Lines of Code and Functional Points

- LOC and FP data are used in two ways
- during software project estimation: (1) as estimation variables to “size” each element
- of the software and (2) as baseline metrics collected from past projects and used in
- conjunction with estimation variables to develop cost and effort projections.

A three-point or expected value can then be computed. The *expected value* for the estimation variable (size) S can be computed as a weighted average of the optimistic (s_{opt}), most likely (s_m), and pessimistic (s_{pess}) estimates. For example,

$$S = \frac{s_{opt} + 4s_m + s_{pess}}{6} \quad (26.1)$$

- Once the expected value for the estimation variable has been determined, historical LOC or FP productivity data are applied.

Example of LOC

- The mechanical CAD software will accept two- and three-dimensional geometric data from an engineer. The engineer will interact and control the CAD system through a user interface that will exhibit characteristics of good human/machine interface design. All geometric data and other supporting information will be maintained in a CAD database.
- Design analysis modules will be developed to produce the required output, which will be displayed on a variety of graphics devices. The software will be designed to control and interact with peripheral devices that include a mouse, digitizer, laser printer, and plotter.

- A range of LOC estimates is developed for each function. For example, the range of LOC estimates for the 3D geometric analysis function is optimistic, 4600 LOC; most likely, 6900 LOC; and pessimistic, 8600 LOC. Applying Equation 26.1, the expected value for the 3D geometric analysis function is 6800 LOC.

Function	Estimated LOC
User interface and control facilities (UICF)	2,300
Two-dimensional geometric analysis (2DGA)	5,300
Three-dimensional geometric analysis (3DGA)	6,800
Database management (DBM)	3,350
Computer graphics display facilities (CGDF)	4,950
Peripheral control function (PCF)	2,100
Design analysis modules (DAM)	8,400
Estimated lines of code	*33,200*

A review of historical data indicates that the organizational average productivity for systems of this type is 620 LOC/pm. Based on a burdened labor rate of $8000 per month, the cost per line of code is approximately $13. Based on the LOC estimate and the historical productivity data, the total estimated project cost is $431,000 (or 432,000 by rounding up) and the estimated effort is 54 person-months

- The function point metric (FP),first proposed by Albrecht [ALB79], can be used effectively as a means for measuring the functionality delivered by a system.
- Function points are derived using an empirical relationship based on **countable (direct) measures of software's information domain** and **assessments of software complexity assessments** of software complexity

- Information domain values are defined in the following manner:

- Number of external inputs (EIs)
- Number of external outputs (EOs)
- Number of external inquiries (EIs)
- Number of internal logical files (ILFs)
- Number of external interface files (EIFs)

- Each **external input** originates from a user or is transmitted from another application and provides distinct application-oriented data or control information. Inputs are often used to update internal logical files (ILFs). (E.g. Writes, deletes, updates)

- Each **external output** is derived data within the application that provides information to the user. In this context external output refers to reports, screens, error messages, etc. It is created by the application, hence derived.

- An **external inquiry** is defined as an online input that results in the generation of some immediate software response in the form of an online output.
- Each **internal logical file** is a logical grouping of data that resides within the application's boundary and is maintained via external inputs.
- is internally maintained,
- it has some logical structure and
- it is stored in a file.

- **Each external interface file** is a logical grouping of data that resides external to the application but provides information that may be of use to the application.

Information Domain Value	Count		Weighting factor Simple	Average	Complex		
External Inputs (EIs)		×	3	4	6	=	
External Outputs (EOs)		×	4	5	7	=	
External Inquiries (EQs)		×	3	4	6	=	
Internal Logical Files (ILFs)		×	7	10	15	=	
External Interface Files (EIFs)		×	5	7	10	=	
Count total	→						

To compute function points (FP), the following relationship is used:

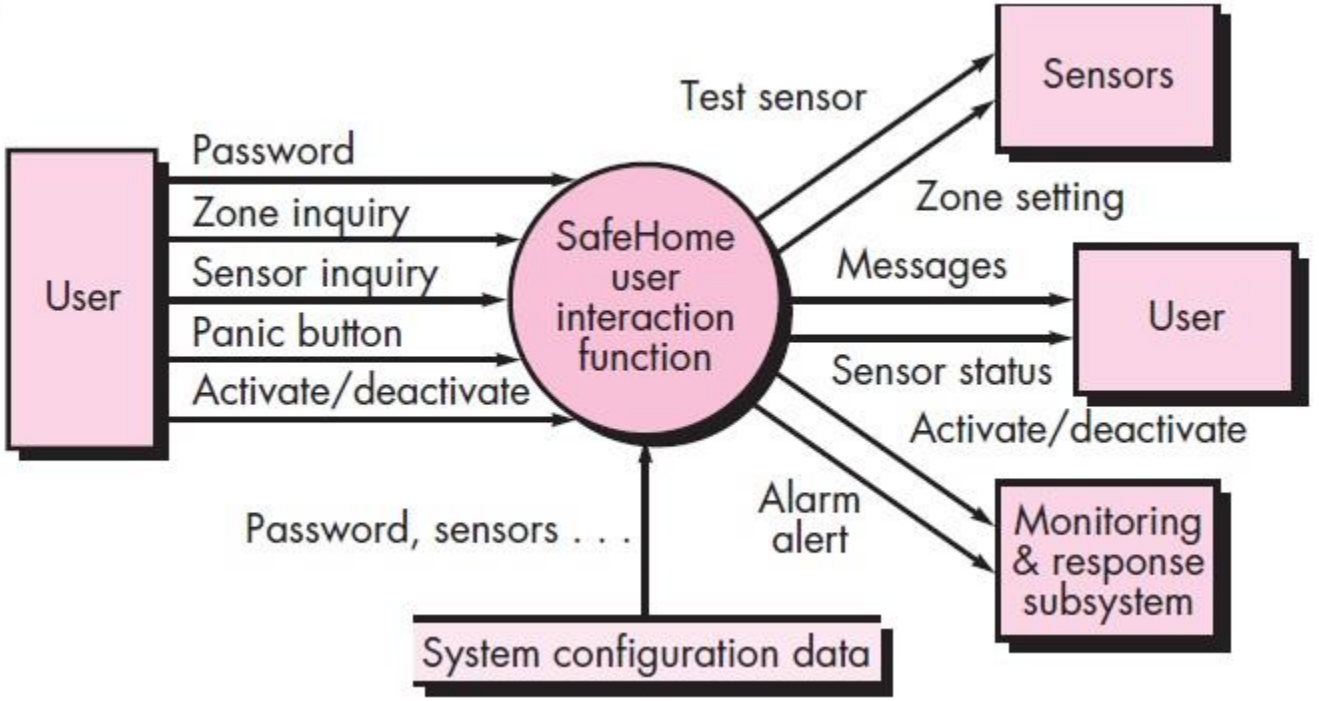
$$FP = \text{count total} \times [0.65 + 0.01 \times \Sigma (F_i)]$$

Value adjustment factors are used to provide an indication of problem complexity.

1. Does the system require reliable backup and recovery?
2. Are specialized data communications required to transfer information to or from the application?
3. Are there distributed processing functions?
4. Is performance critical?
5. Will the system run in an existing, heavily utilized operational environment?
6. Does the system require online data entry?
7. Does the online data entry require the input transaction to be built over multiple screens or operations?
8. Are the ILFs updated online?
9. Are the inputs, outputs, files, or inquiries complex?
10. Is the internal processing complex?
11. Is the code designed to be reusable?
12. Are conversion and installation included in the design?
13. Is the system designed for multiple installations in different organizations?
14. Is the application designed to facilitate change and ease of use by the user?

0 (not important or applicable) to 5 (absolutely essential)

A data flow model for *SafeHome* software



The data flow diagram is evaluated to determine a set of key information domain measures required for computation of the function point metric.

Three external inputs—password, panic button, and activate/deactivate.

Two external inquiries—zone inquiry and sensor inquiry.

One ILF (system configuration file)

Two external outputs (messages and sensor status)

Four EIFs (test sensor, zone setting, activate/deactivate, and alarm alert)

The count total shown in Figure 23.3 must be adjusted using Equation (23.1). For the purposes of this example, we assume that $\Sigma(F_i)$ is 46 (a moderately complex product). Therefore,

$$FP = 50 \times [0.65 + (0.01 \times 46)] = 56$$

Based on the projected FP value derived from the requirements model, the project team can estimate the overall implemented size of the *SafeHome* user interaction

Information Domain Value	Count		Weighting factor Simple	Average	Complex		
External Inputs (EIs)	3	×	3	4	6	=	9
External Outputs (EOs)	2	×	4	5	7	=	8
External Inquiries (EQs)	2	×	3	4	6	=	6
Internal Logical Files (ILFs)	1	×	7	10	15	=	7
External Interface Files (EIFs)	4	×	5	7	10	=	20
Count total						→	50

- Assume that past data indicates that one FP translates into 60 lines of code (an object-oriented language is to be used) and that 12 FPs are produced for each person-month of effort. These historical data provide the project manager with important planning information that is based on the requirements model rather than preliminary estimates. Assume further that past projects have found an average of three errors per function point during requirements and design reviews and four errors per function point during unit and integration testing. These data can ultimately help you assess the completeness of your review and testing activities.

Information domain value	Opt.	Likely	Pess.	Est. count	Weight	FP count
Number of external inputs	20	24	30	24	4	97
Number of external outputs	12	15	22	16	5	78
Number of external inquiries	16	22	28	22	5	88
Number of internal logical files	4	4	5	4	10	42
Number of external interface files	2	2	3	2	7	15
Count total						*320*

Factor	Value
Backup and recovery	4
Data communications	2
Distributed processing	0
Performance critical	4
Existing operating environment	3
Online data entry	4
Input transaction over multiple screens	5
Master files updated online	3
Information domain values complex	5
Internal processing complex	5
Code designed for reuse	4
Conversion/installation in design	3
Multiple installations	5
Application designed for change	5
Value adjustment factor	**1.17**

FP = 375

The organizational average productivity for systems of this type is 6.5 FP/pm. Based on a burdened labor rate of $8000 per month, the cost per FP is approximately $1230.

Based on the FP estimate and the historical productivity data, the total estimated project cost is $461,000 and the estimated effort is 58 person-months.