Lecture - 9

Software Cost Estimation

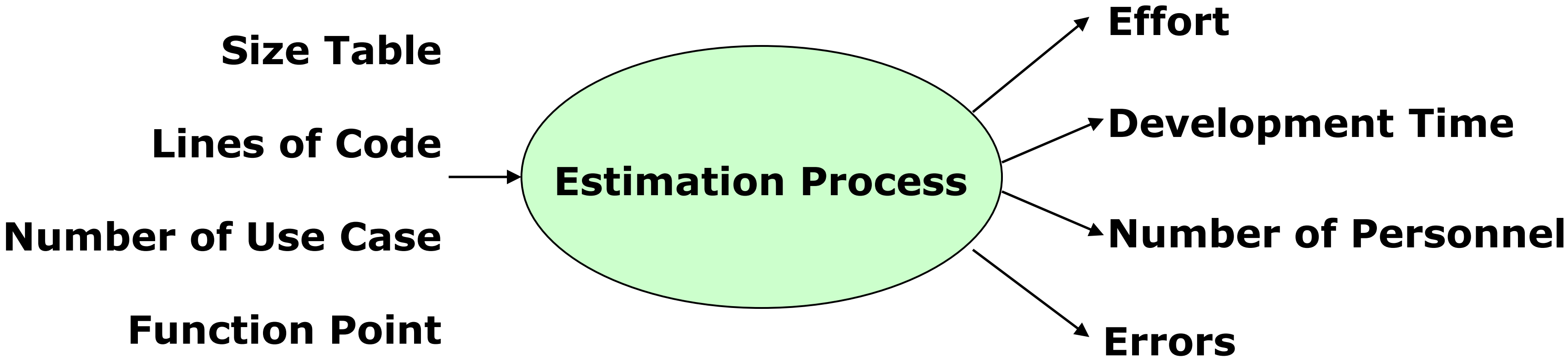
COCOMO Model (CONT.)

- Software cost estimation is done through three stages:
  - Basic COCOMO,
  - Intermediate COCOMO,
  - Complete COCOMO.

COST ESTIMATION PROCESS

Cost=SizeOfTheProject x Productivity

Cost Estimation Process



Basic COCOMO Model (CONT.)

- Gives only an approximate estimation:
- It uses only size and mode to determine the effort and schedule.
  - Effort = a1 (KLOC)a2
  - Tdev = b1 (Effort)b2
    - KLOC is the estimated kilo lines of source code,
    - a1,a2,b1,b2 are constants for different categories of software products,
    - Tdev is the estimated time to develop the software in months,
    - Effort estimation is obtained in terms of person months (PMs).

Effort Computation

- The **Basic COCOMO model** computes effort as a function of program size. The Basic COCOMO equation is:
  - ***E = aKLOC^b***
- Effort for three modes of Basic COCOMO.

Mode	**a**	**b**
Organic	2.4	1.05
Semi-detached	3.0	1.12
Embedded	3.6	1.20

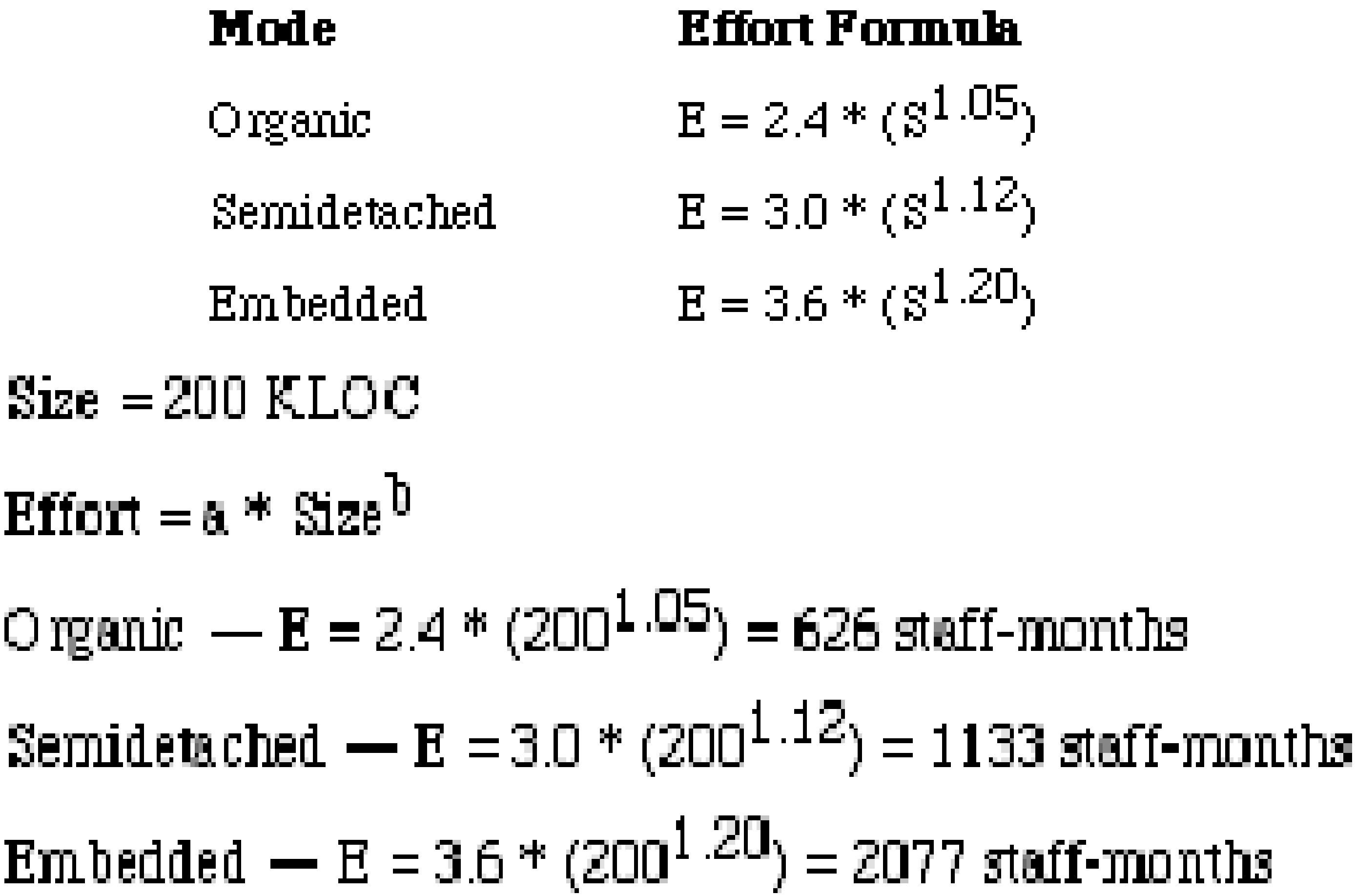
Development Effort Estimation

- Organic :
  - Effort = 2.4 (KLOC)1.05 PM
- Semi-detached:
  - Effort = 3.0(KLOC)1.12 PM
- Embedded:
  - Effort = 3.6 (KLOC)1.20PM

Development Time Estimation

- Organic:
    - Tdev = 2.5 (Effort)0.38 Months
- Semi-detached:
    - Tdev = 2.5 (Effort)0.35 Months
- Embedded:
    - Tdev = 2.5 (Effort)0.32 Months

Example



Mode	Effort Formula
Organic	$E = 2.4 * (S^{1.05})$
Semidetached	$E = 3.0 * (S^{1.12})$
Embedded	$E = 3.6 * (S^{1.20})$

Size = 200 KLOC

$\text{Effort} = a * \text{Size}^{b}$

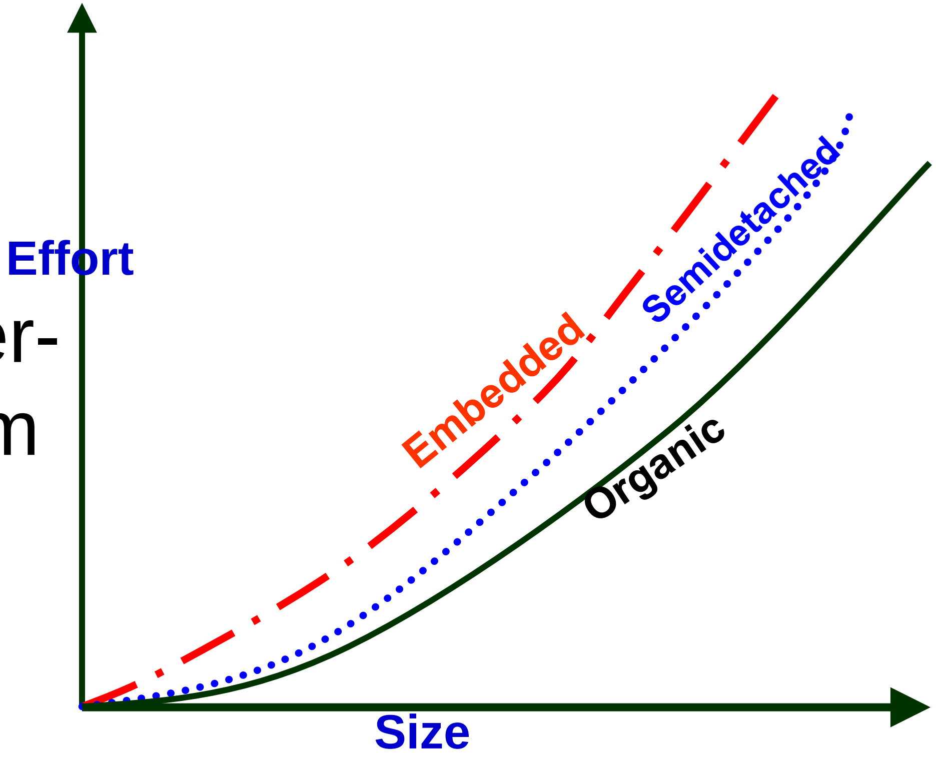
Organic — $E = 2.4 * (200^{1.05}) = 626$ staff-months

Semidetached — $E = 3.0 * (200^{1.12}) = 1133$ staff-months

Embedded — $E = 3.6 * (200^{1.20}) = 2077$ staff-months

Basic COCOMO Model (CONT.)

- Effort is somewhat super-linear in problem size.



Example

- The size of an organic software product has been estimated to be 32,000 lines of source code.

- Effort = 2.4*(32)1.05 = 91 PM
- Nominal development time = 2.5*(91)0.38 = 14 months

Intermediate COCOMO

- Basic COCOMO model assumes
  - effort and development time depend on product size alone.
- However, several parameters affect effort and development time:
    - Reliability requirements
    - Availability of CASE tools and modern facilities to the developers
    - Size of data to be handled

Intermediate COCOMO

- For accurate estimation,
  - the effect of all relevant parameters must be considered:
  - Intermediate COCOMO model recognizes this fact:
    - refines the initial estimate obtained by the basic COCOMO by using a set of 15 cost drivers (multipliers).

Effort Computation

- The **intermediate COCOMO model** computes effort as a function of program size and a set of cost drivers. The Intermediate COCOMO equation is:
  - $E = aKLOC^{b} * EAF$
- Effort for three modes of intermediate COCOMO.

Mode	**a**	**b**
Organic	3.2	1.05
Semi-detached	3.0	1.12
Embedded	2.8	1.20

Effort computation(.)

- **Effort Adjustment Factor**

Cost Driver	Very Low	Low	Nominal	High	Very High	Extra High
Required Reliability	.75	.88	1.00	1.15	1.40	1.40
Database Size	.94	.94	1.00	1.08	1.16	1.16
Product Complexity	.70	.85	1.00	1.15	1.30	1.65
Execution Time Constraint	1.00	1.00	1.00	1.11	1.30	1.66
Main Storage Constraint	1.00	1.00	1.00	1.06	1.21	1.56
Virtual Machine Volatility	.87	.87	1.00	1.15	1.30	1.30
Comp Turn Around Time	.87	.87	1.00	1.07	1.15	1.15
Analyst Capability	1.46	1.19	1.00	.86	.71	.71
Application Experience	1.29	1.13	1.00	.91	.82	.82
Programmers Capability	1.42	1.17	1.00	.86	.70	.70
Virtual machine Experience	1.21	1.10	1.00	.90	.90	.90
Language Experience	1.14	1.07	1.00	.95	.95	.95
Modern Prog Practices	1.24	1.10	1.00	.91	.82	.82
SW Tools	1.24	1.10	1.00	.91	.83	.83
Required Dev Schedule	1.23	1.08	1.00	1.04	1.10	1,10

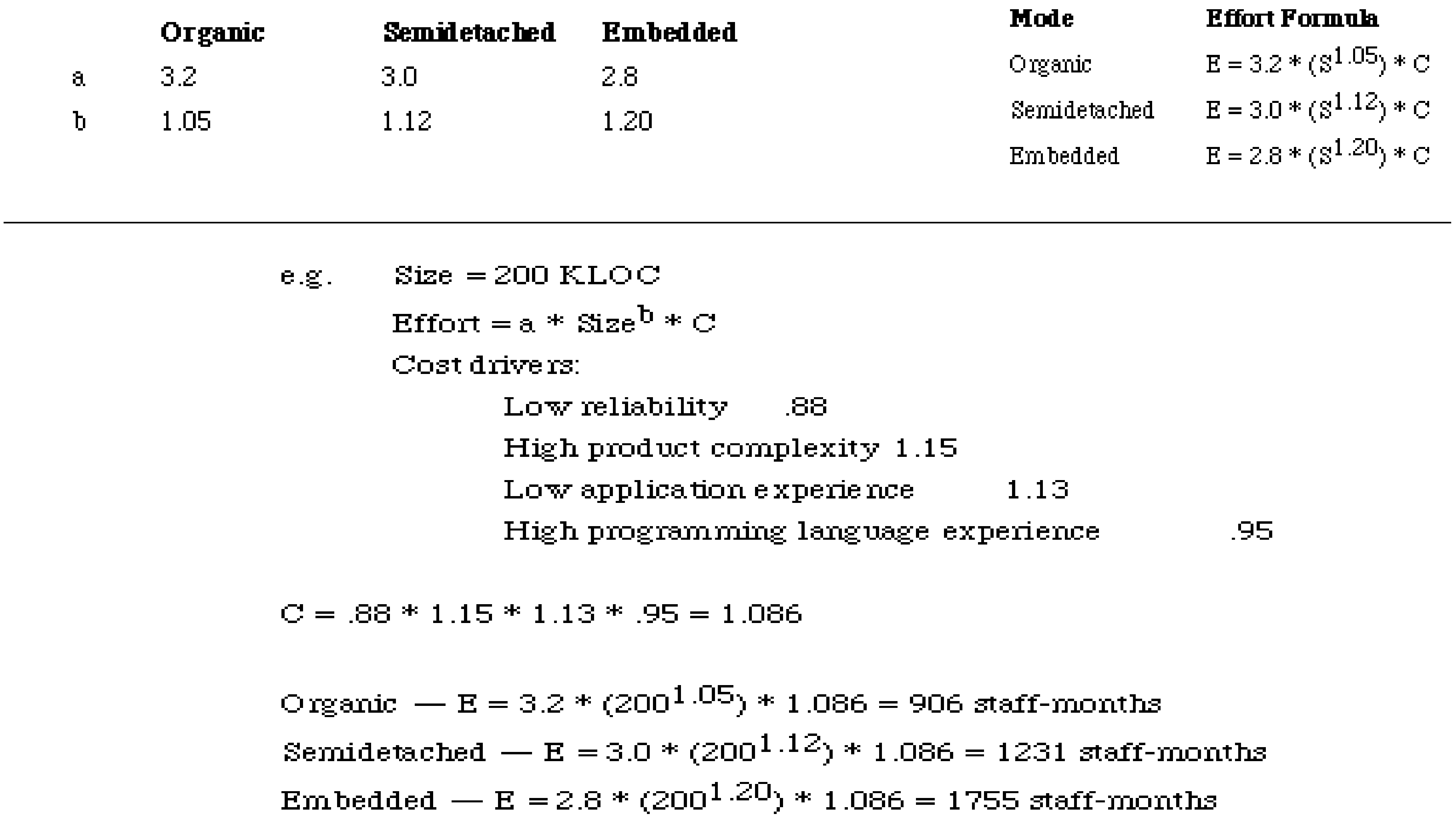
Effort Computation (..)

Total EAF = Product of the selected factors

Adjusted value of Effort: Adjusted Person Months:

APM = (Total EAF) * PM

Example



	Organic	Semidetached	Embedded
a	3.2	3.0	2.8
b	1.05	1.12	1.20

Mode	Effort Formula
Organic	$E = 3.2 * (S^{1.05}) * C$
Semidetached	$E = 3.0 * (S^{1.12}) * C$
Embedded	$E = 2.8 * (S^{1.20}) * C$

e.g. Size = 200 KLOC

$\text{Effort} = a * \text{Size}^{b} * C$

Cost drivers:

Low reliability	.88
High product complexity	1.15
Low application experience	1.13
High programming language experience	.95

$C = .88 * 1.15 * 1.13 * .95 = 1.086$

Organic — $E = 3.2 * (200^{1.05}) * 1.086 = 906$ staff-months

Semidetached — $E = 3.0 * (200^{1.12}) * 1.086 = 1231$ staff-months

Embedded — $E = 2.8 * (200^{1.20}) * 1.086 = 1755$ staff-months

Software Development Time

- **Development Time Equation Parameter Table:**

Parameter	Organic	Semi-detached	Embedded
C	2.5	2.5	2.5
D	0.38	0.35	0.32

Development Time, **TDEV = C * (APM **D)**

Number of Personnel, **NP = APM / TDEV**

Intermediate COCOMO (CONT.)

- If modern programming practices are used,
  - initial estimates are scaled downwards.
- If there are stringent reliability requirements on the product :
  - initial estimate is scaled upwards.

Shortcoming of basic and intermediate COCOMO models

- Both models:
  - consider a software product as a single homogeneous entity:
  - However, most large systems are made up of several smaller sub-systems.
    - Some sub-systems may be considered as organic type, some may be considered embedded, etc.
    - for some the reliability requirements may be high, and so on.

Complete COCOMO

- Cost of each sub-system is estimated separately.
- Costs of the sub-systems are added to obtain total cost.
- Reduces the margin of error in the final estimate.

Complete COCOMO Example

- A Management Information System (MIS) for an organization having offices at several places across the country:
  - Database part (semi-detached)
  - Graphical User Interface (GUI) part (organic)
  - Communication part (embedded)
- Costs of the components are estimated separately:
  - summed up to give the overall cost of the system.