
An Introduction to the Quantitative, Rational and Scientific Process of Software Development (Part 1)

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Outline of Part 1

The final objective: To establish Quantitative,
Rational and Scientific Management of Development

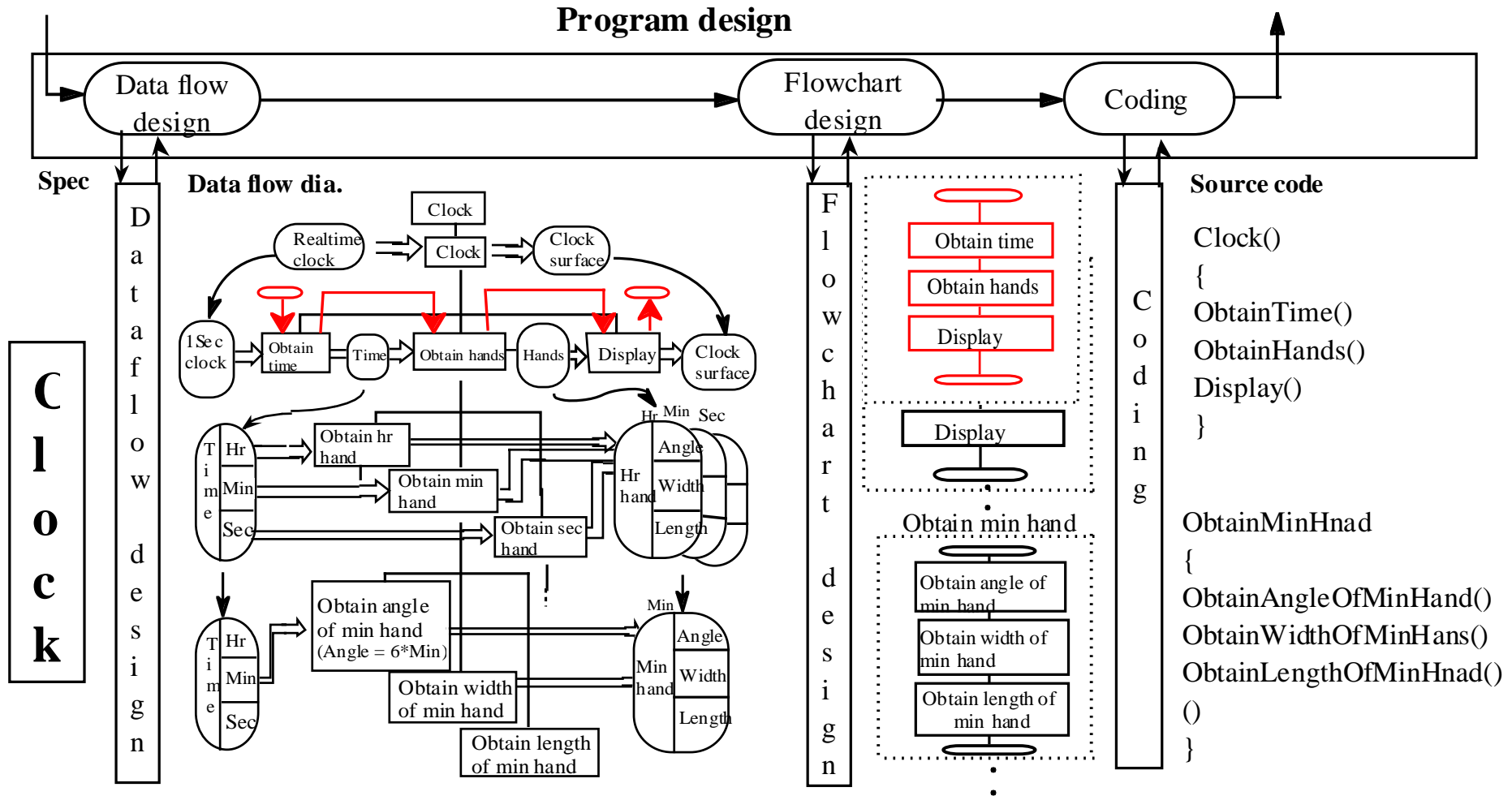
In hardware, Industrial Engineering (IE) had established that way since the end of the 19th Century, that enabled present day prosperity of H/W.

Tactical Object of Part 1: Establishing Basis

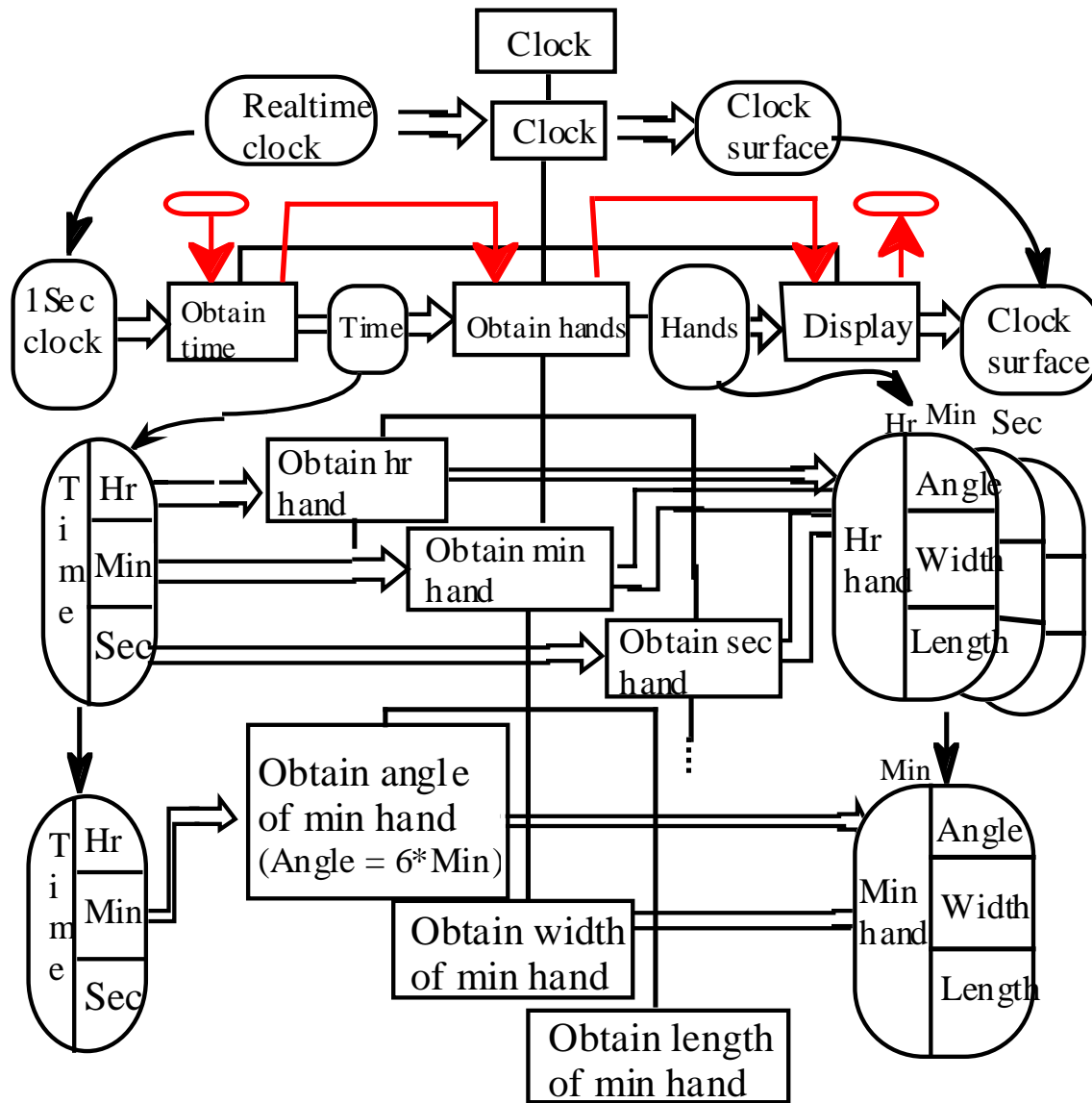
1. What is design: Human Intentional Activities
2. Quantitative Characteristics
3. Quantitative Model of S/W Development

A Program Design

Design is a repetitive hierarchical decomposing



Data Flow Design Steps



A step of design:
A parent concept
(elementary DFD)

↓
hierarchical
decomposition

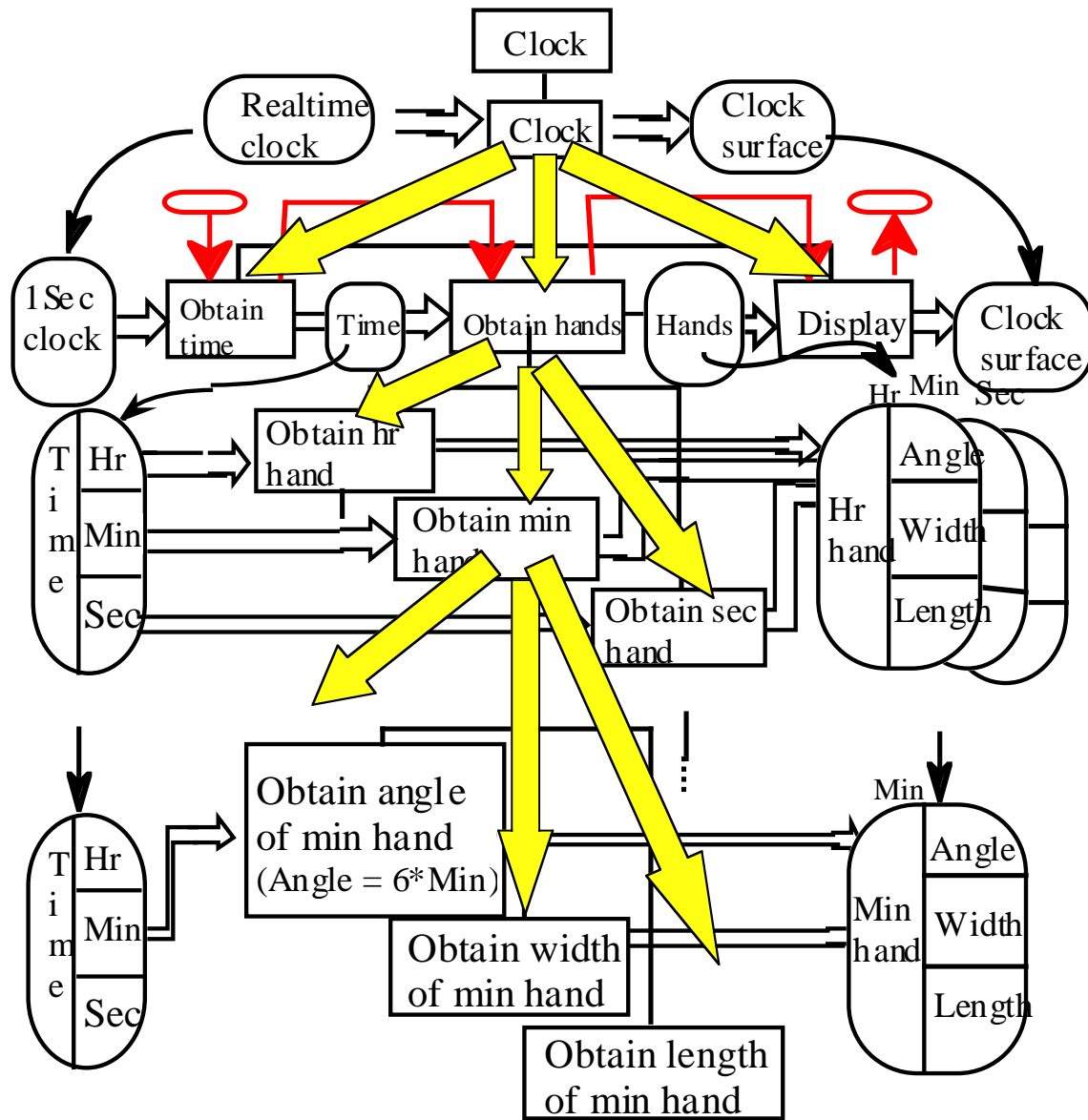
↓
A child concept
(detailed DFD)

+
Flowchart

Design is a repetitive hierarchical decomposing

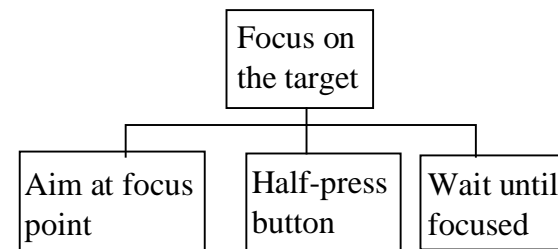
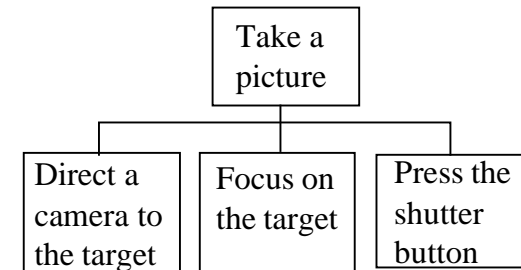
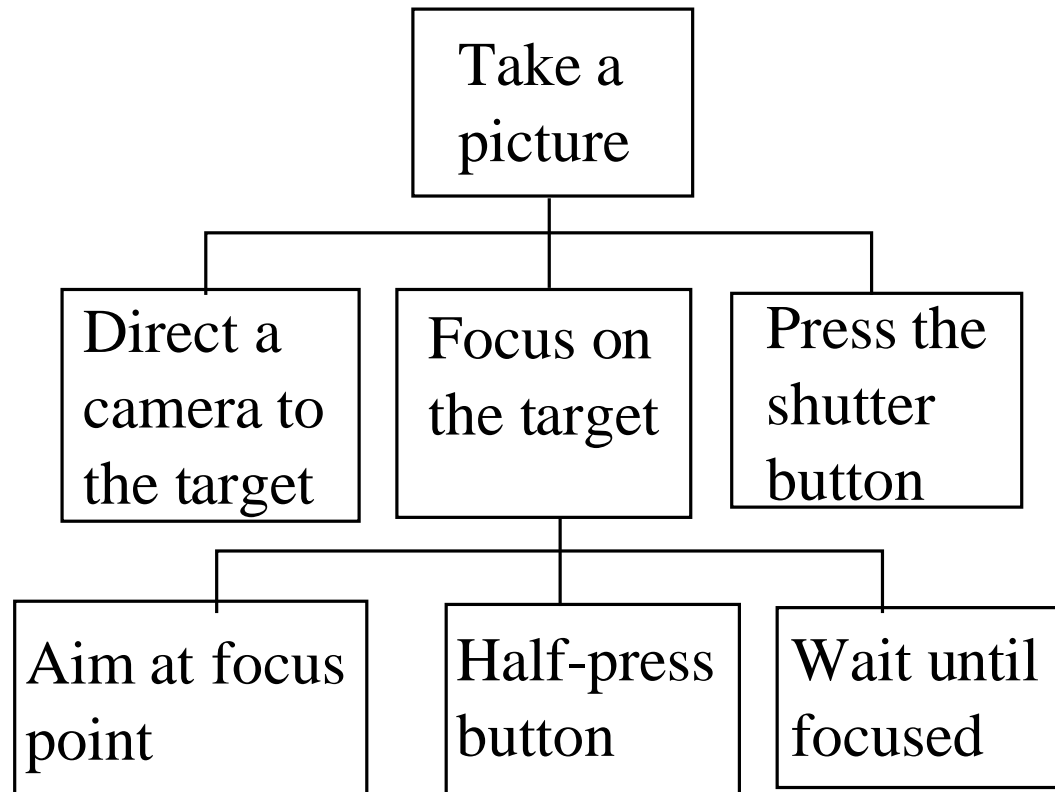
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All 3-way Decompositions

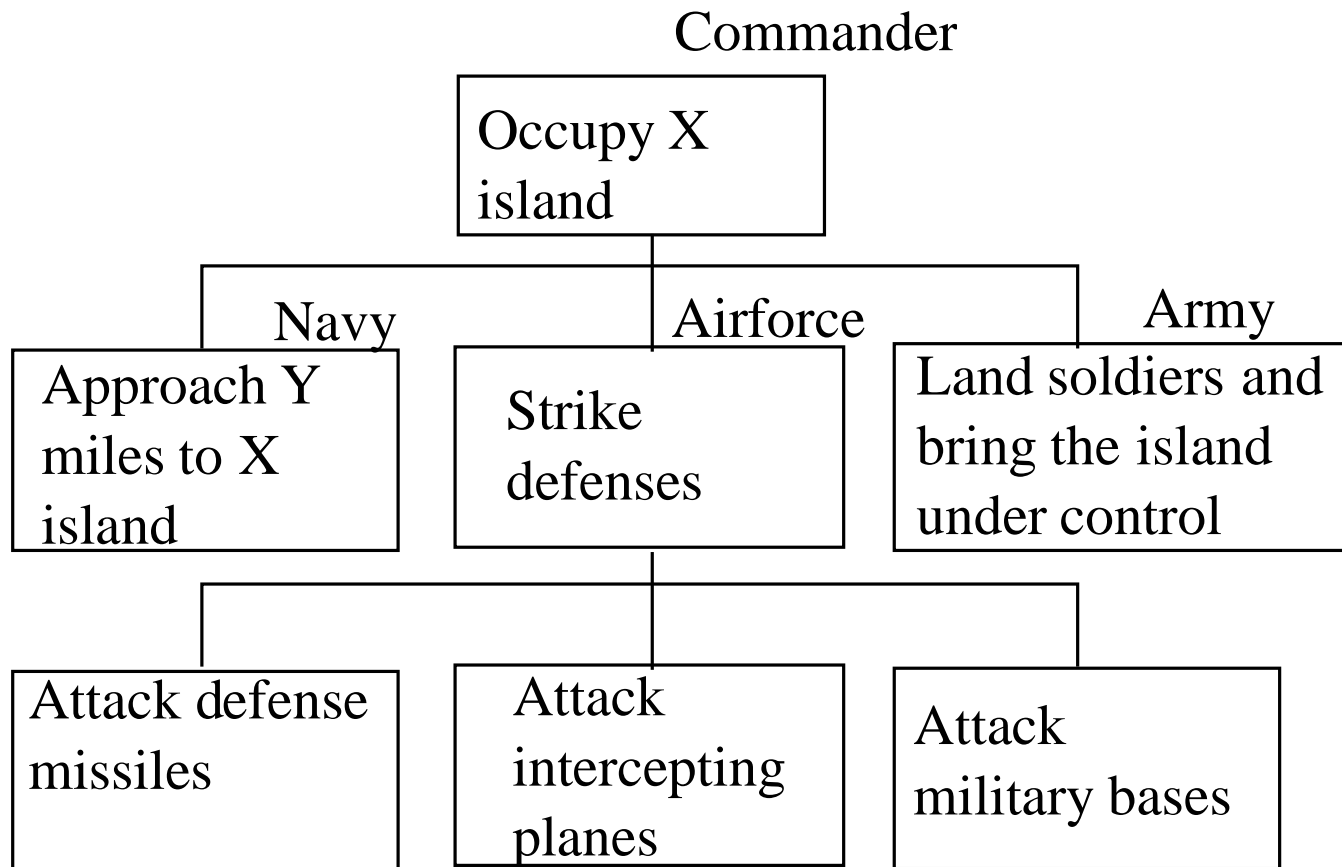


Human Physical Action

Repetitive hierarchical decomposing



Top-level Management Activity



Clausewitz 1780-1831

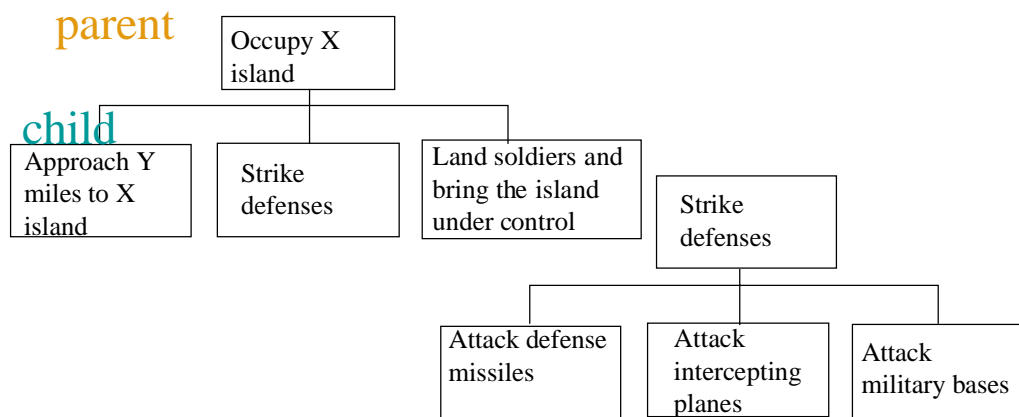
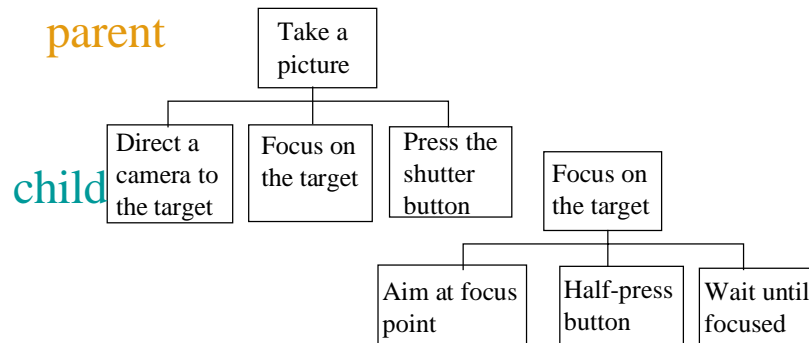
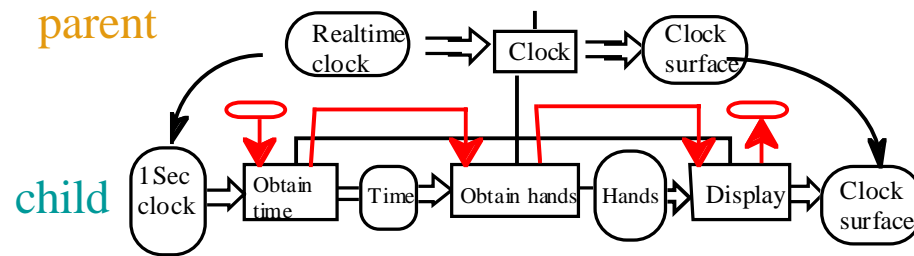
Prussian military thinker

“Principles of war”

“Hierarchical objective”

Repetitive hierarchical decomposing

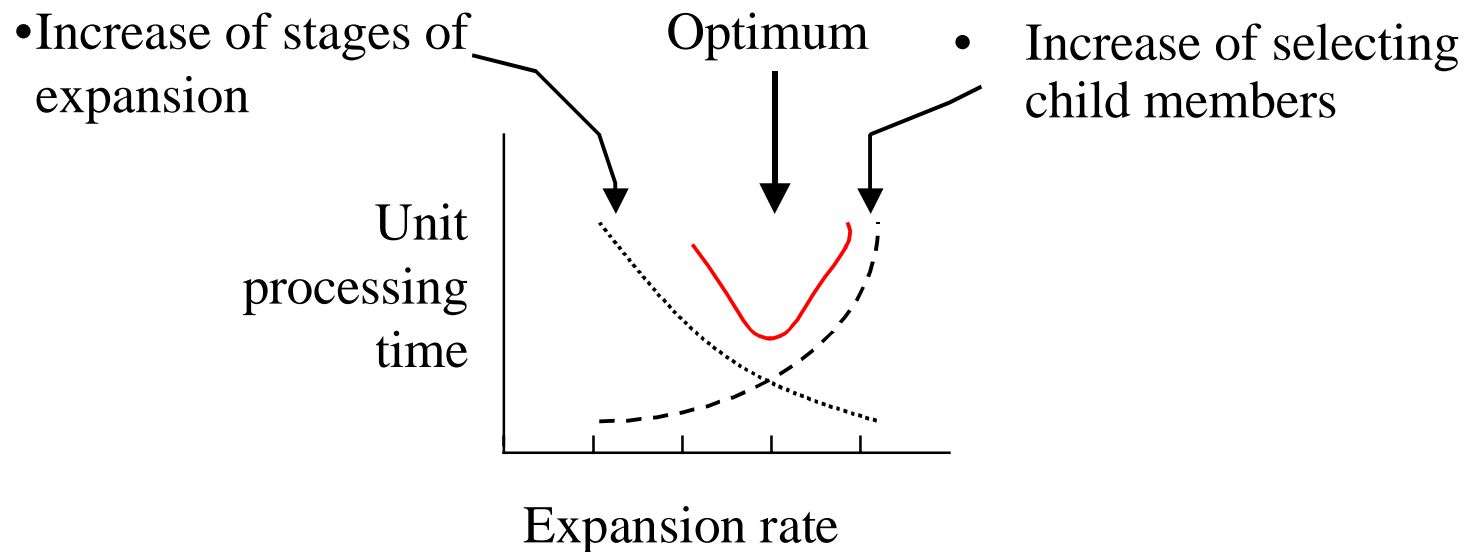
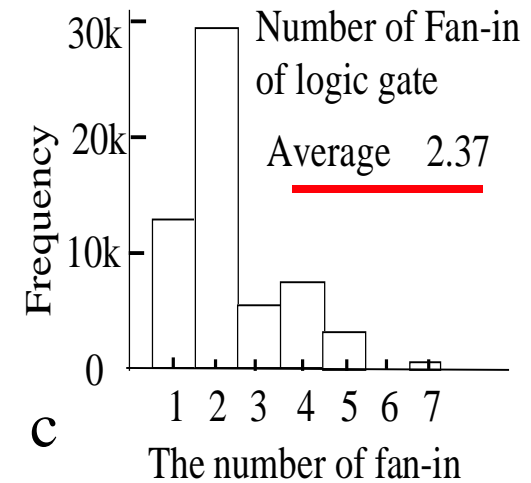
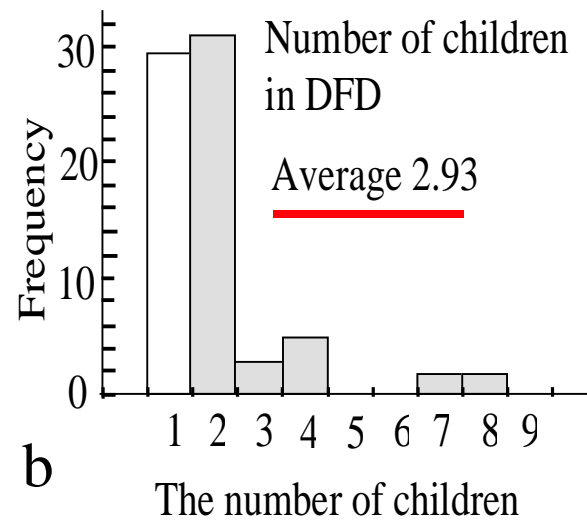
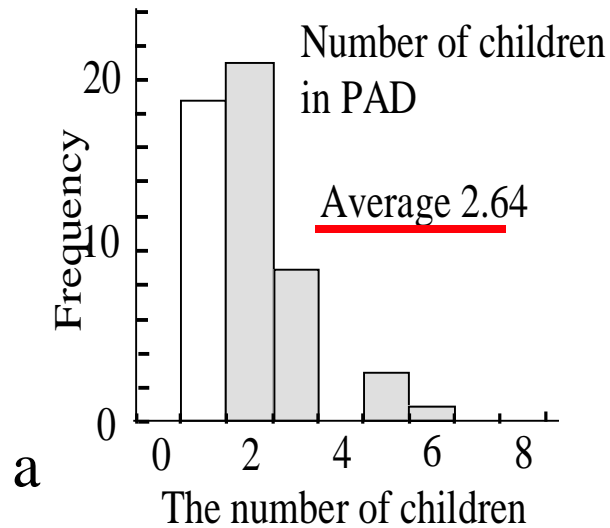
Human Intentional Activities



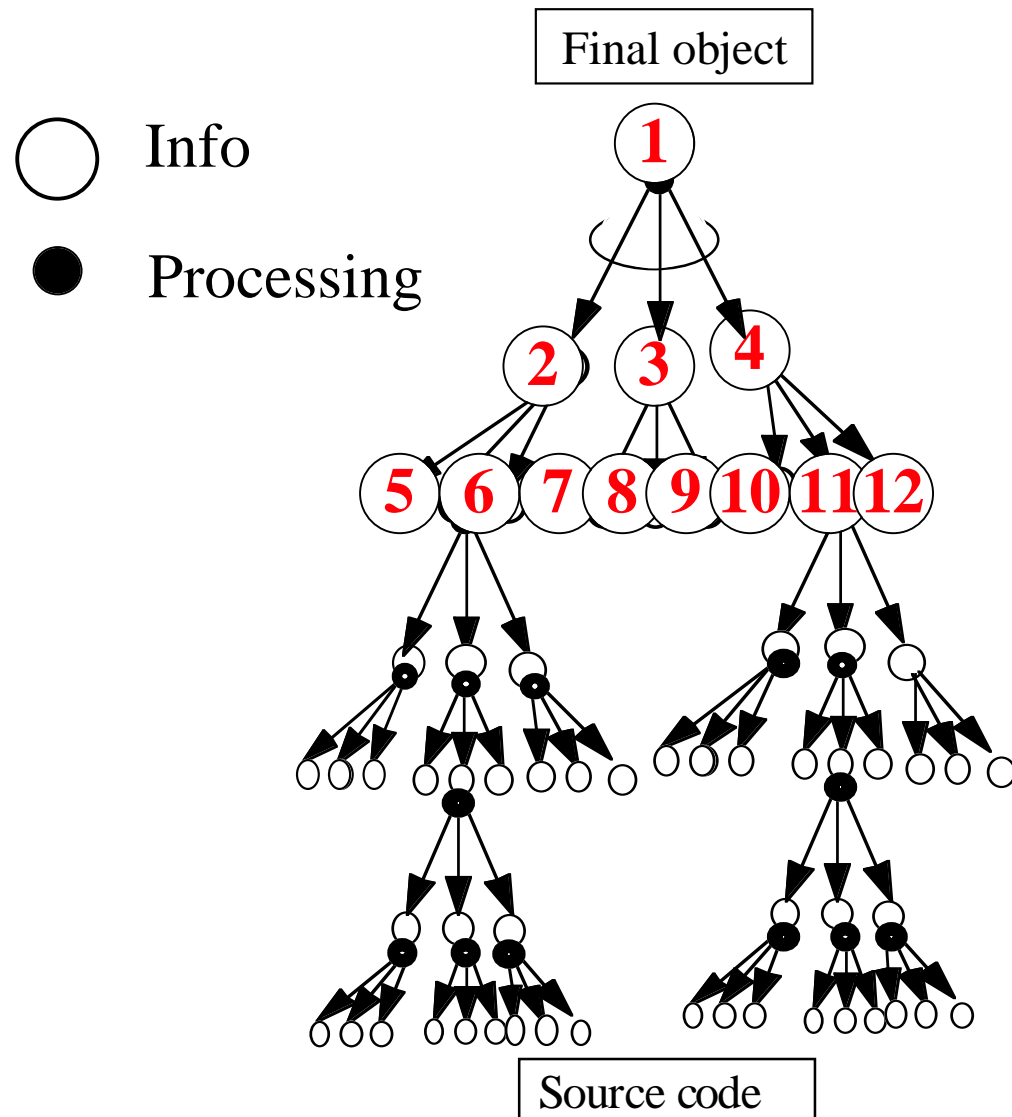
Human Intentional Activities are achieved by repeating hierarchical decomposing

Cognitive Science External stimuli is coded in some form and processes in a human brain.

The Constant Rate Expansion

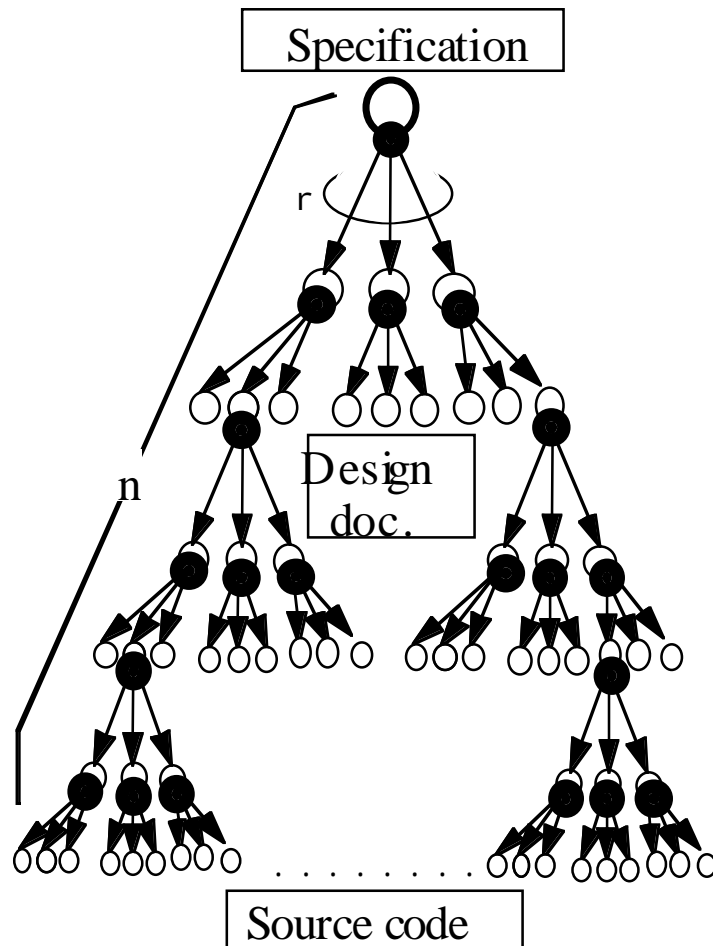


Hierarchical Expanding Network Model



The operation advances like the single stroke of a brush

Productivity and Error(defect) Intensity



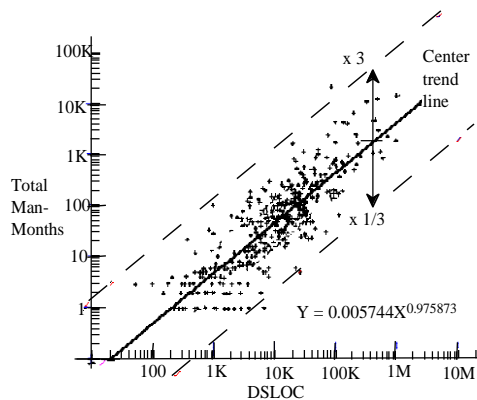
- Constant rate increasing series
- Number of processing node N_p
- Number of output information N_o
- Small man-hours are consumed at each node
- Productivity = $k \{N_p / N_o\} = \text{const.}$
- Processing errs at a small probability
- Error (defect) intensity
= $q \{N_p / N_o\} = \text{constant}$
- The system is linear

Verification by Field Data

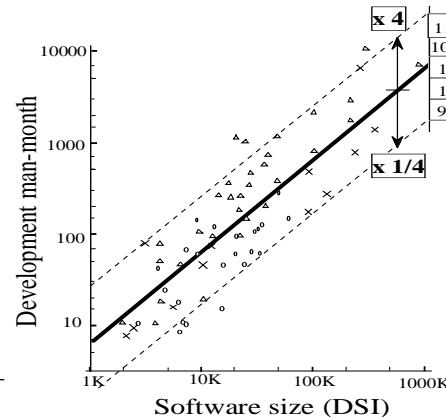
Man-hour

Error

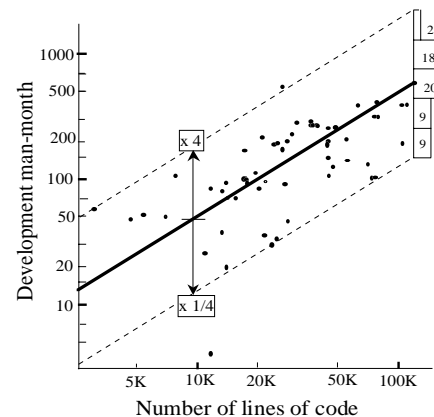
RADC [Nelson78]



COCOMO [Boehm81]



Fujitsu [Yoshida]



TRW [Thayers76]

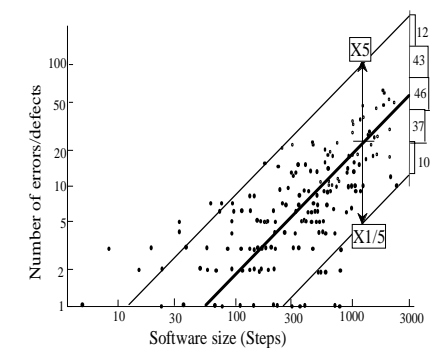


Figure 6. Software size vs. defect (log)

Theoretical trend-lines, threading plots, agree with field data.

Productivity = constant. Man-hours is proportional to software size

Error intensity = const. Total of errors is proportional to software size

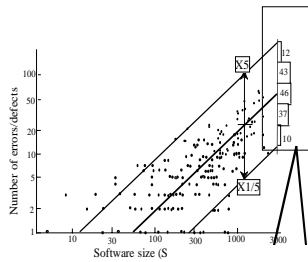
**The same as empirical rules for physical works,
used from the end of the 19th Century**

Plots form a belt-zone of nearly the same width. (C) 2007 Koono

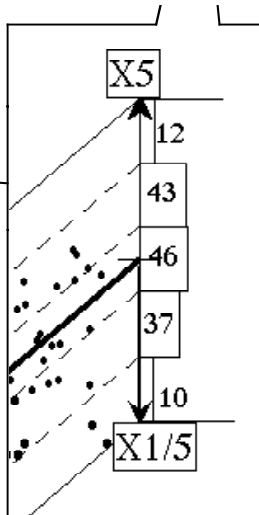
Log-Normal Nature

Bell-shaped (normal-like) distribution on logarithmic scale
 Plots range from N times to 1/N times, of the mean

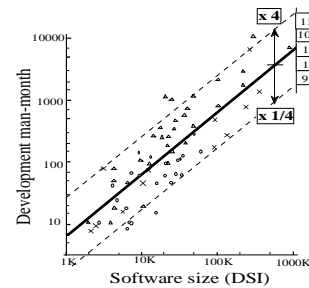
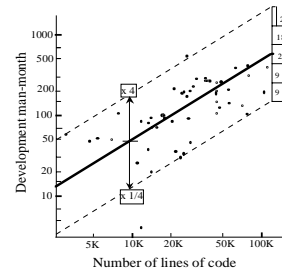
N = 5
 Error number
 Incorrect counting



Close up

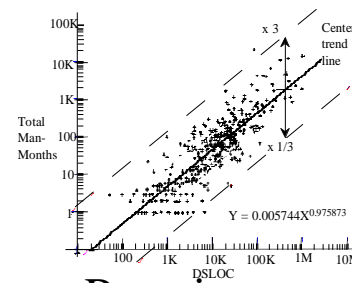


N = 4
 Man-hours
 Variations

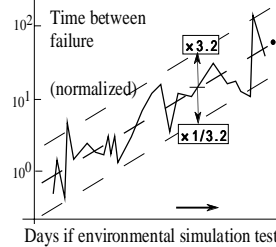


N = approx. 3

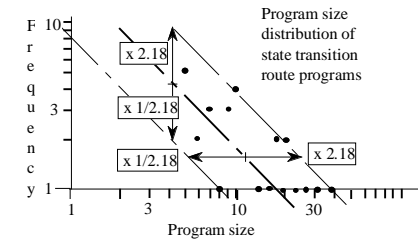
Man-hours



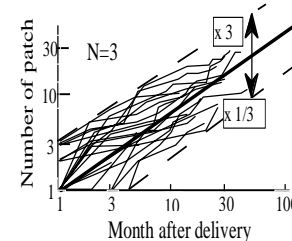
Run-time



N = 2.18
 Prog. Size
 Controlled design



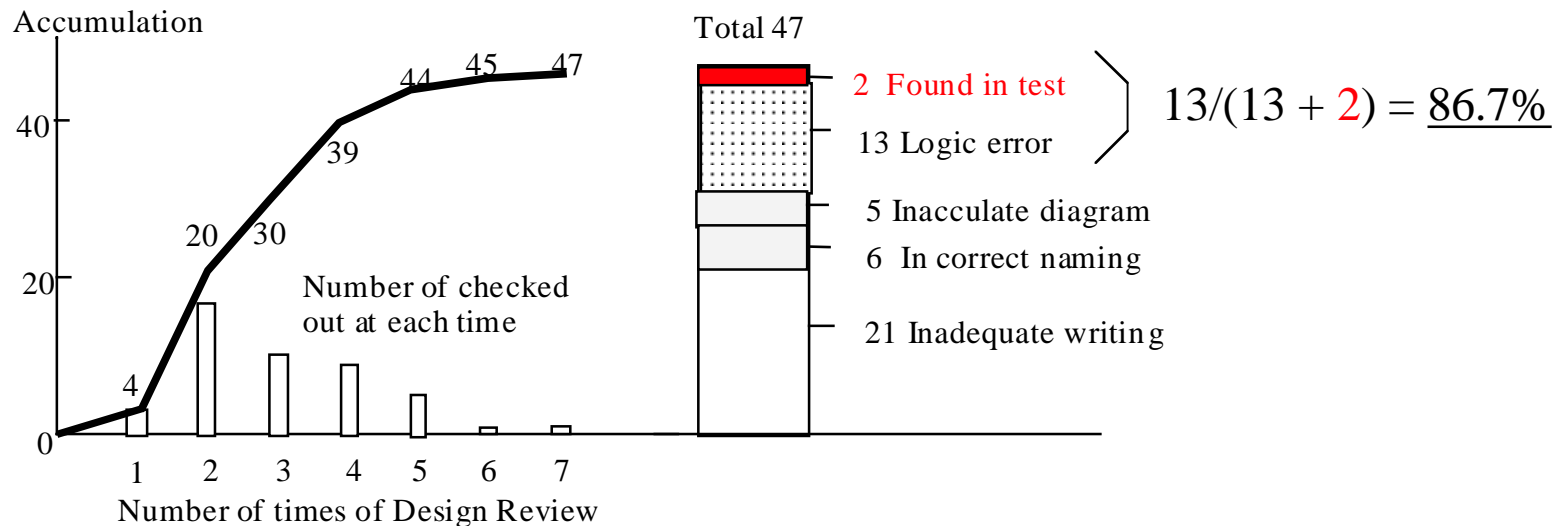
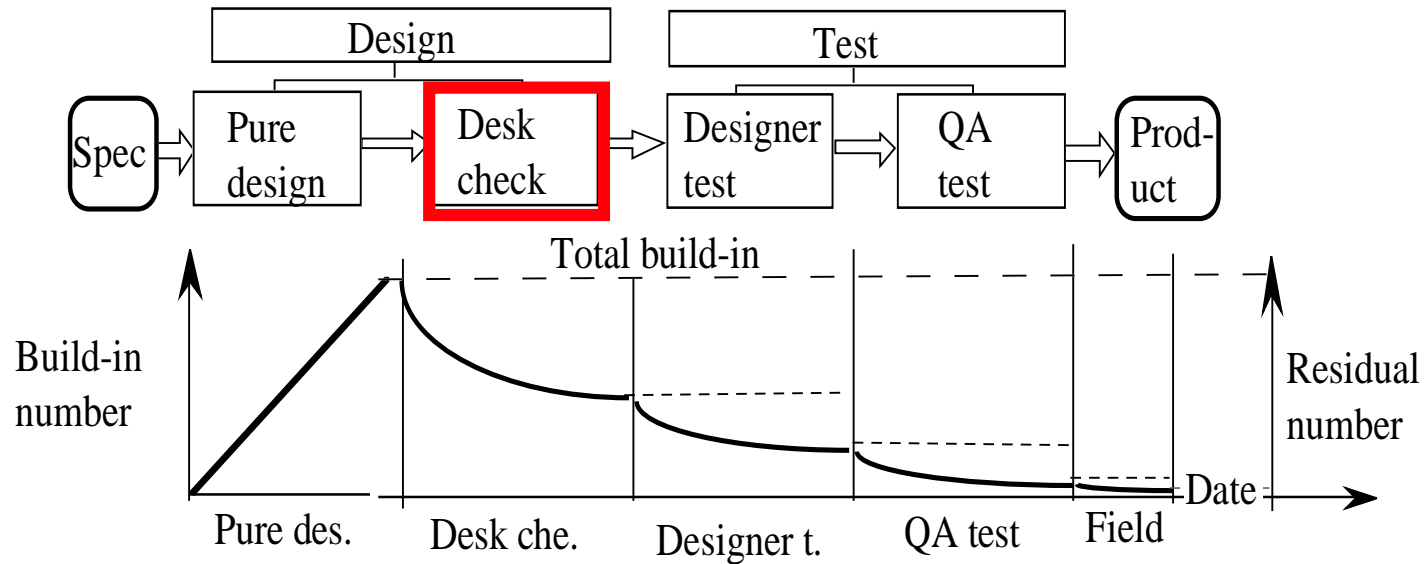
Accumulated error



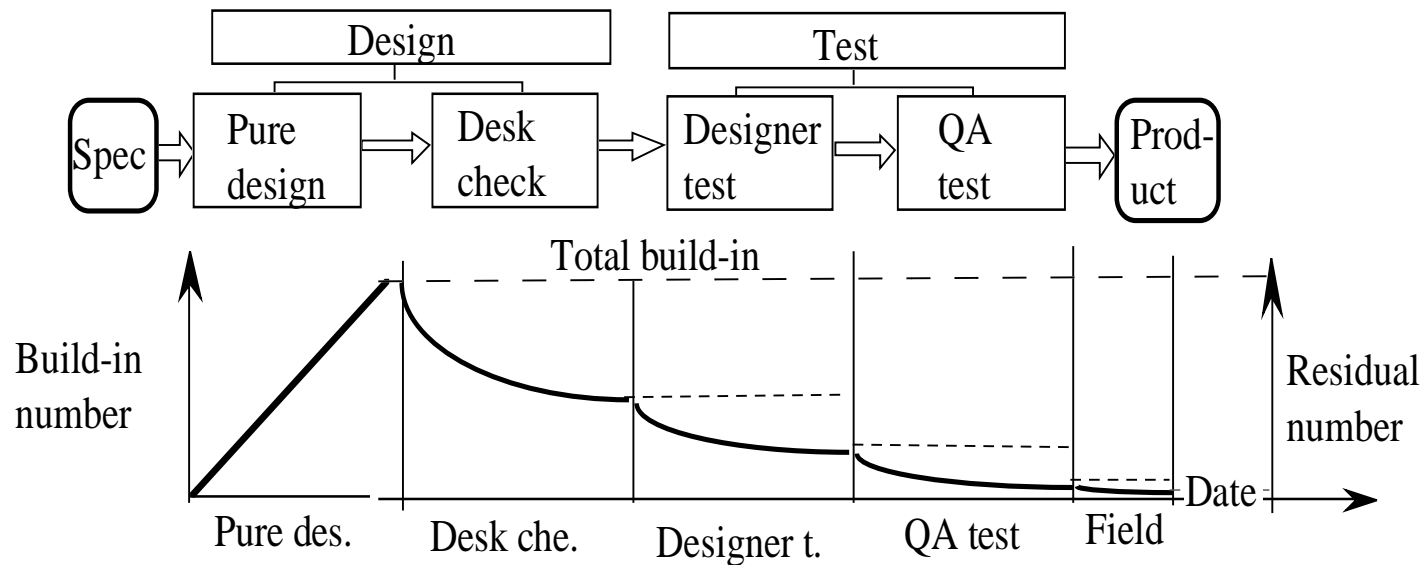
Lognormal Distribution

- In an idealistic lognormal distribution, mean is equal to standard variation. And, plots distribute within a range from $1/3$ to 3 of the mean (= standard deviation). $N = 3$.
- A variable might be modeled as log-normal if it can be thought of as the multiplicative **product of many small independent factors [Wikipedia]**
- Human Reliability Engineering studies revealed that errors follow lognormal distribution

Desk Check



Characteristics of Desk Check and Test



Removal of errors by desk check:

Let us assume from best 80% to poor 10%

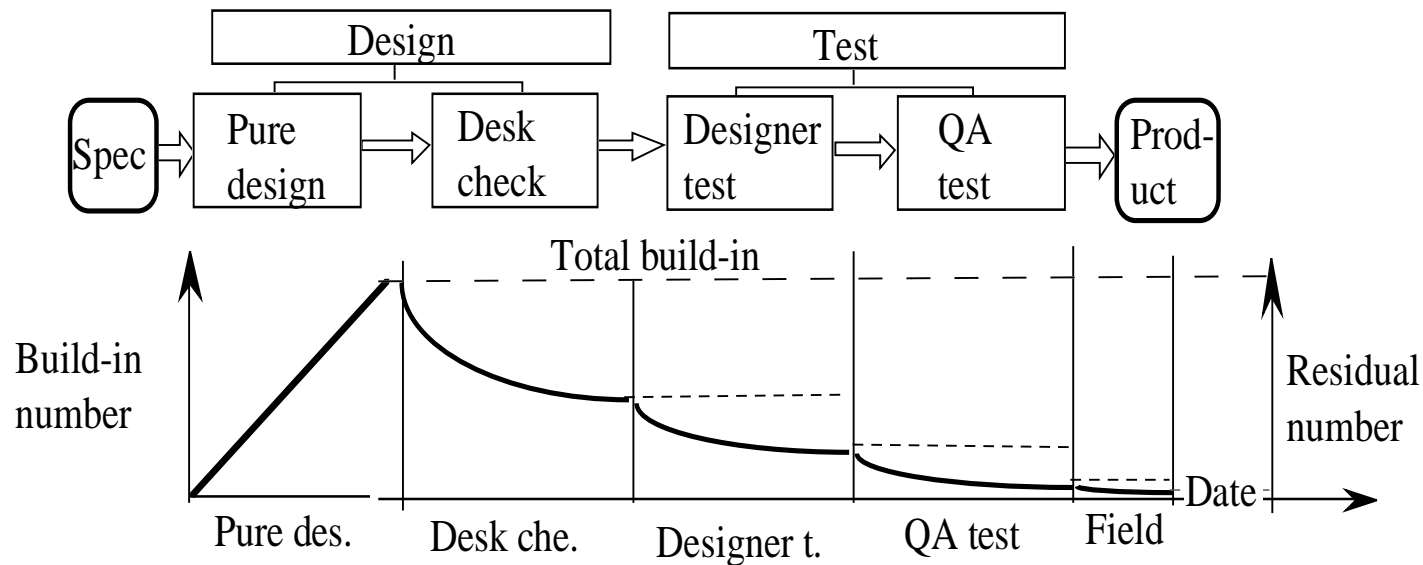
Namely another variation $\{0.45 \pm 0.35\}$ is added.

This resulted in larger number of the width of $N=5$.

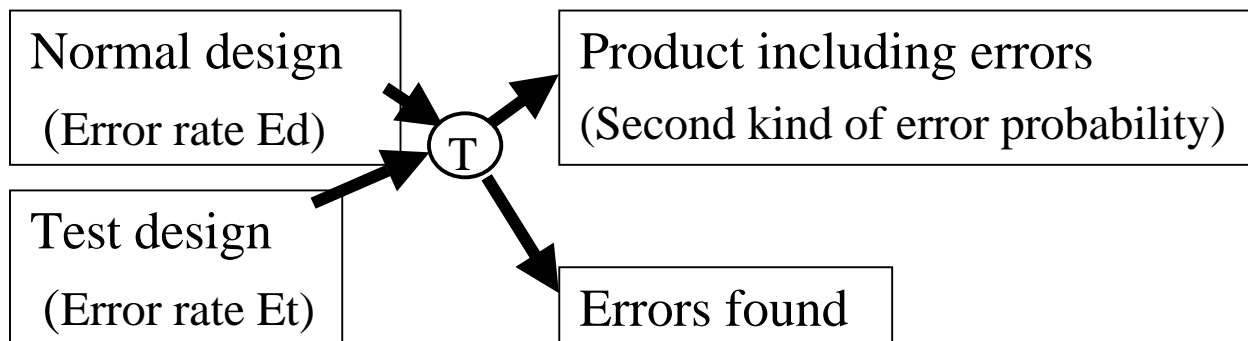
Intrinsic characteristic is the build-in error rate or defect intensity

One round of a design ends, “End” is declared, and thereafter all the checked-out (including desk check) errors are counted.

Desk Check

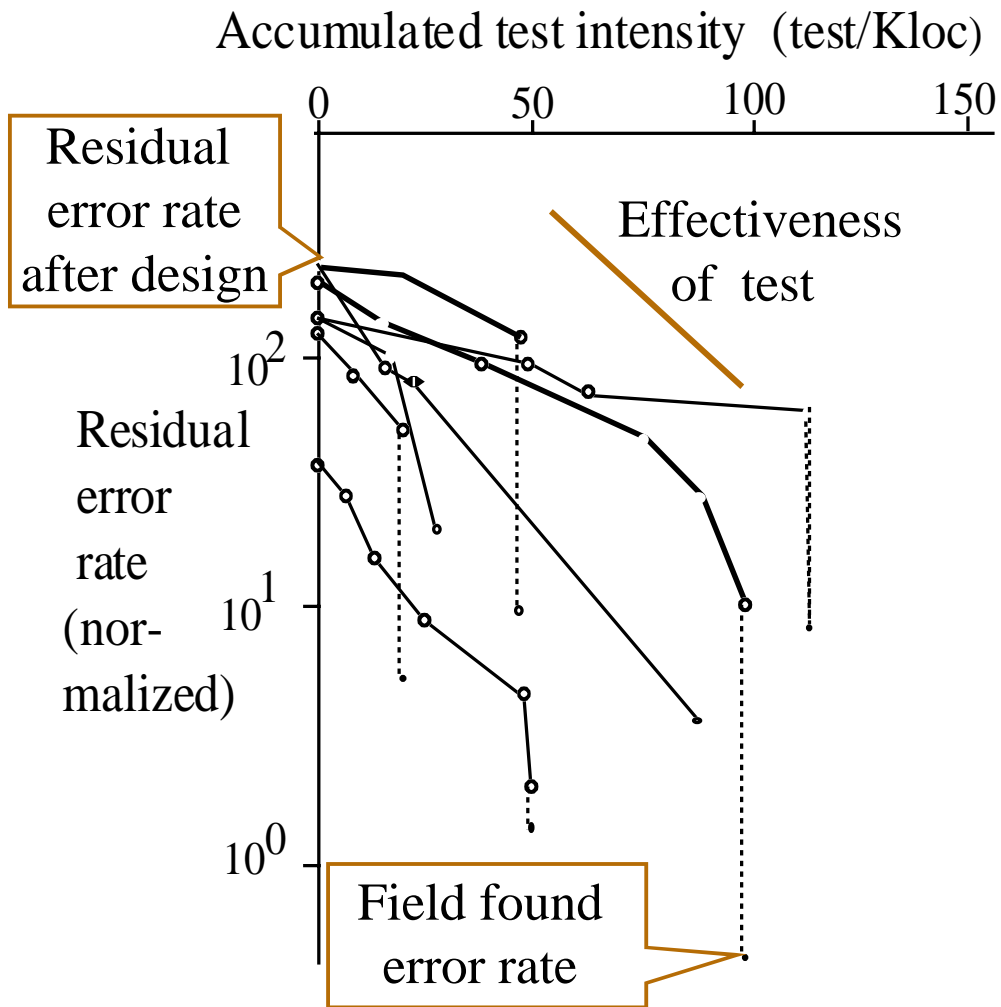


Decaying curves may be approximated as Ee^{-ax}



Test (check) decreases residual error rate by error probability of second kind.
It is like an error rate attenuator.

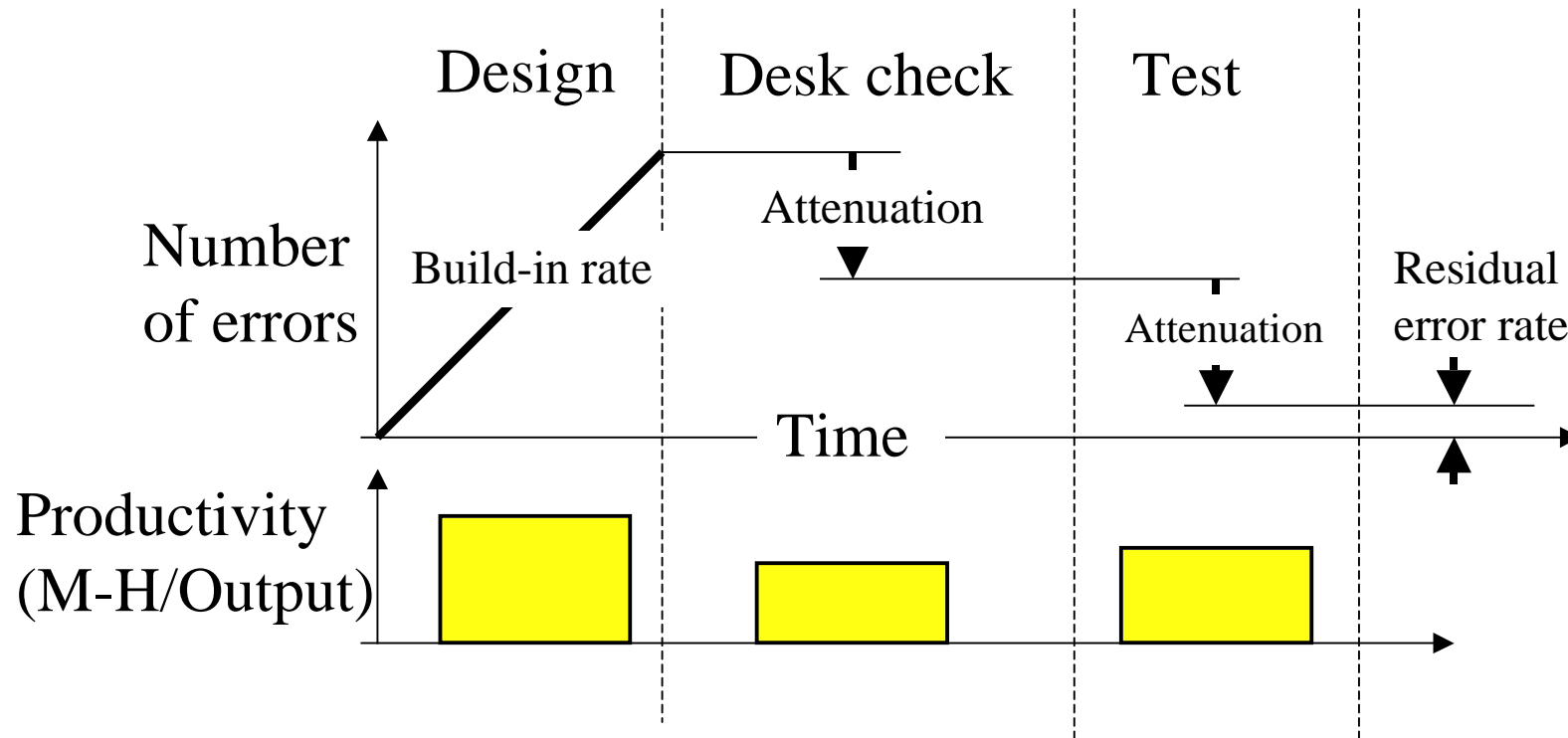
Error Attenuating Characteristics



Attenuation by test
-> linear trend line
Attenuation is
proportional to
test intensity
(no. of test/s/w size)
The gradient is
the effectiveness of test

The necessary number of
test may be planned
The effectiveness of test
may be evaluated

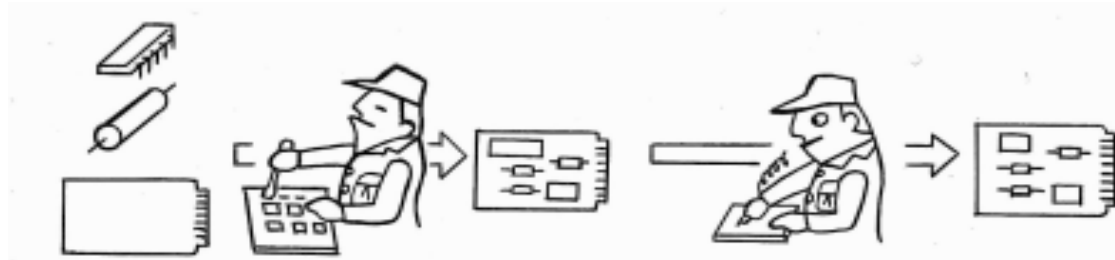
Quantitative model of process



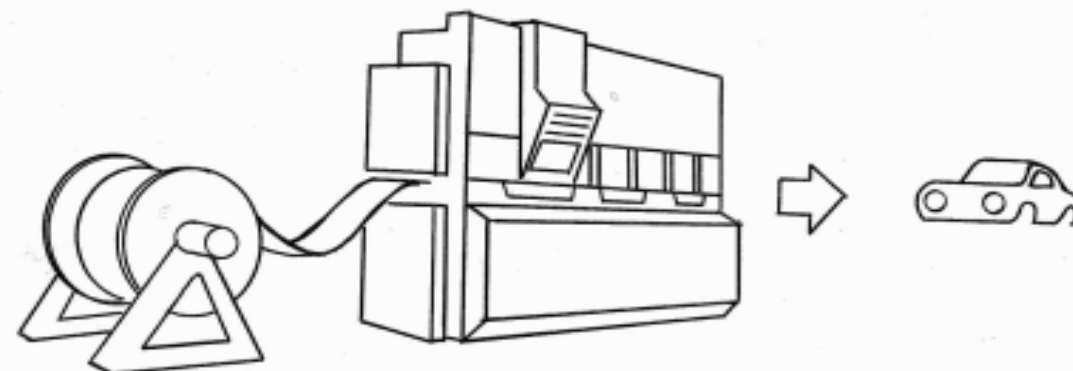
A process is hierarchically decomposed to its lower level ones
Each process shows respective external characteristics

Human Intentional Activities

a. Human direct work



b. Machine work



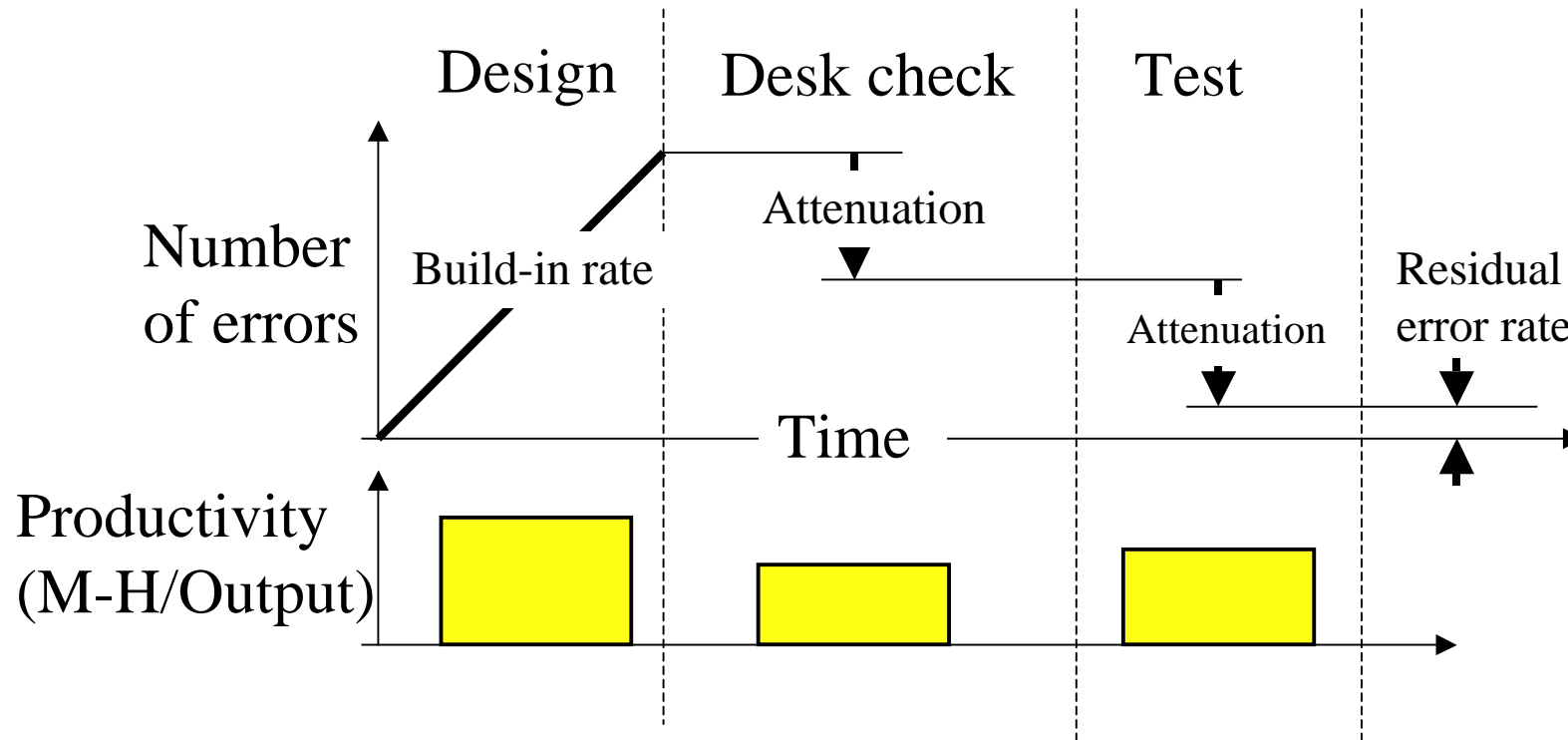
c. Human indirect work



All human intentional activities show the same type of (**external**) characteristics. And, **based on this fact, each specialties appear.**

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Conclusion of part 1



The same model may be used.

Q & A

Thank you for your kind attention.

Before advancing to part 2,

please make Q & A.