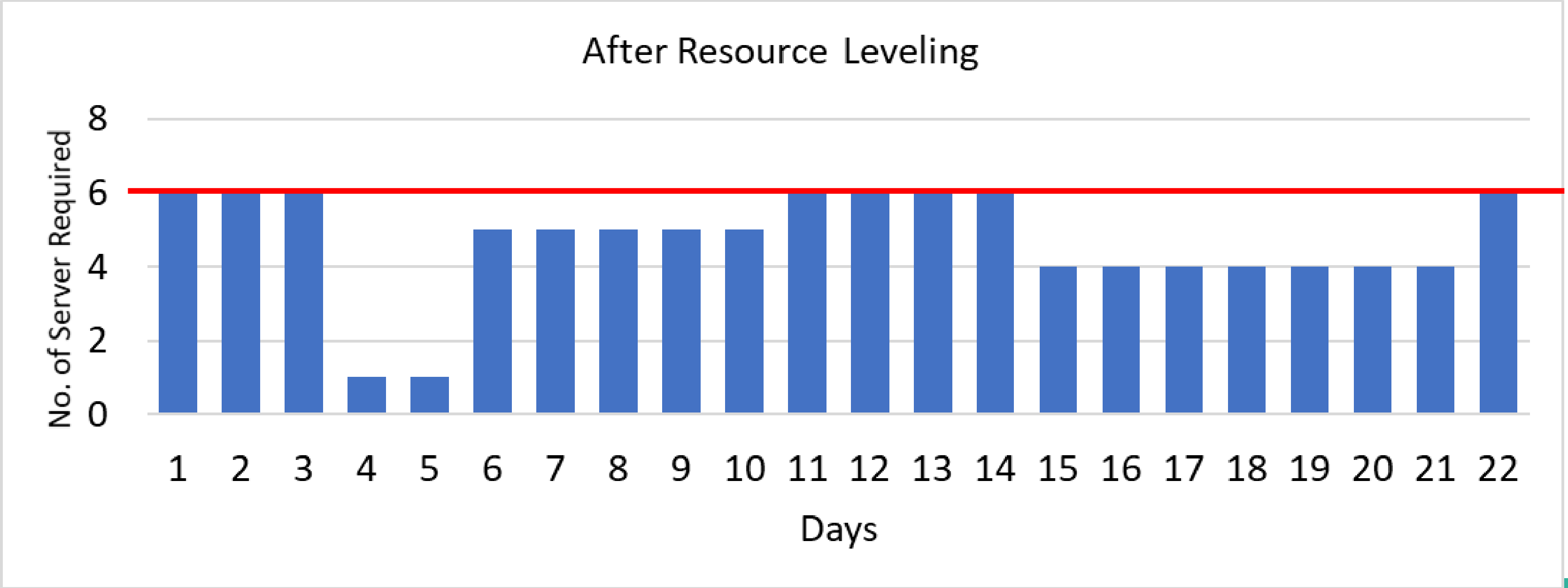

Resource Leveling

•The downside of resource leveling is that it might extend the overall project duration, as adjustments are made to avoid resource conflicts.

•Resource leveling may impact the critical path of the project

DEVELOP SCHEDULE

Tools & Techniques: Resource Optimization

Activity	Duration (days)	No. of Server Required	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
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Tools & Techniques: Resource Optimization

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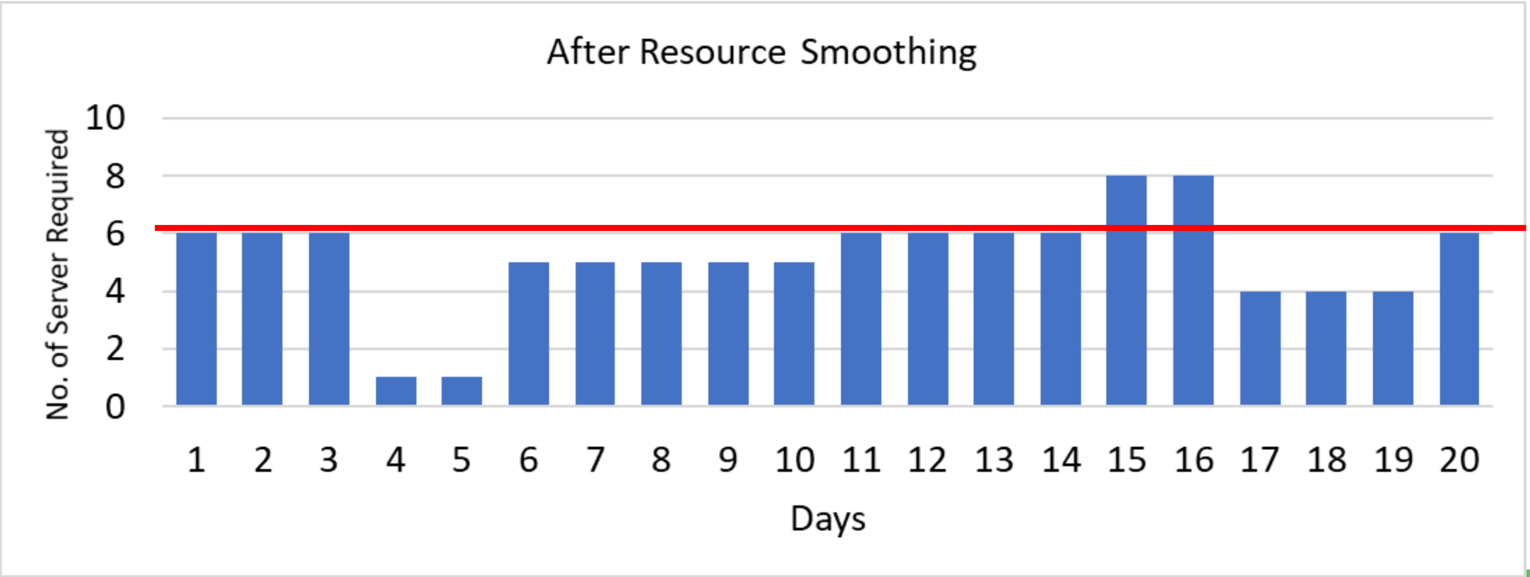

Quiz Time (Ungraded)

According to the draft project schedule, coding work on an IT project spanned for 2.5 months with a 0.5-month free float. The number of developers required for month 1, 2 and 3 were 8, 2, and 5 respectively. According to the budget, the project can afford a maximum of 6 developers in any month. Alice, the project manager, requested Bob, the Development Lead, to adjust the resource requirements for the coding activities to align with the available budget. Melissa rearranged the activities such that the developers required for month 1, 2 and 3 changed to 6, 4, and 5 respectively, and it resulted in extending the coding activity duration to 2.75 months.

This exercise of adjusting the schedule to meet the project constraints is an example of________

Develop Schedule

Tools & Techniques: Resource Optimization

Resource leveling is used when:

1. A critical resource may not be available for a certain duration;
2. A critical resource may not be available at a certain point of time;
3. You have to share a resource with another project;
4. The demand for a resource exceeds the supply.

Resource Smoothing is used when:

1. The end date is the main constraint of your project.

DEVELOP SCHEDULE

Tools & Techniques: Data Analysis

What-if scenario analysis

- What-if scenario analysis is the process of evaluating scenarios in order to predict their effect, positive or negative, on project objectives.
- This is an analysis of the question, “What if the situation represented by scenario X happens?”
- The outcome of the what-if scenario analysis can be used to assess the feasibility of the project schedule under different conditions, and in preparing schedule reserves and response plans to address the impact of unexpected situations.

Simulation

- Simulation models the combined effects of individual project risks and other sources of uncertainty to evaluate their potential impact on achieving project objectives.
- The most common simulation technique is Monte Carlo analysis, in which risks, and other sources of uncertainty are used to calculate possible schedule outcomes for the total project.

Develop Schedule

Tools & Techniques: Data Analysis

What-if scenario analysis

- What-if analysis is used to explore and compare various plan and schedule alternatives based on changing conditions..
- This is an analysis of the question, "What if the situation represented by scenario X happens?"
- The outcome of the what-if scenario analysis can be used to assess the feasibility of the project schedule under different conditions, and in preparing schedule reserves and response plans to address the impact of unexpected situations.

Some examples might be:

- ✓ What if lead time for major equipment or components is extended?
- ✓ What if we need to extend the duration of certain designing activities?
- ✓ What is the effect on completion date and resources if the current performance trend continues?
- ✓ What if you hire more people?
- ✓ What if your priorities change?

DEVELOP SCHEDULE

Tools & Techniques: Data Analysis

Simulation

- simulation is a powerful technique to assess schedule risk in project management.
- The most common simulation technique is **Monte Carlo analysis.**
- Monte Carlo simulation is a method of generating random samples from a specified distribution and using them to simulate the outcomes of a complex system or process.
- In project management, Monte Carlo simulation can be used to model the duration and cost of a project based on the estimates and assumptions of the project team.

DEVELOP SCHEDULE

Tools & Techniques: Data Analysis

- ✓ In a **Monte Carlo analysis**, we run the same model — selecting a random value for each task
- ✓ We do it hundreds or thousands of times.
- ✓ Each time it runs, we record the values.

DEVELOP SCHEDULE

Tools & Techniques: Data Analysis

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Consider a simple project plan. This plan includes a single project, with three tasks:

DEVELOP SCHEDULE

Tools & Techniques: Data Analysis

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Consider a simple project plan. This plan includes a single project, with three tasks:

Task	Best-Case	Expected	Worst-Case
Task 1	10 Days	20 Days	30 Days
Task 2	10 Days	20 Days	30 Days
Task 3	5 Days	10 Days	20 Days

Let's assume that, these tasks must be completed in sequence, meaning each task is dependent on the task before it. How long will the project take to complete?

DEVELOP SCHEDULE

Tools & Techniques: Data Analysis

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Consider a simple project plan. This plan includes a single project, with three tasks:

Task	Best-Case	Expected	Worst-Case
Task 1	10 Days	20 Days	30 Days
Task 2	10 Days	20 Days	30 Days
Task 3	5 Days	10 Days	20 Days
Total	25 Days	50 Days	80 Days

This is useful, but still unrealistic; because it's unlikely that each task will take the best-case time, or the worst-case time. More likely, Some may take longer, while others finish ahead of schedule.

DEVELOP SCHEDULE

Tools & Techniques: Data Analysis

- ✓ Now to add some randomness we will introduce PERT (Program Evaluation Review Technique)

$$PERT = (O + 4M + P) / 6$$

DEVELOP SCHEDULE

Tools & Techniques: Data Analysis

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Task	Best-Case	Expected	Worst-Case	Sample (PERT)
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Tools & Techniques: Data Analysis

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In this case, with random values selected for each task, you can see that the first task takes a little longer than expected. The last task takes longer as well. The second task is completed ahead of schedule.

DEVELOP SCHEDULE

Tools & Techniques: Data Analysis

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In this case, with random values selected for each task, you can see that the first task takes a little longer than expected. The last task takes longer as well. The second task is completed ahead of schedule.

However, A single random case is not useful, because it represents only one out of essentially limitless possibilities. This is where we can use Monte Carlo simulation to measure and understand the risk.

DEVELOP SCHEDULE

Tools & Techniques: Data Analysis

- ✓ In a Monte Carlo analysis, we run the same model — selecting a random value for each task — but we do it hundreds or thousands of times.
- ✓ Each time it runs, we record the values.
- ✓ When the simulation is complete, we can look at statistics from the simulation' to understand the risk in the model.
- ✓ We'll start with the basic statistics: the minimum, maximum, and average.

DEVELOP SCHEDULE

Tools & Techniques: Data Analysis

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Task	Best-Case	Expected	Worst-Case	Sample (PERT)	Minimum	Average	Maximum
Task 1	10 Days	20 Days	30 Days	...	11 Days	20 Days	29 Days
Task 2	10 Days	20 Days	30 Days	...	10 Days	20 Days	29 Days
Task 3	5 Days	10 Days	20 Days	...	5 Days	11 Days	19 Days
Total	25 Days	50 Days	80 Days	...	32 Days	51 Days	70 Days

This data comes from a Monte Carlo analysis of 1,000 trials.

Develop Schedule

Tools & Techniques: Data Analysis

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The first thing we can observe that the average completion time is close to our central estimate. That is what we would expect; it's the most likely case for each task. We can now say that the worst case scenario is 70 days, instead of 80.

Develop Schedule

Tools & Techniques: Data Analysis

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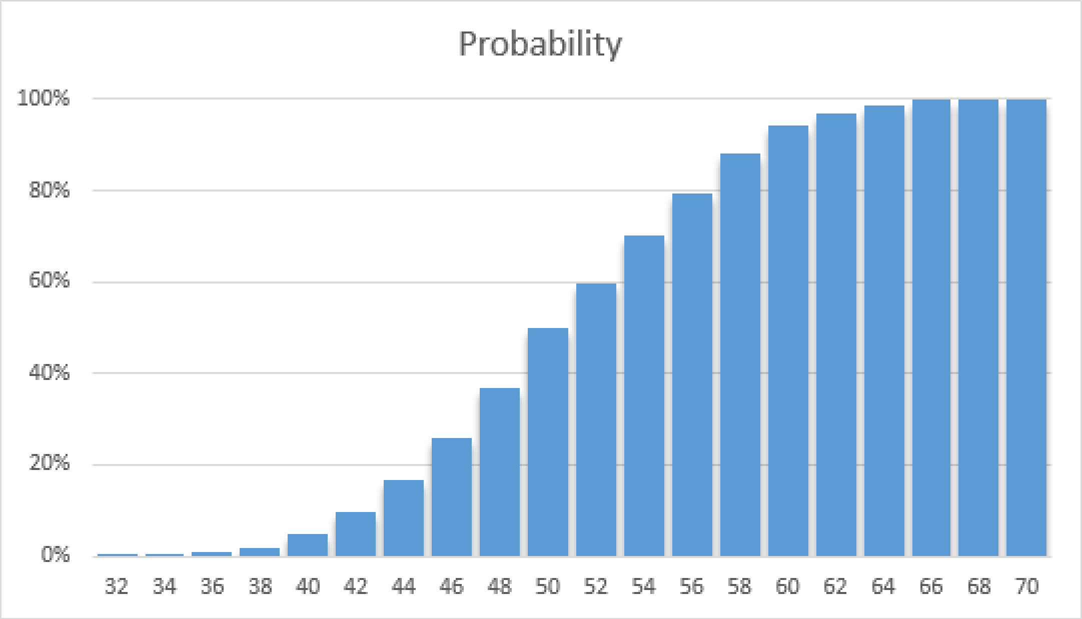
Next, we can look at the range of data generated during the Monte Carlo simulation to understand more about the projections.

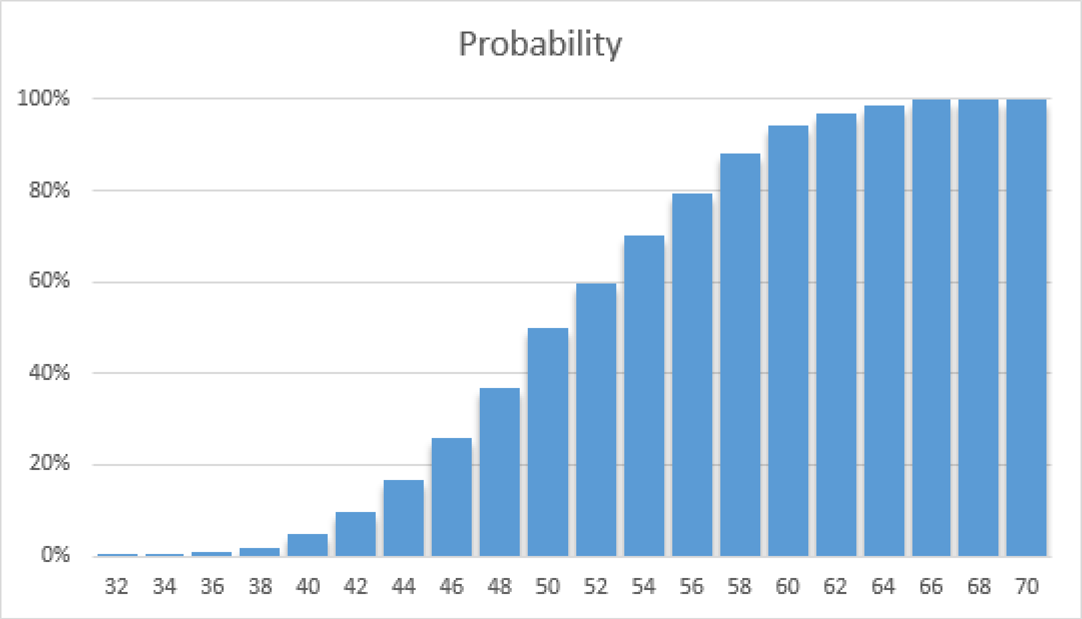
Develop Schedule

Tools & Techniques: Data Analysis



DEVELOP SCHEDULE

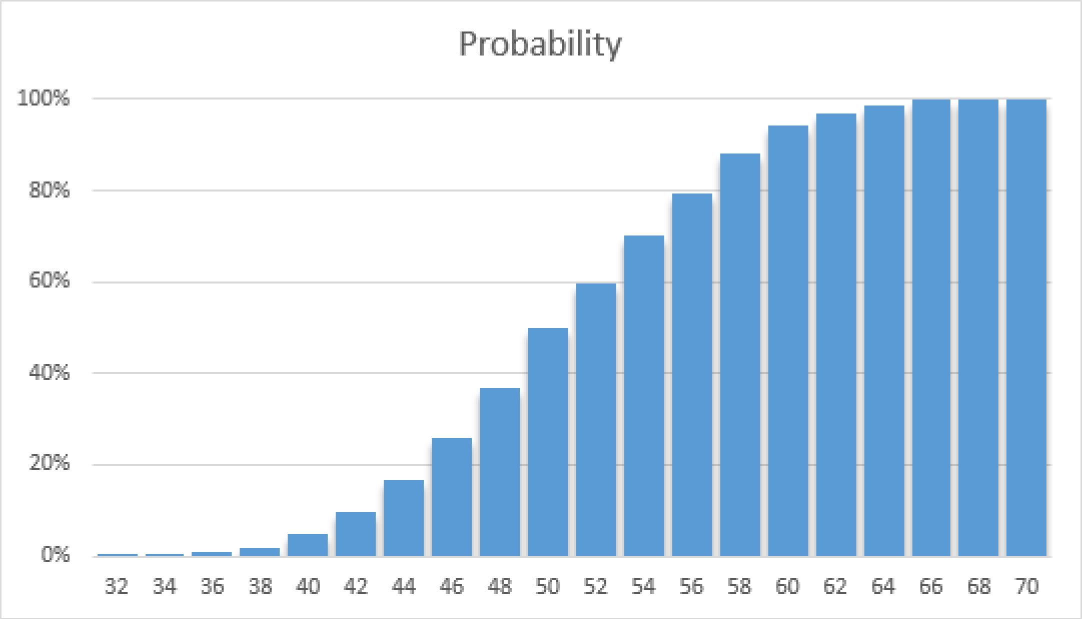
Tools & Techniques: Data Analysis



- ✓ there is only a 5% chance that the project will be completed within 40 days
- ✓ there is a 94% chance the project will be completed within 60 days.

Develop Schedule

Tools & Techniques: Data Analysis



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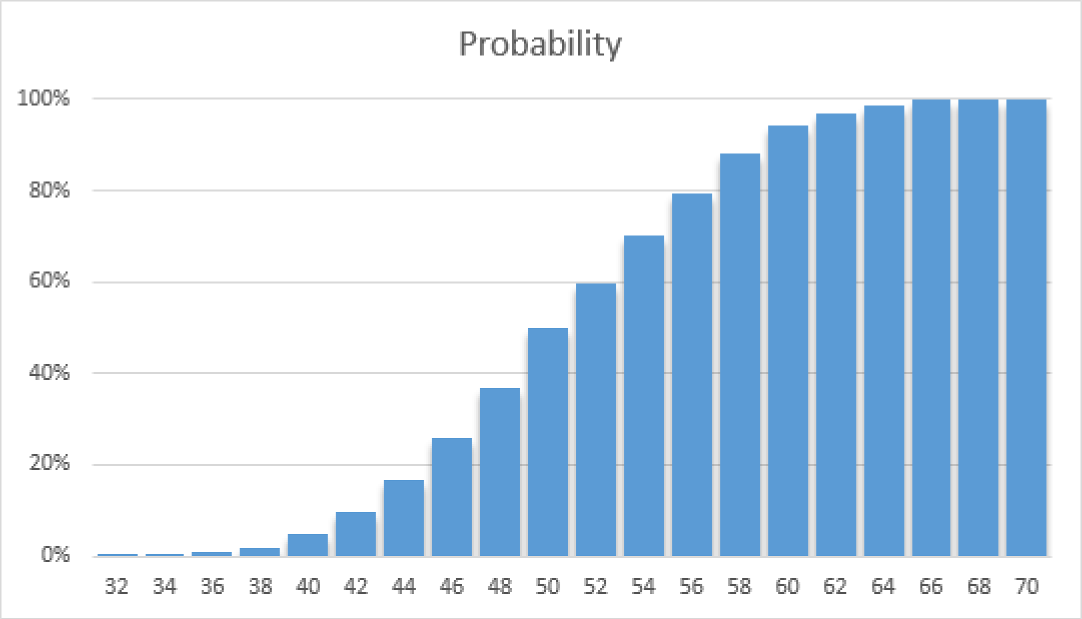
What does it mean?

DEVELOP SCHEDULE

Tools & Techniques: Data Analysis



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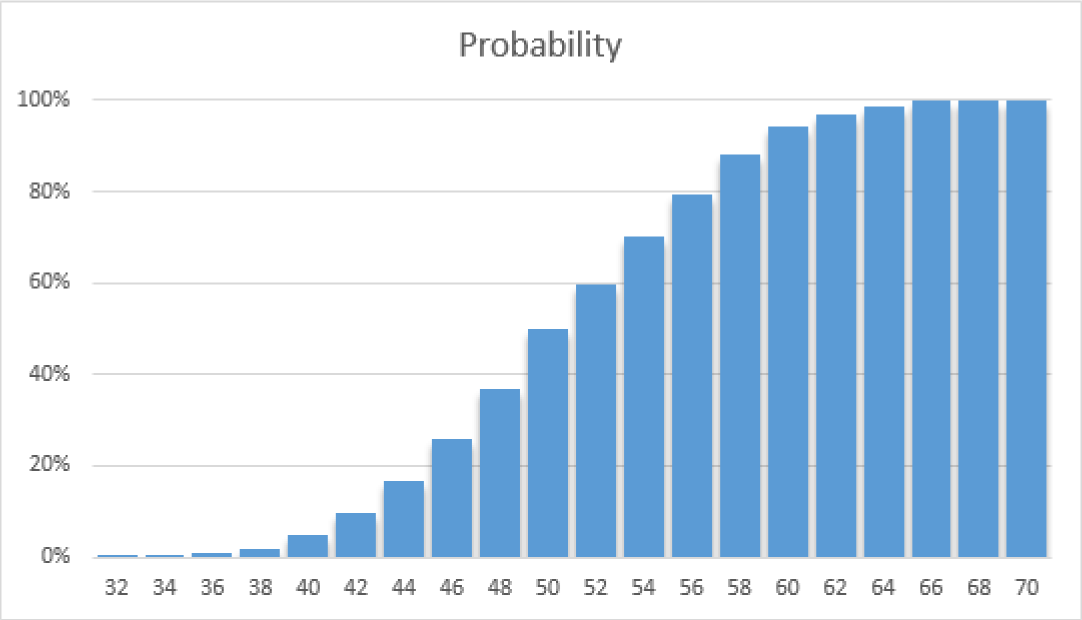
What does it mean?

- In only 5% of the trials (50 out of 1,000) the total project time was 40 days or less. We can therefore say that, during the simulation, there was a 5% probability that the project would be completed within 40 days.

DEVELOP SCHEDULE

Tools & Techniques: Data Analysis



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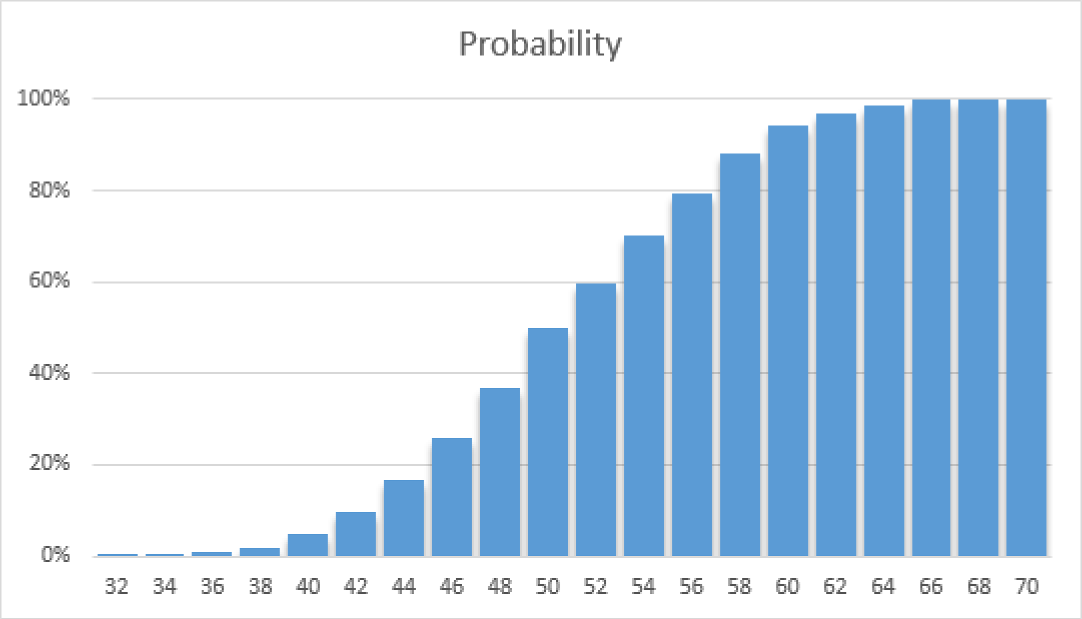
DEVELOP SCHEDULE

Tools & Techniques: Data Analysis



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- Similarly, during the simulation, there was a 94% chance that the project was completed within 60 days.

Key Points

- ✓ Estimated Range is 32-70 Days (Even though our best- and worst-case estimates result in totals of 25-80 days)
- ✓ Probability of Completion within 50 Days is 50%
- ✓ For 75% Confidence, Budget 55 Days; for 85% Confidence, Budget 58 Days
- ✓ We can say that in 75% of the simulation trials, the project was completed within 55 days. We can budget for various confidence levels by looking at probability from the simulation.

DEVELOP SCHEDULE

Tools & Techniques:

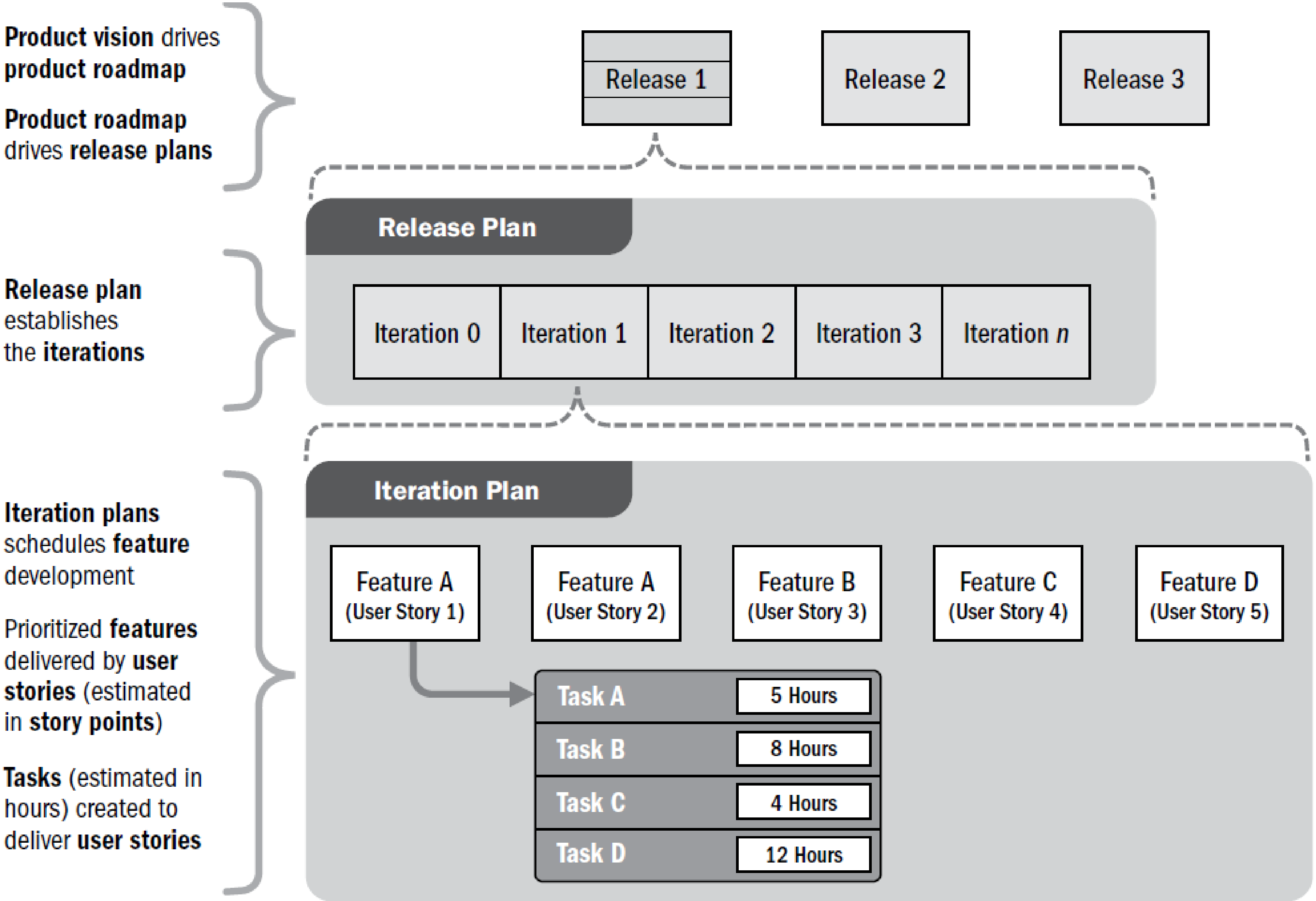
Leads and lags

Project Management Information System (PMIS)

Agile Release Planning

- ✓ Agile release planning provides a high-level summary timeline of the release schedule (typically 3 to 6 months) based on the product roadmap and the product vision for the product’s evolution.
- ✓ also determines the number of iterations or sprints in the release and allows the product owner and team to decide how much needs to be developed and how long it will take to have a releasable product based on business goals, dependencies, and impediments

Develop Schedule



Relationship Between Product Vision, Release Planning, and Iteration Planning

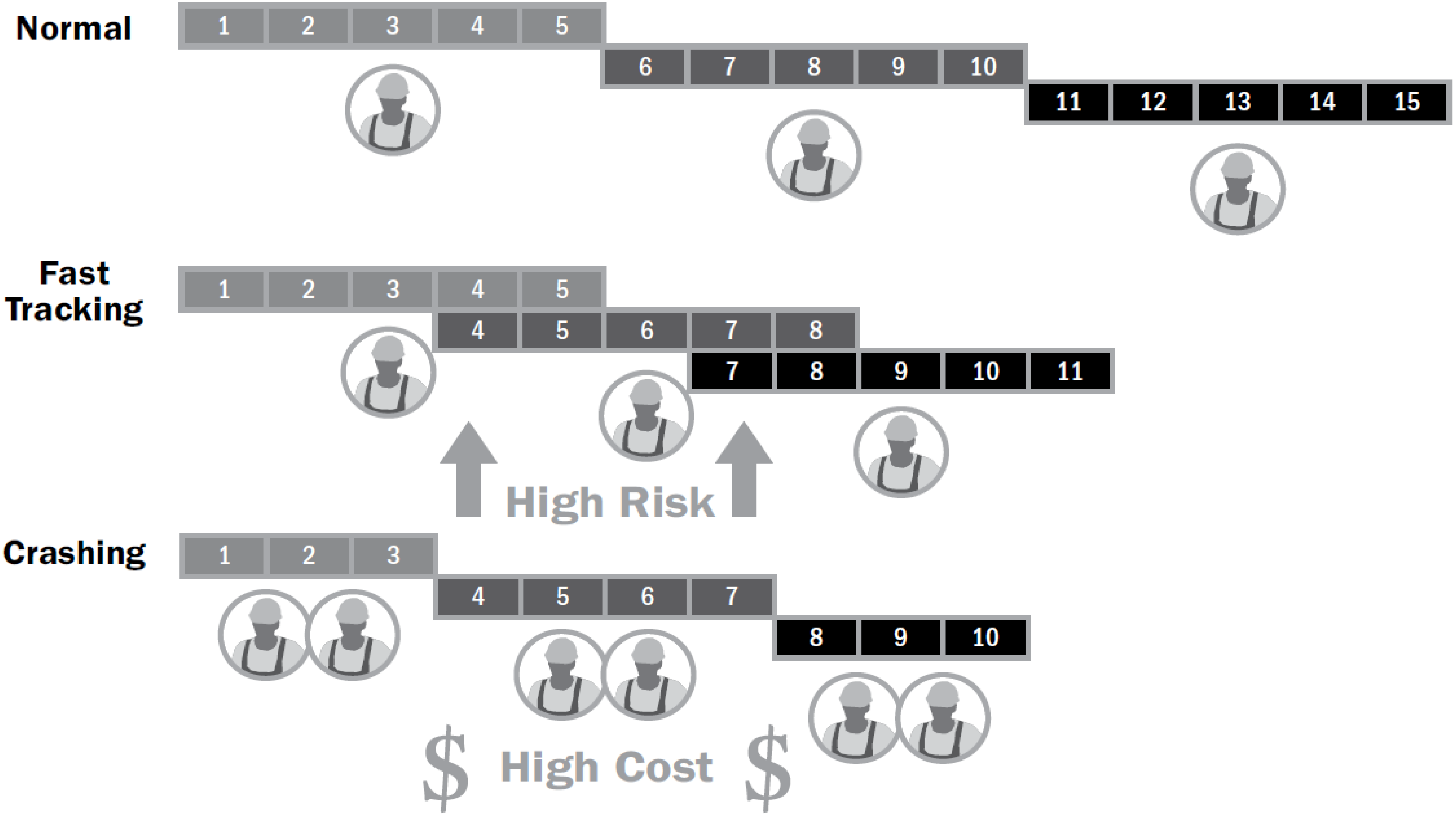
DEVELOP SCHEDULE

Tools & Techniques: Schedule compression

✓ Schedule compression techniques are :

- Crashing.
  - ➢ With crashing, resources are added to the activities on the critical path, and the duration of the activities is reduced as a result.
- Fast tracking.
  - ➢ A schedule compression technique in which activities or phases normally done in sequence are performed in parallel for at least a portion of their duration

Develop Schedule



Schedule Compression Comparison

DEVELOP SCHEDULE

Tools & Techniques: Schedule compression - Crashing

Time Is Money: Cost-Time Tradeoffs

- ✓ Reducing the time of a critical activity usually incurs additional direct costs.

Reasons for imposed project duration dates:

- ✓ Time-to-market pressures
- ✓ An unrealistic schedule
- ✓ Unforeseen delays
- ✓ Incentive contracts (bonuses for early completion)
- ✓ Imposed deadlines and contract commitments
- ✓ Overhead and public goodwill costs
- ✓ Pressure to move resources to other projects

DEVELOP SCHEDULE

Tools & Techniques: Schedule compression - **Crashing**

Determining Activities to Shorten

Shorten the activities with the smallest increase in cost per unit of time.

Assumptions:

The cost relationship is linear.

Normal time assumes low-cost, efficient methods to complete the activity.

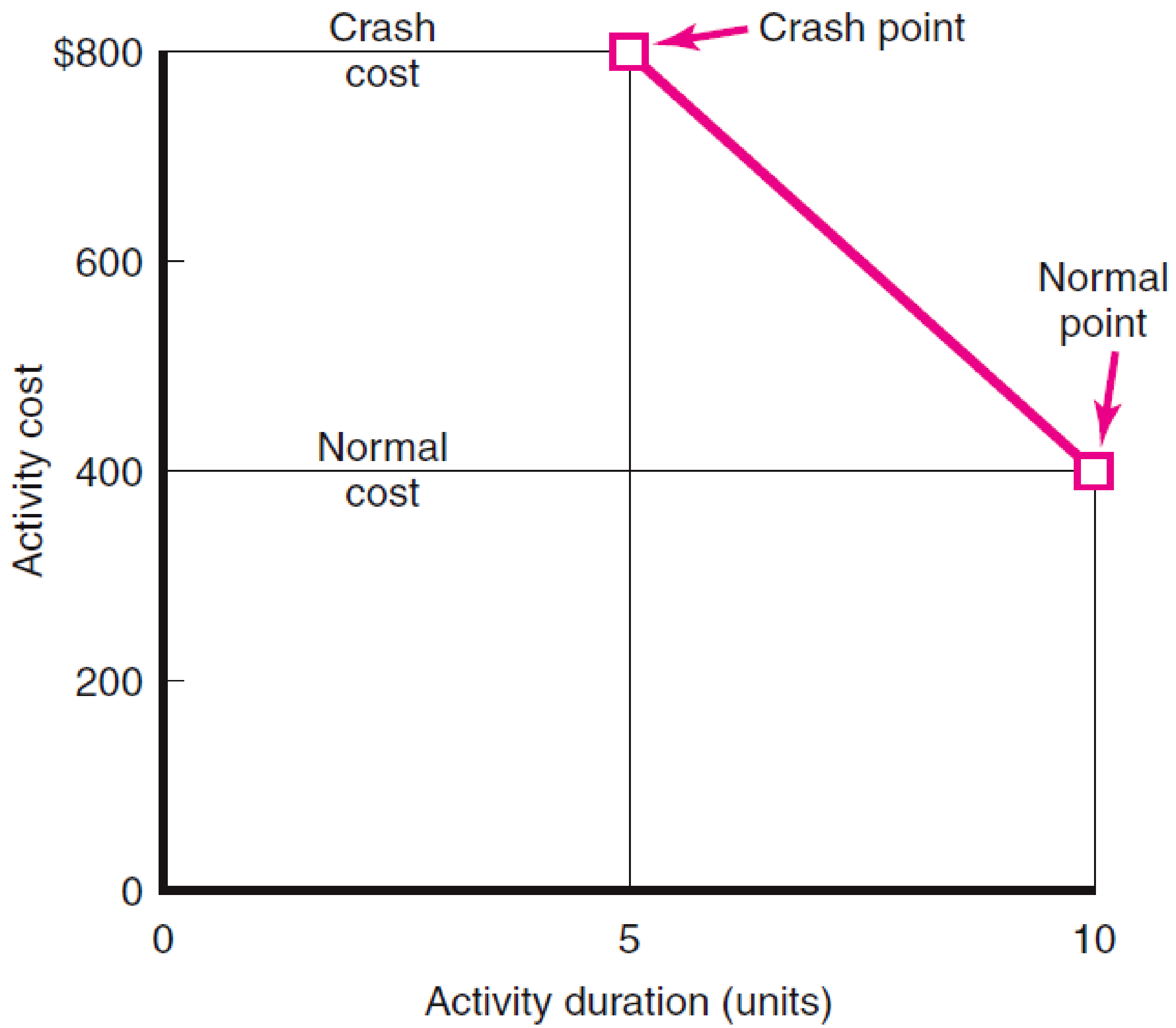
Crash time represents a limit—the greatest time reduction possible under realistic conditions.

Slope represents a constant cost *per unit of time*.

All accelerations must occur within the normal and crash times.

DEVELOP SCHEDULE

Tools & Techniques: Schedule compression - **Crashing**



Develop Schedule

Tools & Techniques: Schedule compression - **Crashing**

Based on the data provided in Table1, calculate the lowest cost of crashing to complete the project four weeks earlier than the baseline schedule. What activities should go through crashing for that?

Activity	Predecessor	Baseline		Crash	
		Time	Cost ($)	Time	Cost ($)
A		10	4000	8	6000
B	A	2	6000	2	6000
C	A	14	22000	12	26000
D	A	6	9000	5	10000
E	B,D	9	14000	7	19000
F	C,E	8	18000	4	36000

DEVELOP SCHEDULE

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- ✓ Identify the critical path in the baseline schedule (A-B-C-F).

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✓ Identify the critical path in the baseline schedule (A-B-C-F).

- **Activity A:** Baseline Time Savings = 10−8=2 weeks
- **Activity C:** Baseline Time Savings = 14−12=2 weeks
- **Activity F:** Baseline Time Savings = 8−4=4 weeks

DEVELOP SCHEDULE

Tools & Techniques: Schedule compression - Crashing

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Now, let's calculate the cost:

- **Total Cost of Crashing:**
  - Total Cost of Crashing=Sum of (Additional Crash Time Needed × Crash Cost Per Time Saved)

DEVELOP SCHEDULE

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Now, let's calculate the cost:

- **Total Cost of Crashing:**
  - Total Cost of Crashing=Sum of (Additional Crash Time Needed × Crash Cost Per Time Saved)

Activity A:

Crash Cost Per Time Saved = (6000−4000)/2=1000

Total Cost of Crashing for A = 2×1000=2000 dollars

Total Cost of Crashing for C = 2×2000=4000 dollars

Total Cost of Crashing for F = 4×4500=18000

Develop Schedule

Tools & Techniques: Schedule compression - **Crashing**

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  - Total Cost of Crashing=Sum of (Additional Crash Time Needed × Crash Cost Per Time Saved)

Activity A:

Crash Cost Per Time Saved = (6000−4000)/2=1000

Total Cost of Crashing for A = 2×1000=2000 dollars

Total Cost of Crashing for C = 2×2000=4000 dollars

Total Cost of Crashing for F = 4×4500=18000

Total Cost of Crashing = 2000 + 4000 = 6000

DEVELOP SCHEDULE

Output:

Schedule Baseline	• Specific approved version of the project schedule model • Can be changed through formal change control • Used as the basis for comparison
Project Schedule	• Bar chart • Milestone Chart • Project schedule network diagram
Schedule Data	• Resource requirement by the time period, • Alternative schedule (best case, worst case), • Scheduling of contingency reserve
Project calendars	• Identifies working days and shifts • Time period in days or part in days is available or not available

Develop Schedule

Output:

Change Requests	• Modifications to the project scope or project schedule may result in change requests to the scope baseline, and/or other components of the project management plan.
Project management plan update	• Schedule management plan • Cost baseline
Project Document update	• Activity attribute, Assumption log, Duration estimates, LL register, Resource requirement, Risk register

Develop Schedule

Milestone Schedule

Activity Identifier	Activity Description	Calendar units	Project Schedule Time Frame				
			Period 1	Period 2	Period 3	Period 4	Period 5
1.1.MB	Begin New Product Z	0					
1.1.1.M1	Complete Component 1	0					
1.1.2.M1	Complete Component 2	0					
1.1.3.M1	Complete Integration of Components 1 & 2	0					
1.1.3.MF	Finish New Product Z	0					

Data Date

Summary Schedule

Activity Identifier	Activity Description	Calendar units	Project Schedule Time Frame				
			Period 1	Period 2	Period 3	Period 4	Period 5
1.1	Develop and Deliver New Product Z	120					
1.1.1	Work Package 1: Component 1	67					
1.1.2	Work Package 2: Component 2	53					
1.1.3	Work Package 3: Integrated Components 1 and 2	53					

Data Date

Develop Schedule

Detailed Schedule

Activity Identifier	Activity Description	Calendar units
1.1.MB	Begin New Product Z	0
1.1	Develop and Deliver Product Z	120
1.1.1	Work Package 1: Component 1	67
1.1.1.D	Design Component 1	20
1.1.1.B	Build Component 1	33
1.1.1.T	Test Component 1	14
1.1.1.M1	Complete Component 1	0
1.1.2	Work Package 2: Component 2	53
1.1.2.D	Design Component 2	14
1.1.2.B	Build Component 2	28