NANYANG TECHNOLOGICAL UNIVERSITY

CZ3002 - Advanced Software Engineering

Software Project Management - Project Estimation (COCOMO)

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Lesson Objectives

At the end of the lesson, you should be able to:

- Use the COCOMO to estimate effort, cost, schedule and resources
- Apply COCOMO 81 and COCOMO II into different projects
- Investigate schedule compression

Steps in Creating a Project Estimate

Estimate the effort needed to create the system (e.g., persons-month)

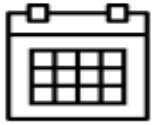
Estimate the manpower (e.g., how many people)

Estimate the phase schedule

Step 1 → **Step 2** → **Step 3** → **Step 4** → **Step 5** → **Step 6**

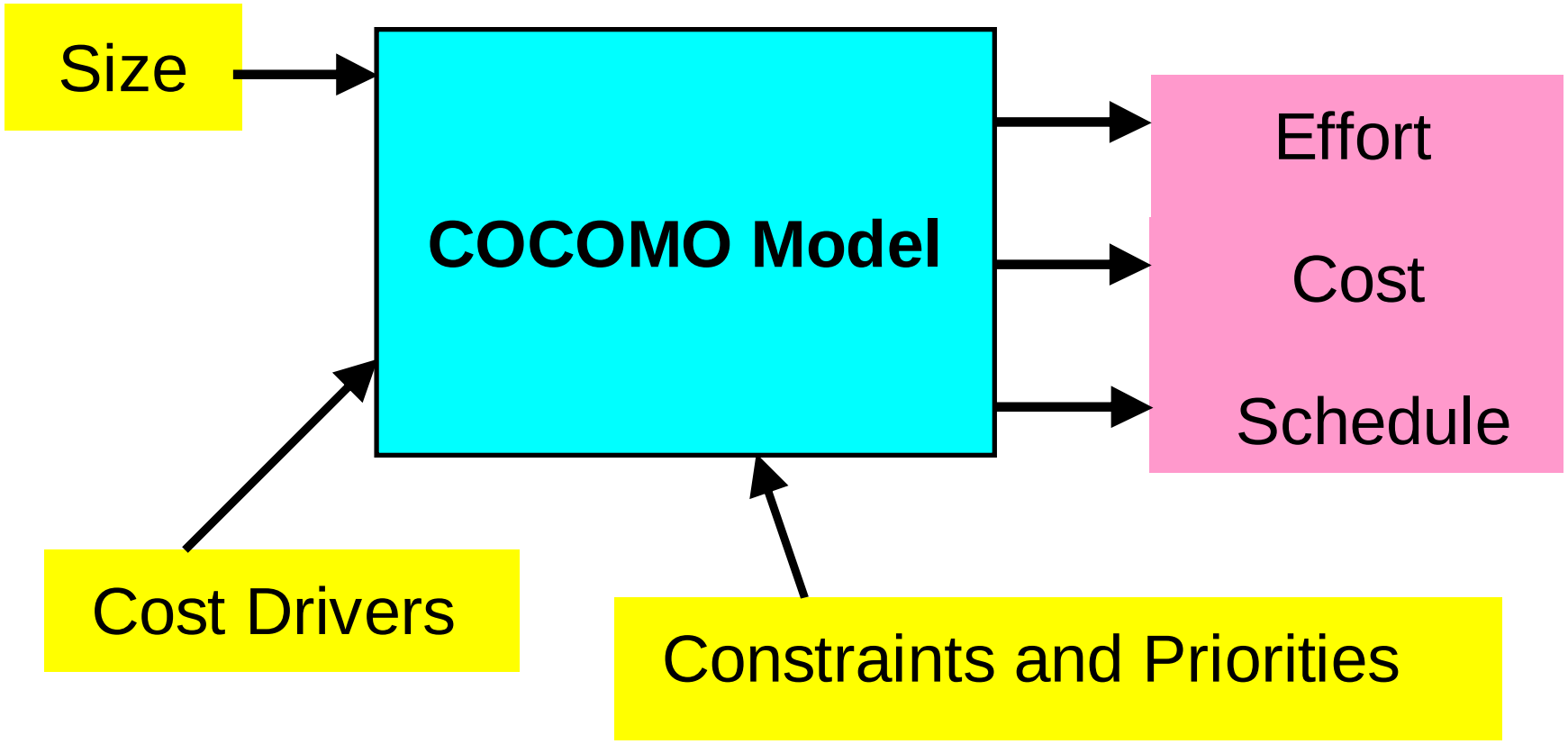
Estimate the size of the product/ system

Estimate the duration (calendar time)



Estimate the costs ($)

Size ⟶ Effort, Schedule & Cost

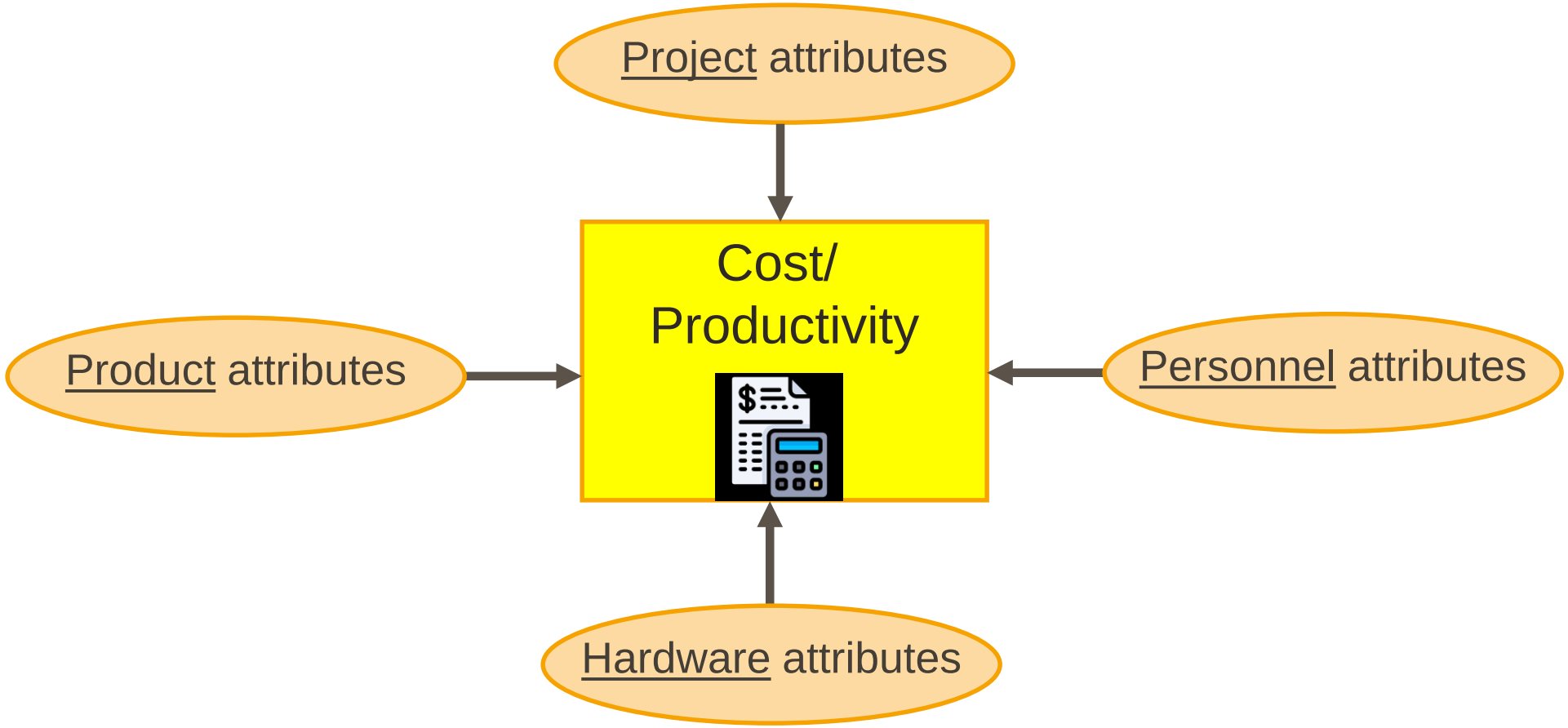


Constraints and Priorities

- Constraint examples:
  - Maximum schedule
  - Maximum effort
  - Maximum cost
- Priority examples:
  - E.g., “Least cost” or “Shortest schedule” or “Smallest number of staff” is top priority

Cost (or Productivity) Drivers

- Additional parameters that affect productivity:



COCOMO

- **COCOMO (Constructive Cost Model)**
  - Barry Boehm's work started in 1970's, book 1981
  - COCOMO 81

Model type	Effort
Basic	size (static single-valued model)
Intermediate	size + cost drivers
Advanced	size + cost drivers + driver impact on each project phase

  - COCOMO II (1997)

COCOMO 81: Basic Model

Effort $E = a (KDSI)^b$
Duration $D = c(E)^d$
Recommended Staff Size $S = E / D$
KDSI – thousand delivered source instruction

Constants For Different Development Modes:

Organic	2.4	1.05	2.5	.38
Semi-detached	3.0	1.12	2.5	.35
Embedded	3.6	1.2	2.5	.32
	a	b	c	d

COCOMO 81: Intermediate Model

- Uses slightly different ‘a’ constants
  - Organic (3.2)
  - Semi-detached (3.0)
  - Embedded (2.8)
- Adds “Effort Adjustment Factor” (EAF) computed from 15 cost drivers
- The EAF is the product of the cost drivers

$$\text{Effort } E = a\,(KDSI)^b \times EAF$$
$$\text{Duration } D = c(E)^d$$
$$EAF = Val_1 \times Val_2 \times \cdots \times Val_n$$

Val_i is the rating value of cost driver *i*

Cost Drivers

- Personnel attributes: analyst capability, application experience, programming language experience
- Product attributes: required reliability, database size, product complexity
- Project attributes: modern programming practices, software tools, schedule constraints
- Hardware attributes: execution time constraints, storage constraints

Example of Cost Drivers

	RATINGS				
COST DRIVERS	**Very Low**	**Low**	**Nominal**	**High**	**Very High**
Product attributes					
Software reliability	0.75	0.88	1.00	1.15	1.40
Product complexity	0.70	0.85	1.00	1.15	1.34
Personnel attributes					
Analyst capability	1.46	1.19	1.00	0.86	0.71
Applications experience	1.29	1.13	1.00	0.91	0.82
Language and tools experience	1.22	1.09	1.00	0.86	0.70

COCOMO II 1997: Efforts

$$\text{Effort} = 2.94 \times \text{EAF} \times (\text{KSLOC})^{E}$$

- Where:
  - EAF is the Effort Adjustment Factor derived from the cost drivers, it is the product of the cost drivers
  - E is an exponent derived from the five scale drivers (precedentedness, development flexibility, architecture/ risk resolution, team cohesion, process maturity)

COCOMO II 1997: Duration

$$\text{Duration} = 3.67 \times (\text{Effort})^{SE}$$

- Where:
  - Effort is the effort from the COCOMO II effort equation
  - SE is the schedule equation exponent derived from the five scale drivers

Using Historical Project Data

- The best “estimation model” is based on your own organisation’s historical data.

The Practice Sheet

- Effort Adjustment Factor (EAF) =
- Effort =
- Duration =
- Average staffing =

Effort Adjustment Factor Example

- Assuming your project consists of
  - 8,000 source lines of code, and
  - is rated “Very High” for complexity, and
  - “Low” for language and tools experience, and
  - all of the other cost drivers are rated to be “Nominal”
- The schedule equation exponents are SE = 0.3179 and E = 1.0997.

Practice

- Effort Adjustment Factor (EAF) = $1.34 \times 1.09 = 1.46$
- Effort = $2.94 \times (1.46) \times (8)^{1.0997} = 42.3$ Person-Months (PM)
- Duration = $3.67 \times (42.3)^{0.3179} = 12.1$ months
- Average staffing = (42.3 PM) / (12.1 Months) = 3.5 people

Step 5: Project Cost ($)

Internal cost (cost to developers)

- Labour (team)
- Software and hardware
- Overheads (rent, utilities, office supplies, executive salaries, etc.)

Profit margin
(less other factors at work)

External cost (cost to client)

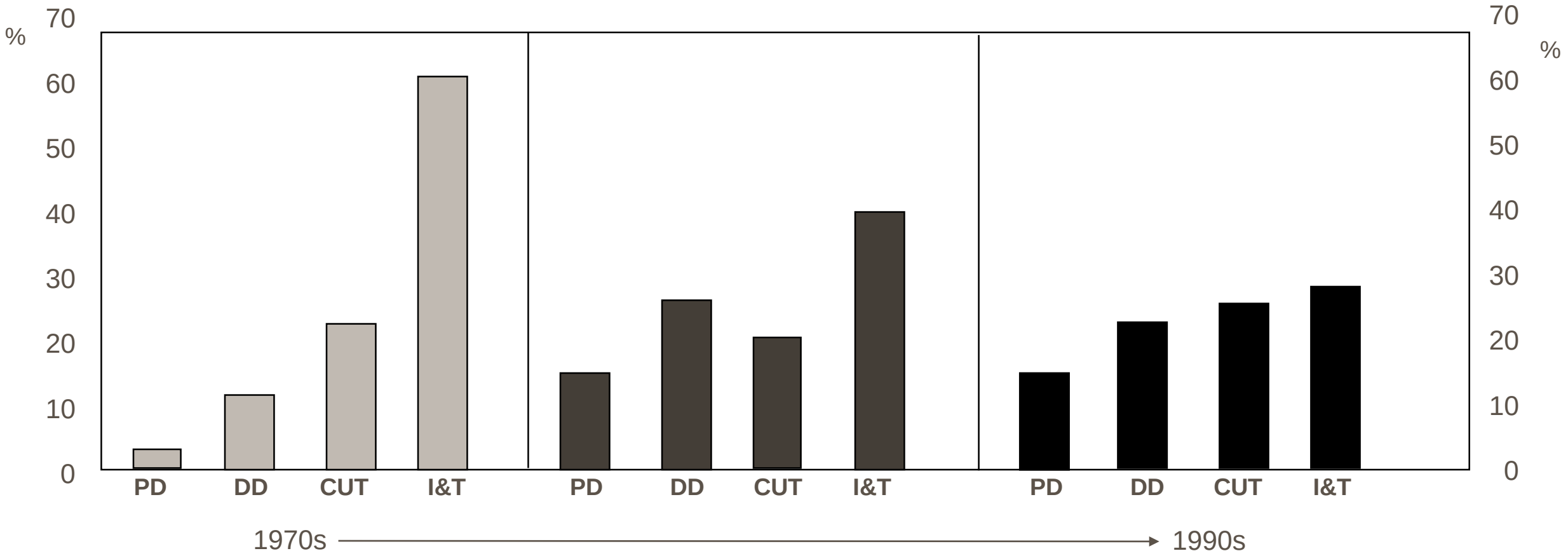
Step 6: From Effort or Duration to a Phase Schedule (Roughly)

- Know the percentage of time spent in each phase:

Requirements analysis	8%
Architectural design	12%
Detailed design	20%
Coding and unit testing	20%
Integration and testing	40%

→ of 11 months = 3.5 weeks

Distribution of Effort



Schedule Compression

- Desired schedule / initial schedule = compression factor
  - E.g., 8 months / 10.7 months = 75%
- Compressed schedule effort = initial effort / compression factor
  - E.g., 46.8 PM / 75% = 62.4 PM
- Extra 15.6 PM to reduce schedule by about three calendar months
- 25% reduction in schedule → 33% increase in effort

Schedule Compression - How?

- Compression = shrink schedule by adding people
  - Team size = Effort / Duration

46.8 PM / 10.7 months	4.4 people
Now 62.4 PM / 8 months	7.8 people
Not 46.8 PM / 8 months	5.85 people
Not 46.8 PM / 7 people	6.7 months

Schedule Compression Limits

"There is a shortest possible schedule, and you can't beat it!"

Research suggests no less than 75% - 80% compression factor is possible

Highlights

- Project estimation
  - Function Points Analysis
  - COCOMO Model **basic, intermediate and COCOMO 2**
- Estimation steps and methods