A New Way of Automatic Design of Software

(Simulating Human Intentional Activity)

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Creation Project

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Outline

Motivation: Automatic design, like a human designer does.

- Strategy: commonality of human knowledge for various activities
- Tactic: Learn from a human designer through their documents

Attainments: Automation in the lower programming level

Human designs may be reproduced by this approach

Quantitative evaluations revealed the inside of human design

-> Impacts on S/W Engineering

Outline:

1. Human design, by repetitive hierarchical decompositions
2. Automatic design system
3. Quantitative evaluations reflecting ‘Human Intelligence’
4. Concluding remarks

Intelligence by natural language

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Software design	Hardware design	Human society	Natural language
Hierarchical design 1971: Wilth Stepwise detailing 1970's-80's Structured designs	Hierarchical design 19-> 20 century Top down design From coarse to fine	Words AD 1st century New Tastament, The First Epistel General of John CHAPTER 1-1 That which was from the beginning, which we have heard, which we have seen with our eyes, which we have looked upon, and our hands have handled, of the Word of life;	Natural language Neanderthalensis, living in caves, perished. During the coldest period of the last glacial age (20000 years ago) Homo sapiens, building houses, survived. Studies show that their civilization, built by their natural language, enabled them to survive

Multiple engines

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1. Zipf's law of least efforts (Ergonomics)

When a person faces a problem, the person tries to solve it in the easiest way. If unsuccessful, the person tries in a more difficult way. Repeat this until it is solved. A multiplicity of engines works in a human brain.

2. Typical three engines by Rasmussen's

Among engines, there are three typical patterns.

Level	Frequency
Skill-based: Simple and fast, reflective operation	Large
Rule-based: Intention -> grammar -> English, French,…….	Small
Knowledge-based: Solution using Basic Concept Dictionary	Very small

What is a software design

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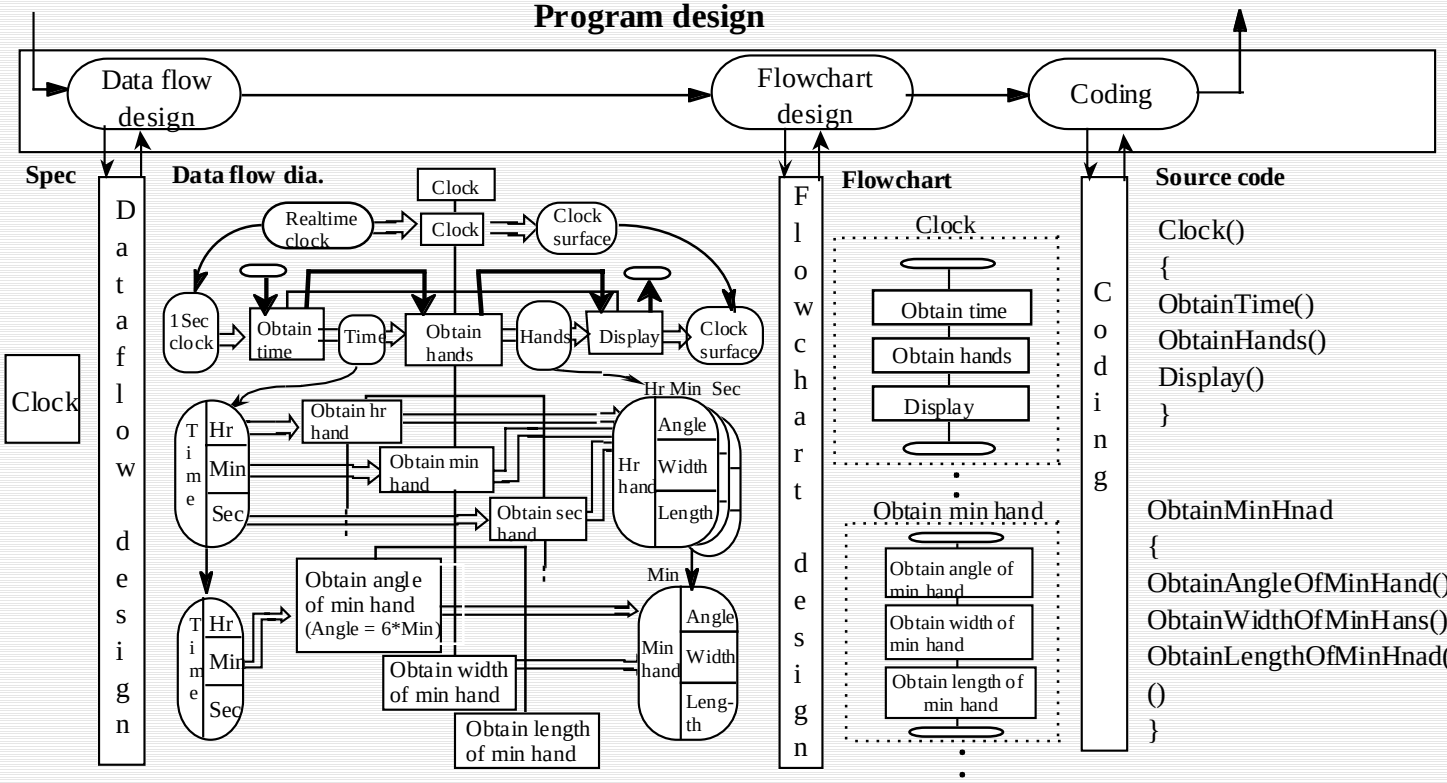
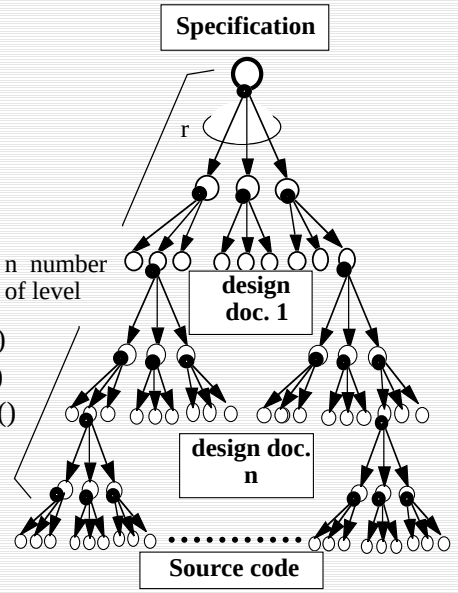
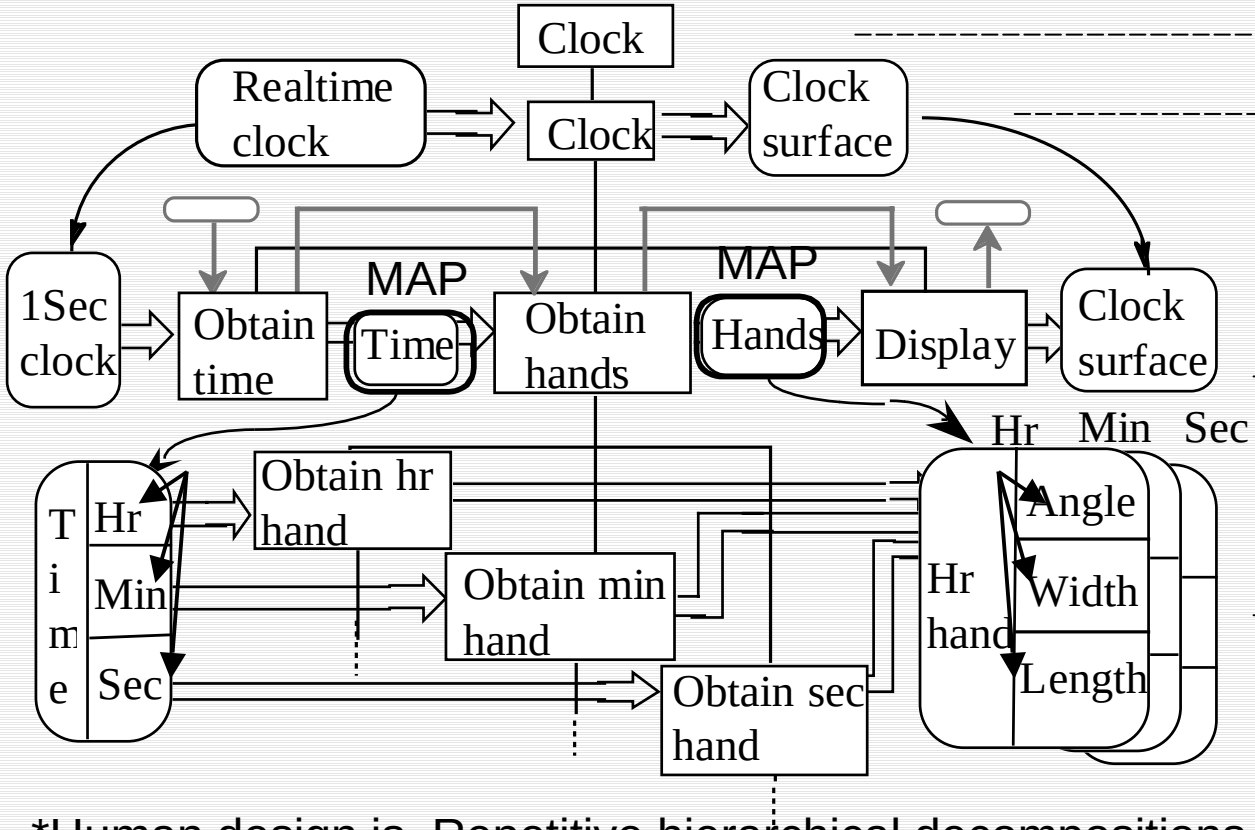
Programming education starts using natural language
What happens if it is continued and extended further?





DFD design



Specification
Elementary DFD

Myers'STS
decomposition

Jackson's
program design
Hierarchical data

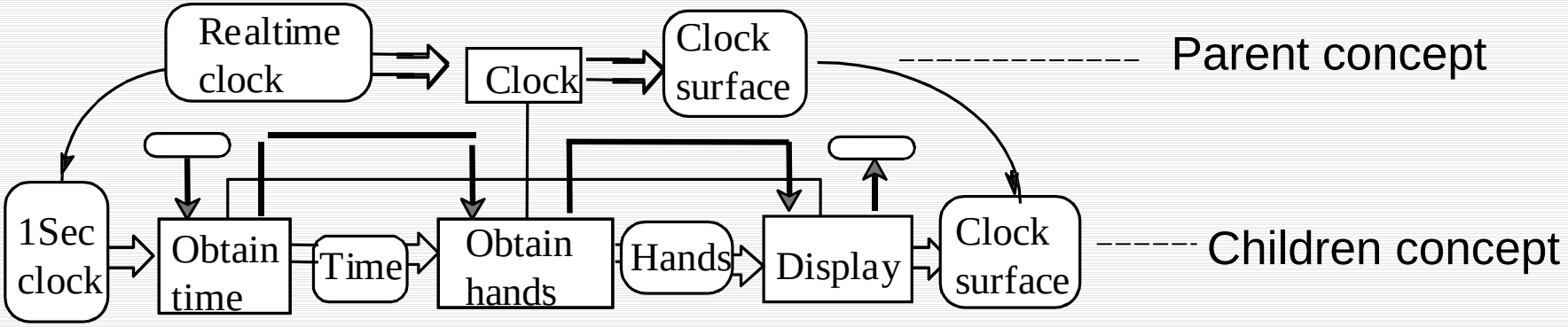
*Human design is Repetitive hierarchical decompositions of concept

*The decomposition is to use 'parent to children' relationship
A pair of the parent and the children is named as a 'Design rule'

*A design rule is formed in Skill-based, Rule-based or Knowledge-based

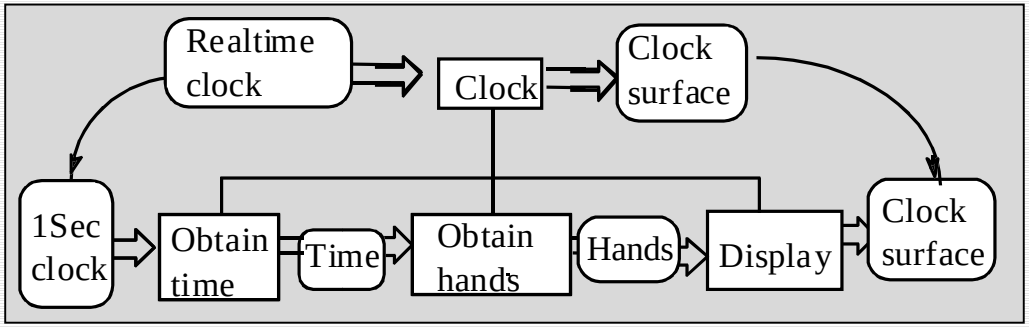
Design rule

Software
Creation
Project

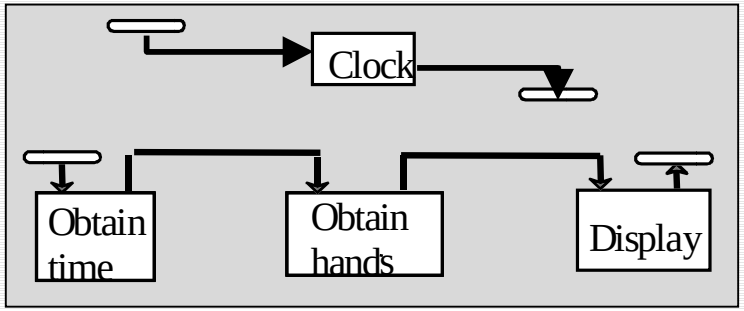


Design rule

DFD



Flowchart



Human intentional activity

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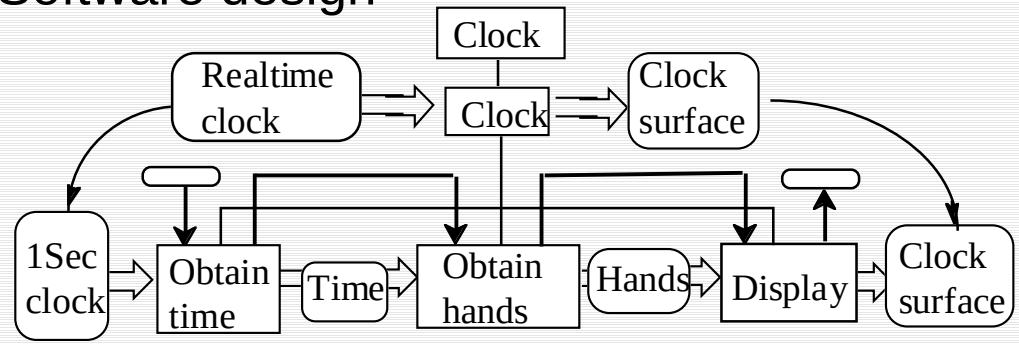
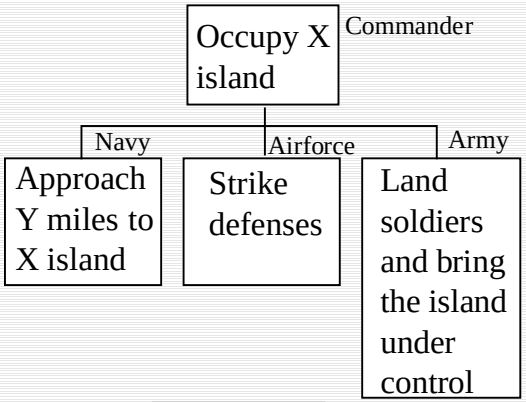
Software design

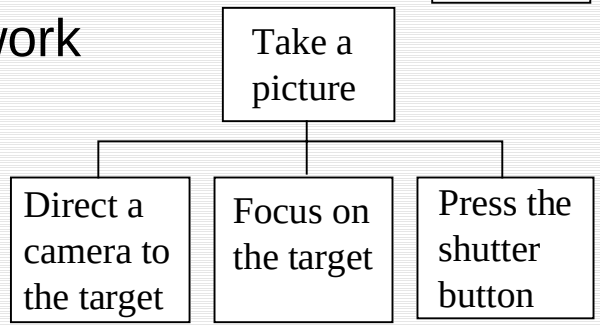


Management

Hierarchy of object



Physical work



Repetitive hierarchical decompositions appear in software design, management and physical work

They are human intentional activity

Mechanization of design

This automatic design, learnt from a human designer, does a design graphically, just the same way as a human designer does

It details both DFD and structured chart PAD (instead of flowchart)

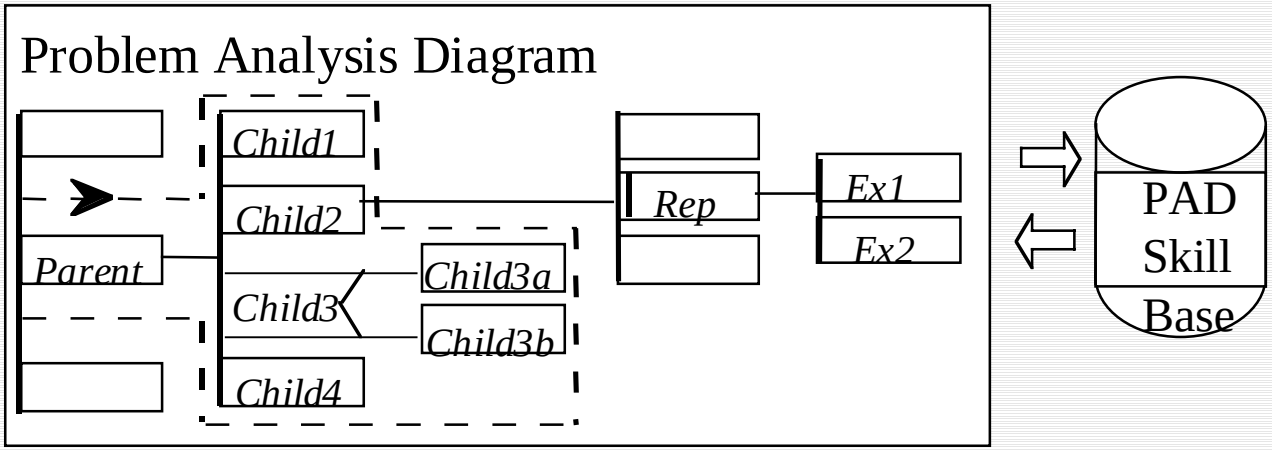
Structured chart Problem Analysis Diagram

Operations: Concatenation, decision and repetition

Graphic symbol with statement

Sequence: Goes in a top down manner

Detailing: Child(ren) put in the right side



Automatic acquisition (skill)

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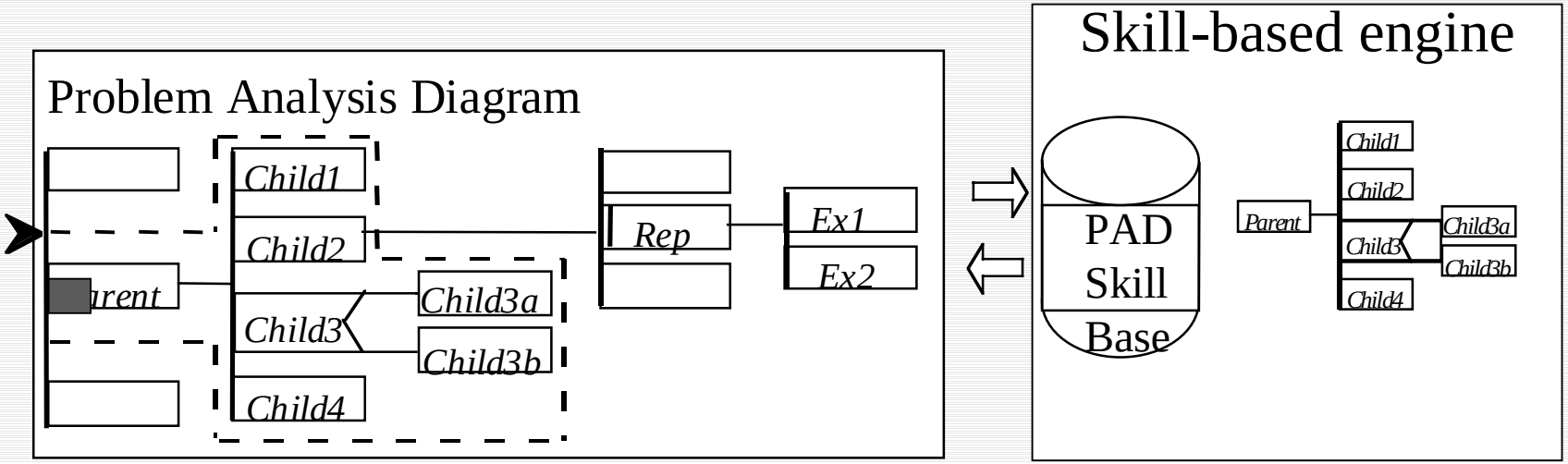

Automatic acquisition is made by a tree-walk,

starting from the parent with a starting mark, goes around the children and returns to the original parent.

Information gained from each symbol is purified to be

a design rule, a pair of the parent and the child(ren).

Automatic acquisition (skill)

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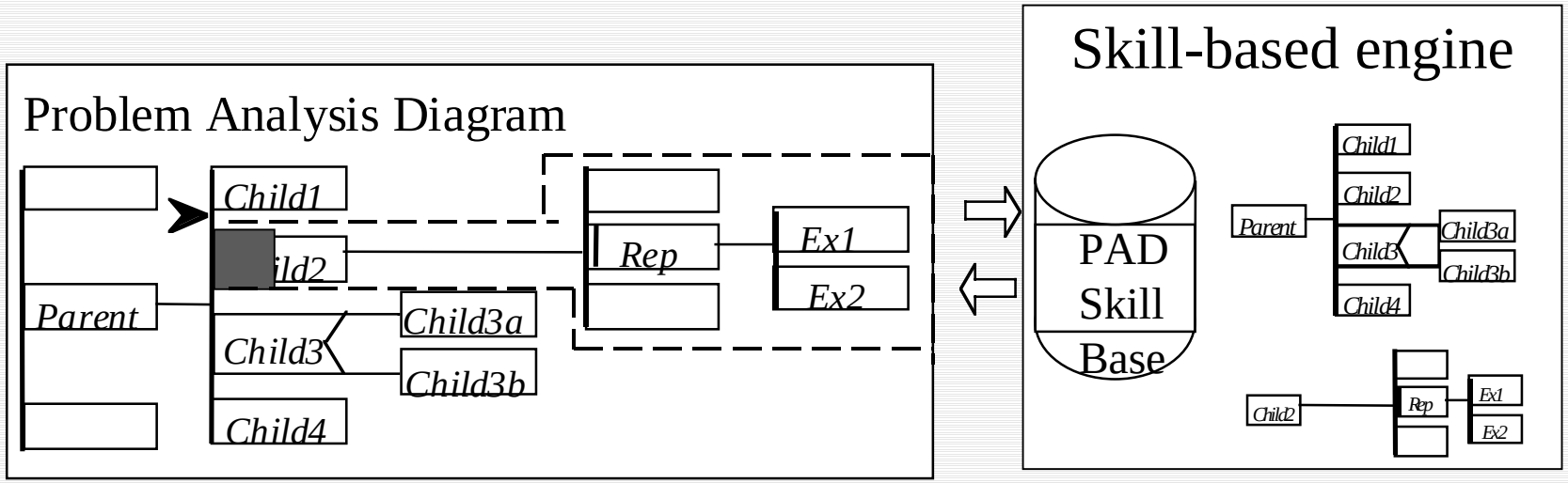

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Automatic design (skill)

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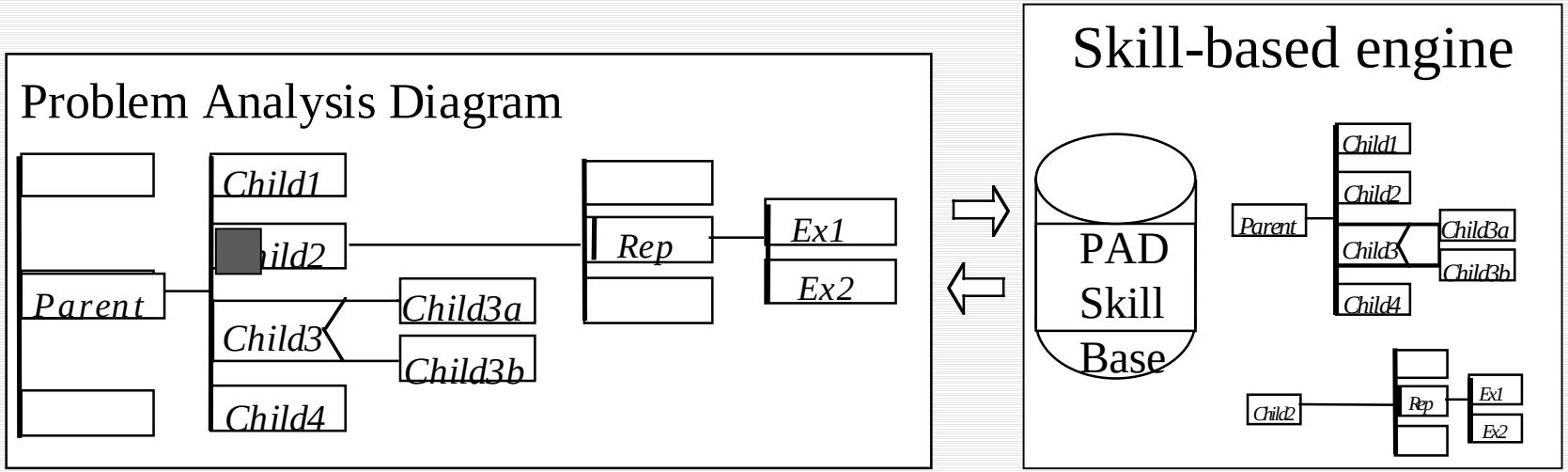

Automatic design is made by,

referring Skill-base by the parent, and

pasting the desired children to the right.

In rule-based and Knowledge based mode,

engines are used for generating a design rule.

Automatic design (skill)

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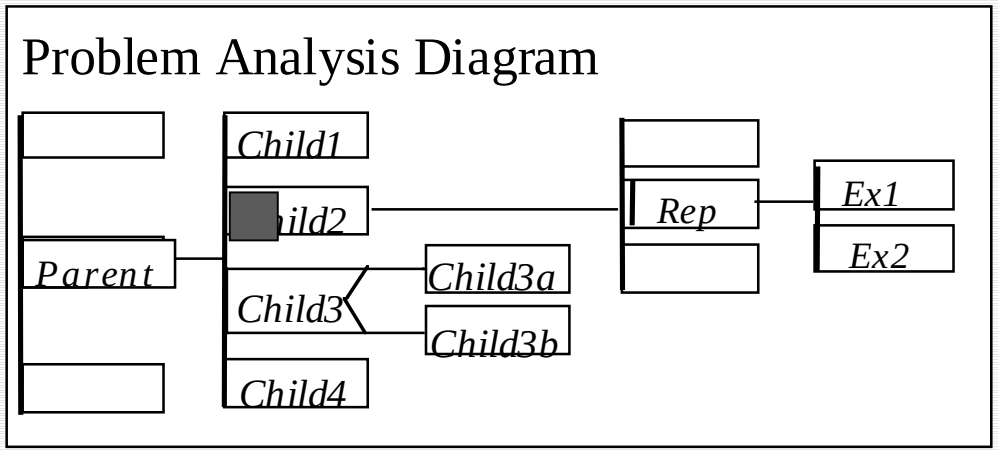


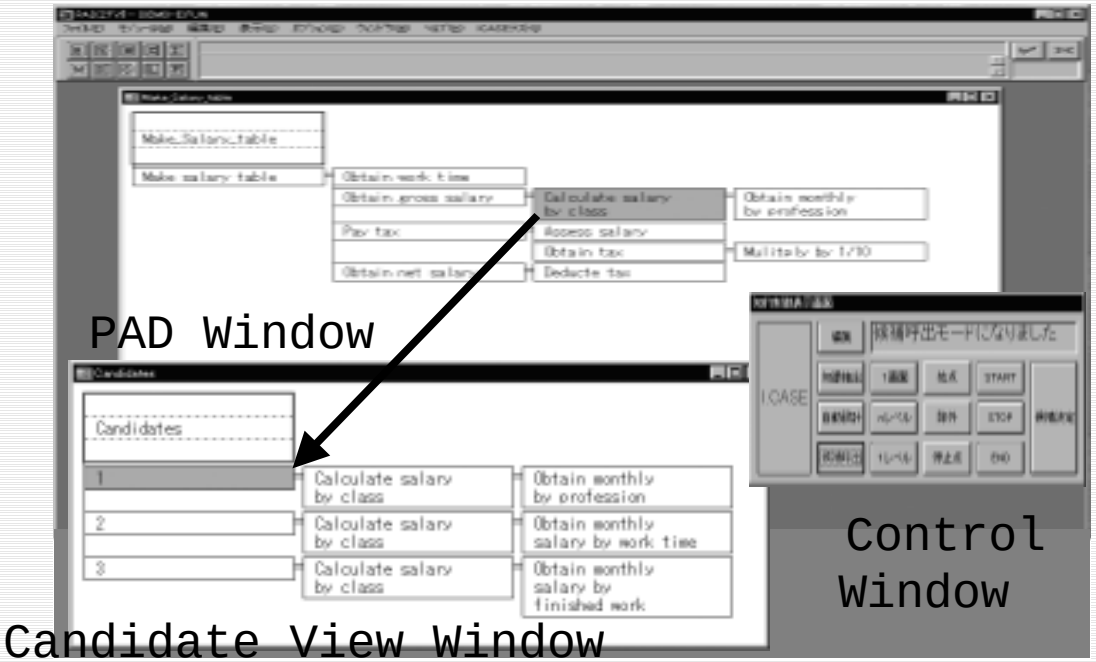
Rule-based engine

Supported by knowledge-based operation, if needed

Automatic design is made by,
referring Skill-base by the parent, and
pasting the desired children to the right.
In rule-based and Knowledge based mode,
engines are used for generating a design rule.

Intelligent CASE (ICASE) tool

Software Creation Project



Developed in 1998

Skill-based operations using PAD CASE tool

- Automatic acquisition
- Automatic design
- Manual selection

Off the shelf PAD CASE tool added with tree-walk programs, graphical acquisition program, and graphical pasting program.

Knowledge-Base for storing skill-based knowledge or a design rule

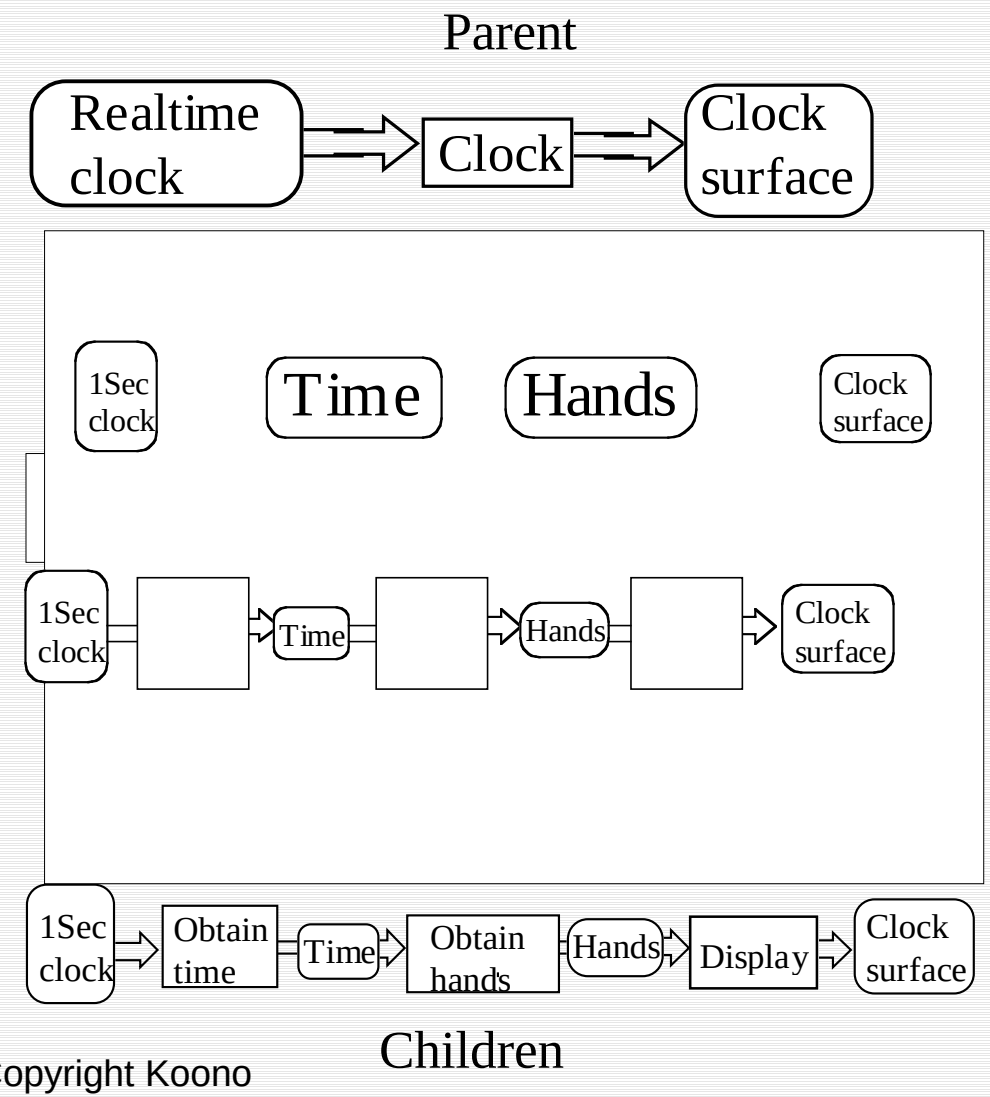
Controller implemented by Finite State Machine model following SDL technology

Event driven Operating system for controller

Inside of a design rule

STS division by Myers

1. 'The **M**ost **A**bstracted **P**oints'
2. Insert blank functions &
3. Create Function Name



Knowledge-based operation

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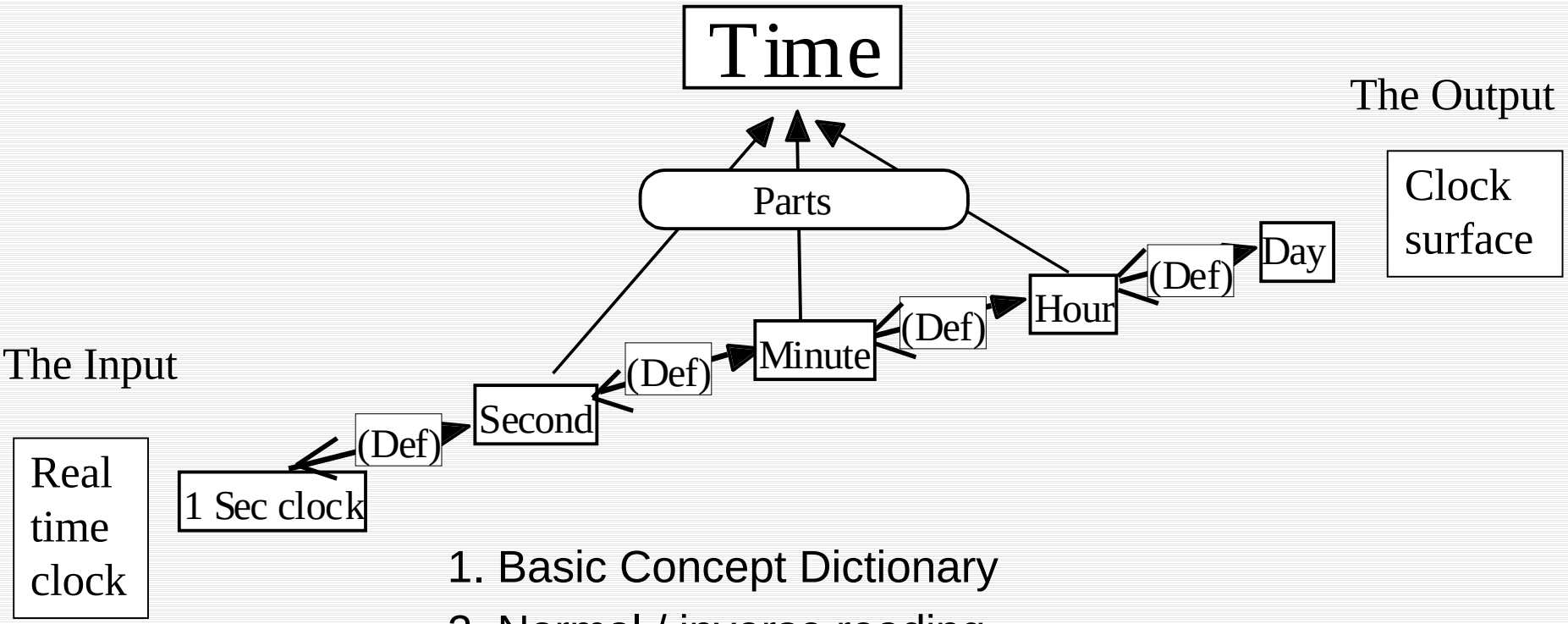
The Input-side **M**ost **A**bstract **P**oint



1. Basic Concept Dictionary
2. Normal / inverse reading
3. Exhaustive operations
4. Small functions (e.g. Create Function name)
5. Dedicated solution

Examples of design

‘Inventory control system’ in order to know actual human design

1. Small but consistent.
2. Business sys., where rules are clear.

Initial 7 programs (approx. 700 C lines) and additional 7 as the maintenance

DFD and PAD designs in a small step of detailing (see right side)

Rigorous checks repeated

From analyses of design results, keys for rule-based operation and Design Direction Finder were found, and the reproduction of human designs becomes possible.

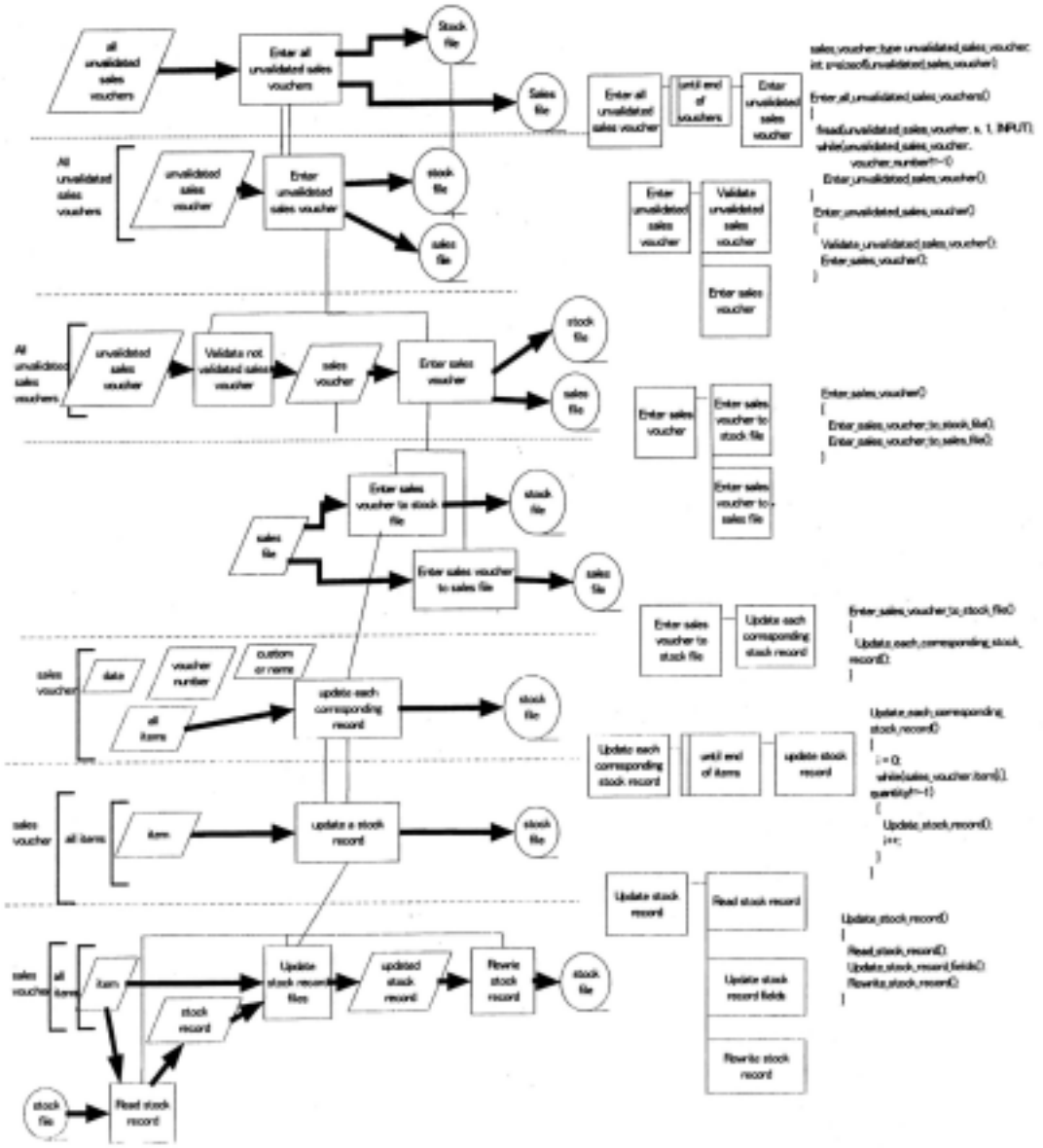


Figure 4.1.E. Sequence of a design

Lessons learnt

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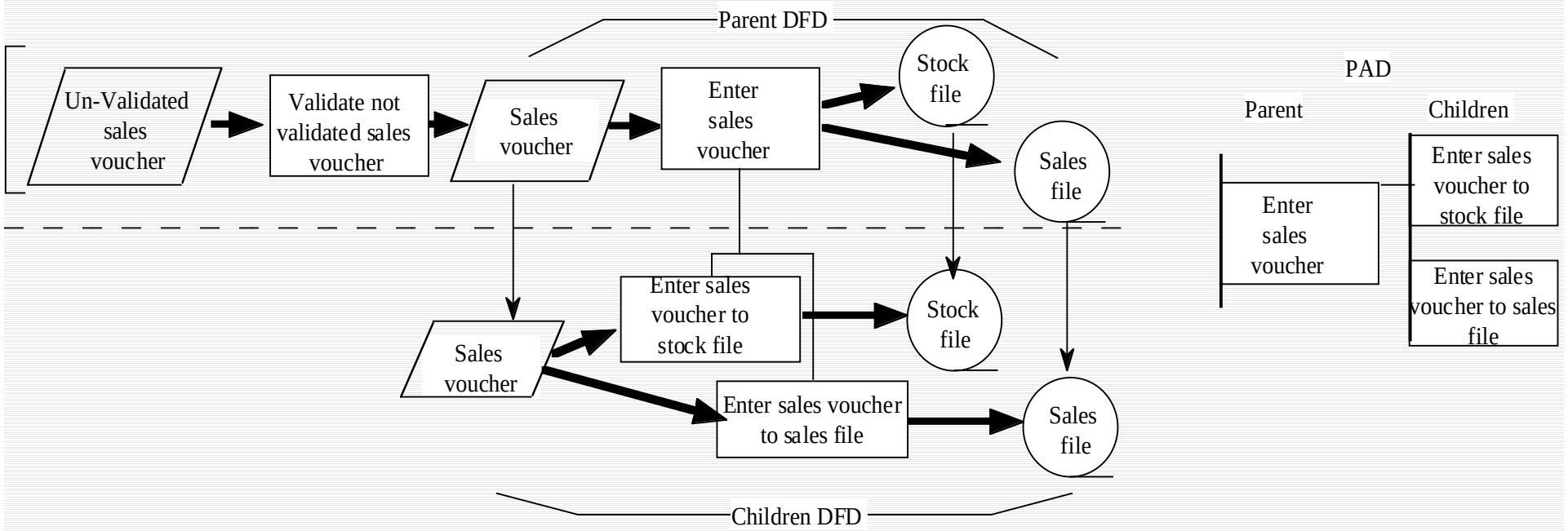


Small step of detailing resulted in;

A few variation on patterns of [‘verb’ + ‘object’], (Restricted grammar)

where ‘objects’ are data under processing. --> Frame memory for a rule

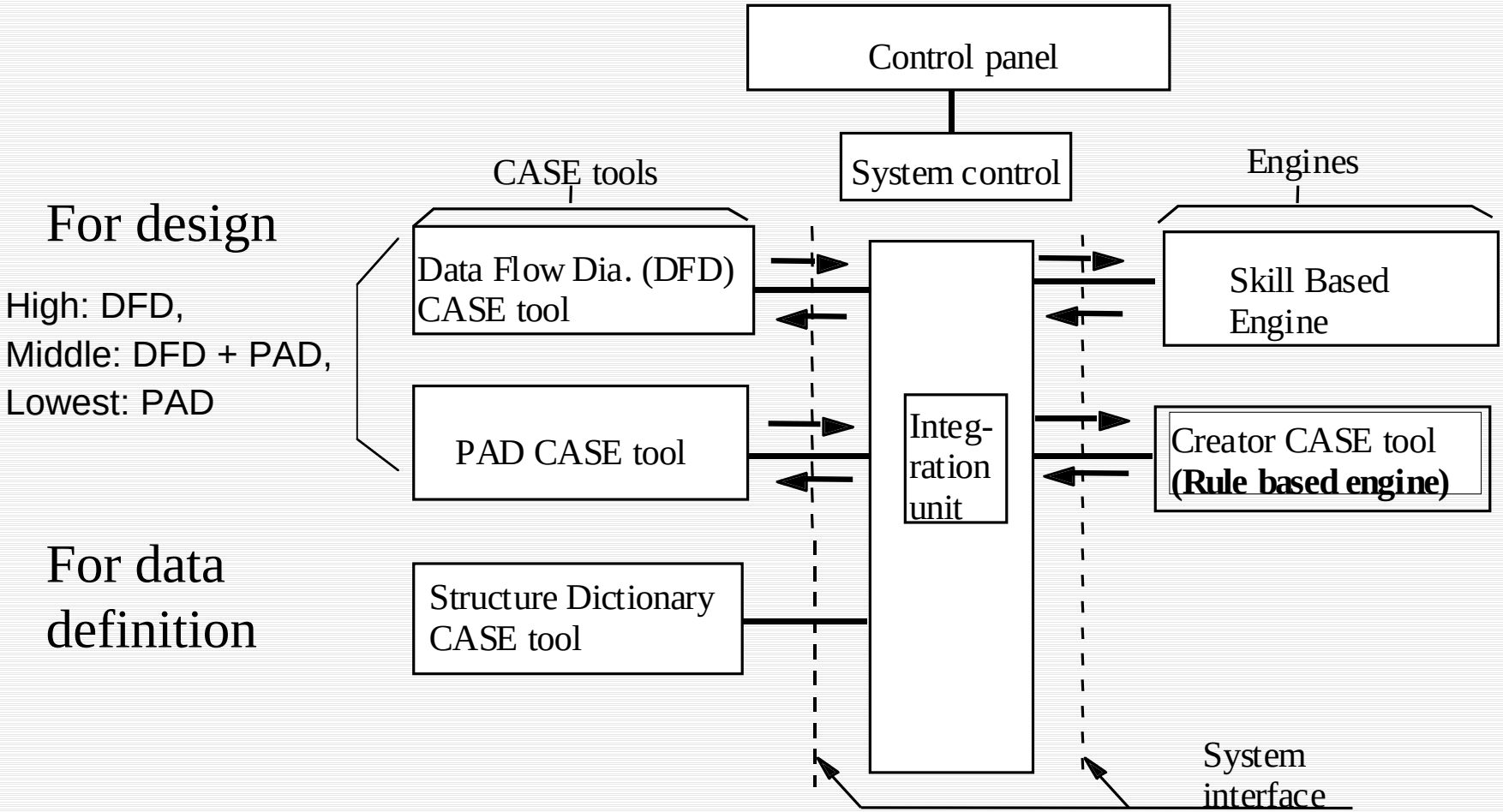
Data defines the way of the processing

The output data defines 80% and the input data defines the way of the processing.

--> Automatic direction of design possible, Design Direction Finder

Integrated Intelligent CASE tool

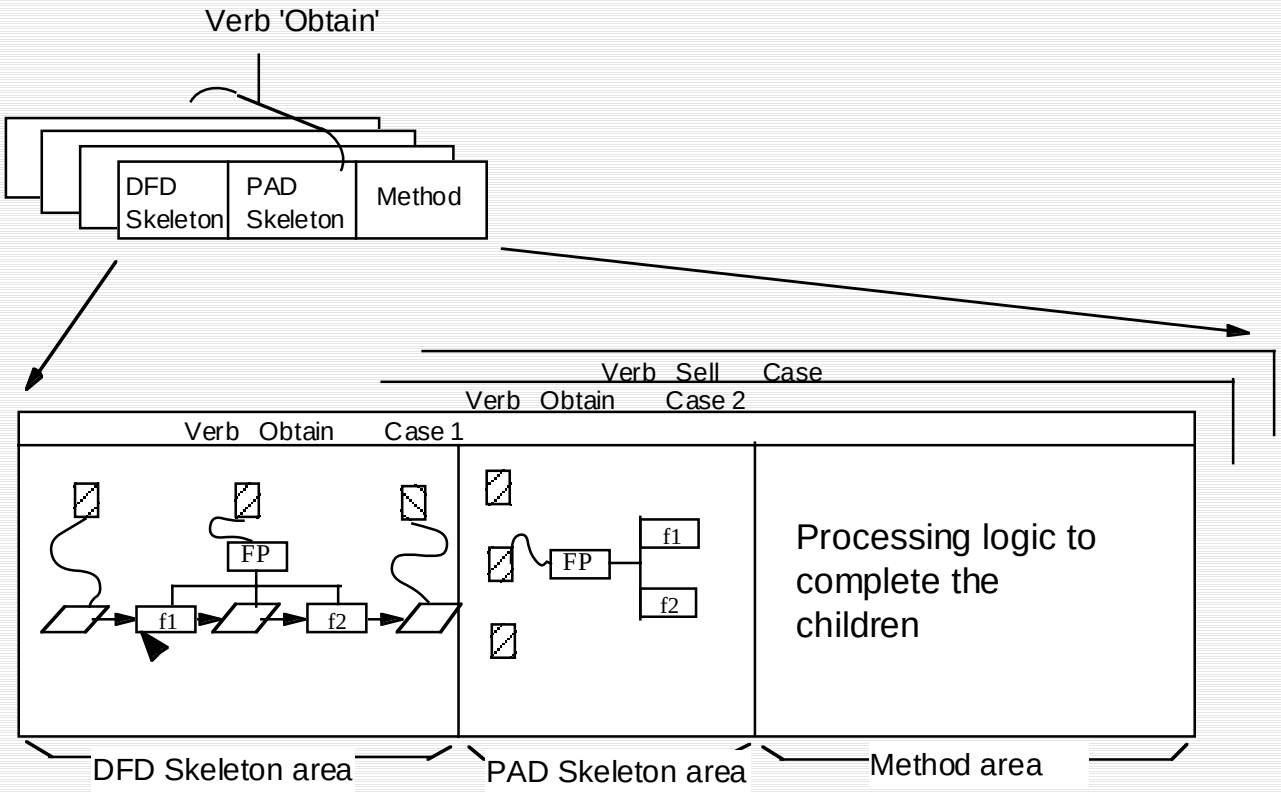
Software Creation Project



The S/W size of a CASE tool is approx. 4 - 5 Kilo lines of C code.
Most of programs are common to all the CASE tools.

Verb dictionary using frame memory

Software Creation Project



*The verb, in a parent function, is extracted and accesses to the dictionary.

*Several pages, corresponding to each meaning of the verb, are read out.

*A dictionary page is for a meaning of the verb. It is a frame consisting of data and method.

*Data for skeleton: blank data - children concept verb - blank data ….
*Method: data transfer to data, in the skeleton, from parent (input) data, insertion of preposition, and so on

PAD operation here may be omitted where derivation form DFD is possible

Design Direction Finder

Software Creation Project

*A verb has several meanings. In the previous ICASE, the manual selection was needed.

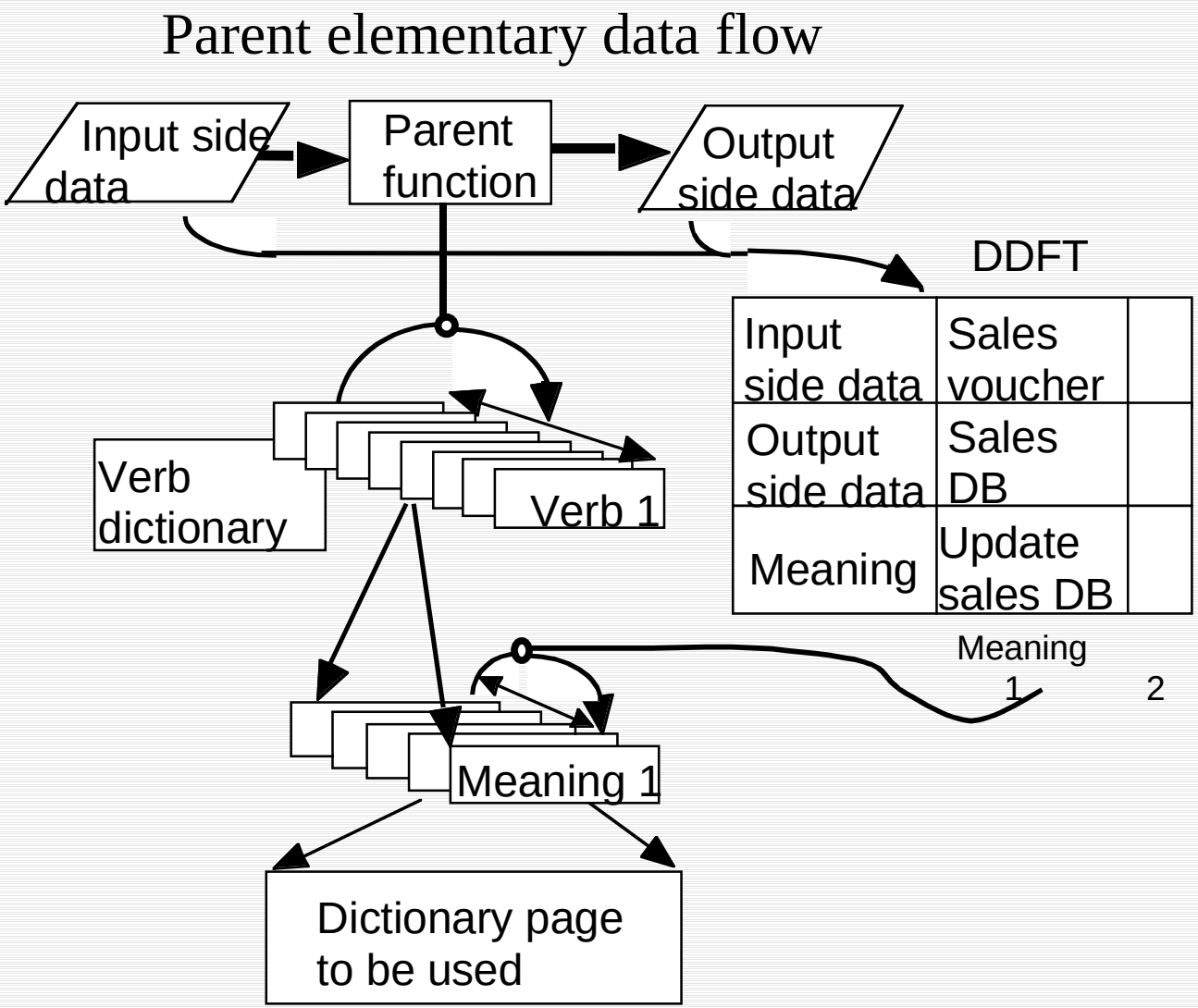
*Design Direction Finder automatically selects the required meaning page.

*The meaning is defined by

1. output data
2. input data

*DDFT has a column of input data, output data and the meaning.

*DDFT is scanned with the present input and output data to define the meaning



Integrated Intelligent CASE tool

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- **Completed in Feburary, 2001**
- **It was confirmed that human designs may be reproduced.**
- **Chinese patent granted in 2006.**
- **USA one is going on.**
- **Japanese one will advance next.**

Evaluation (Skill-based)

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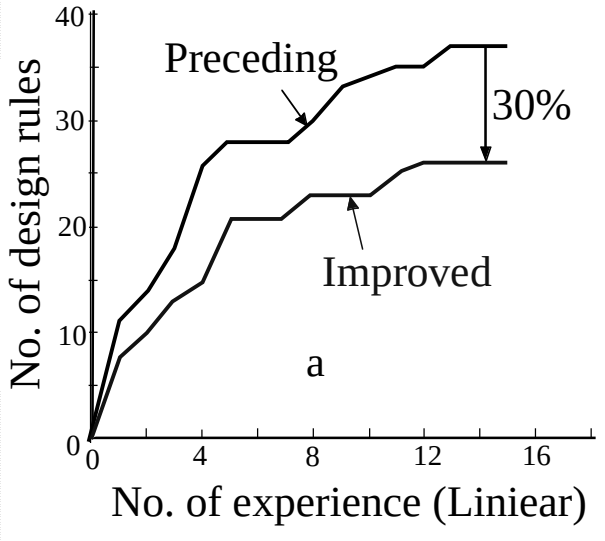
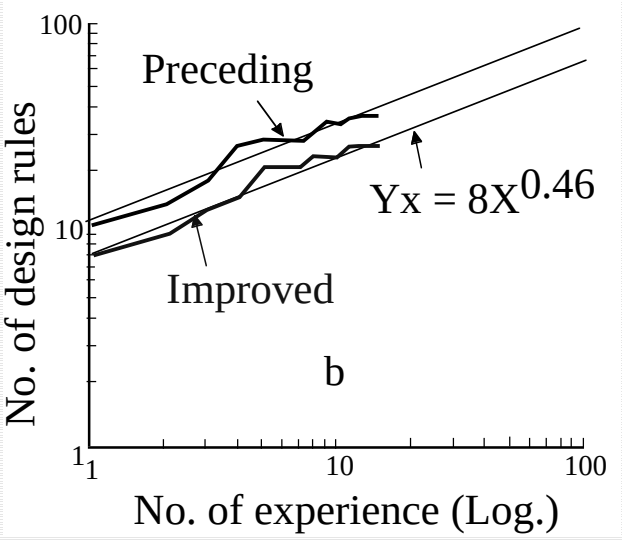
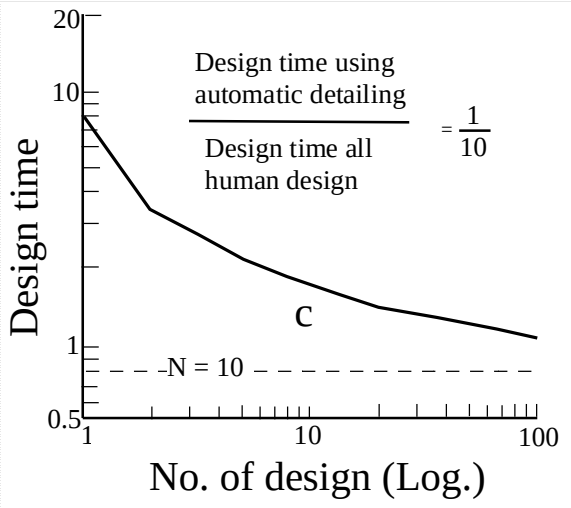
*Evaluation material: Maintenance designs of data access programs in a telephone switching system.

This system is like an apprentice, who remembers at the first experiences.







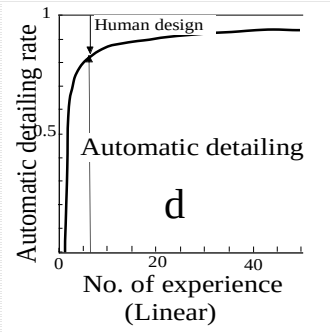
Linear scale graph

A learning Effect
the sharp rise at first and the gradual decrease.

Both logarithmic sales

A linear trend lines
Logarithmic learning effect

Leaning Effect
Caused by logarithmic accumulation of knowledge



The degree of automatic detailing.
Sharply rise to 80% but does not tend to 100%.
It is a reflection of the shallow nature of the knowledge.

Evaluation (Rule-based)

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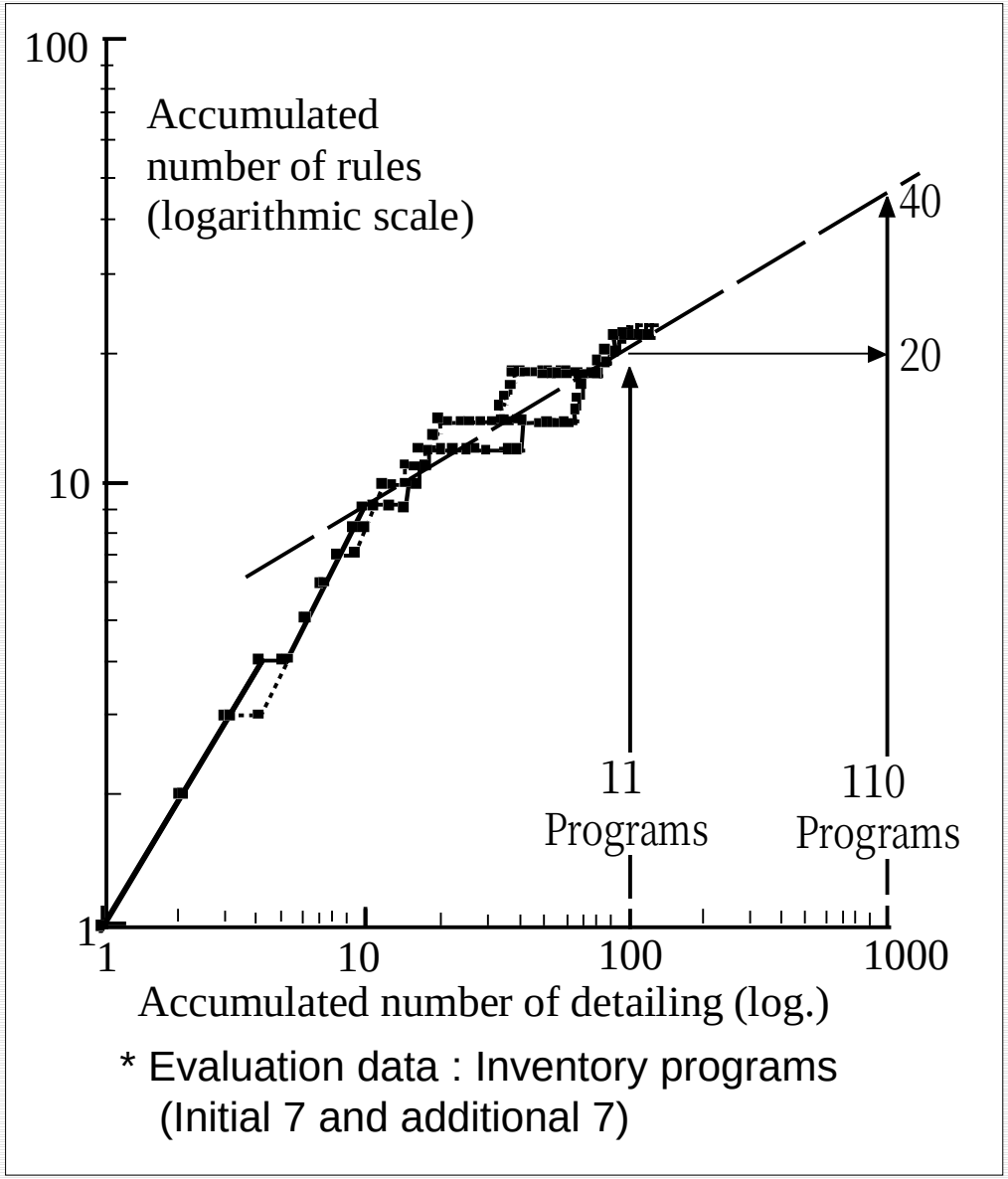


* Evaluation data : Inventory programs (Initial 7 and additional 7)

*Cause of Learning effect

X < 10 Number of verb

X > 10 Number of meaning

*The degree of automatic detailing

From100 detailing to increase up to 1000 detailing,

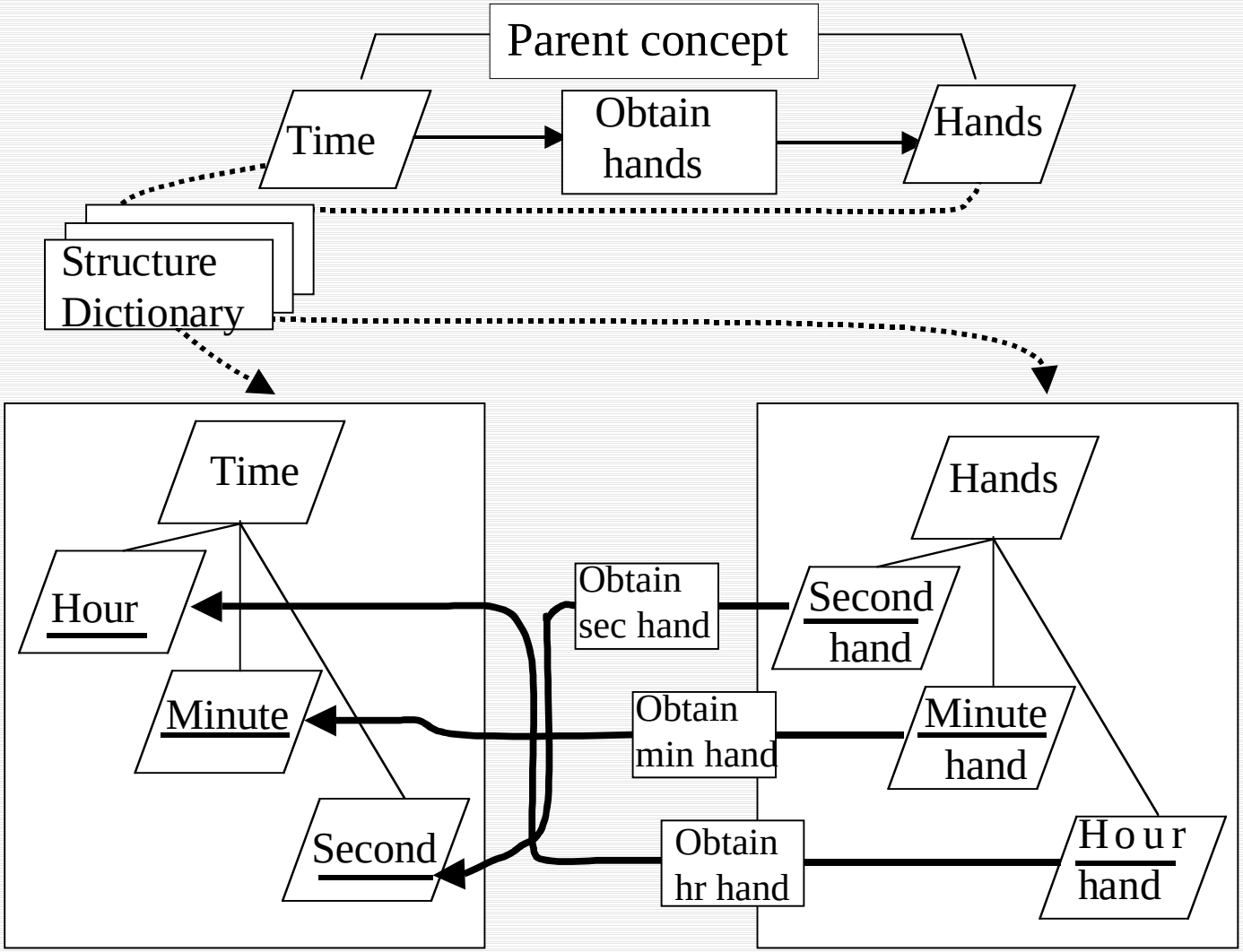
1 - (Additional 20 pages) /900

98%

The degree tends to 100% as the experiences are accumulated.

As designs are repeated, and the amount of the knowledge increases, the probability of getting a new knowledge decreases.

Jackson's case



1. Parent concept
2. Output & input
3. data detailed
4.3. Matching data
5. search for
6. establishing a
7. data flow
8.4. Insert
9. function

Evaluation (knowledge-based)

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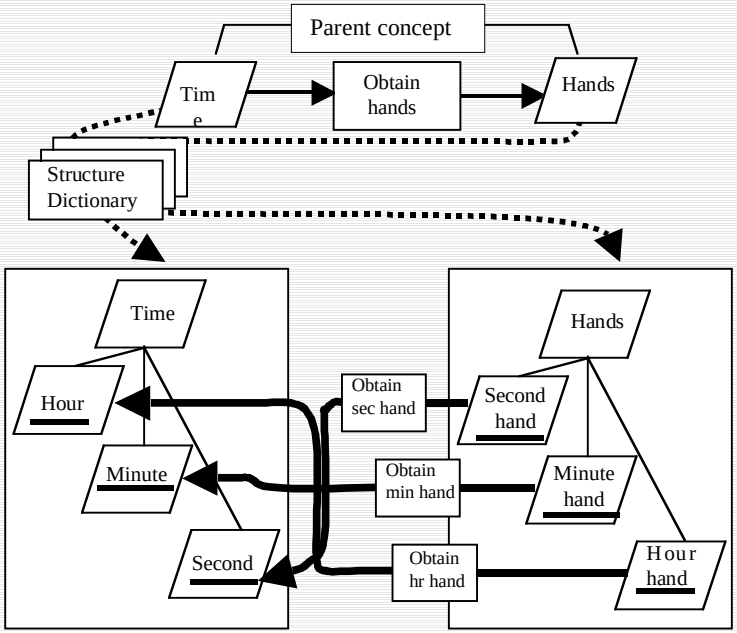
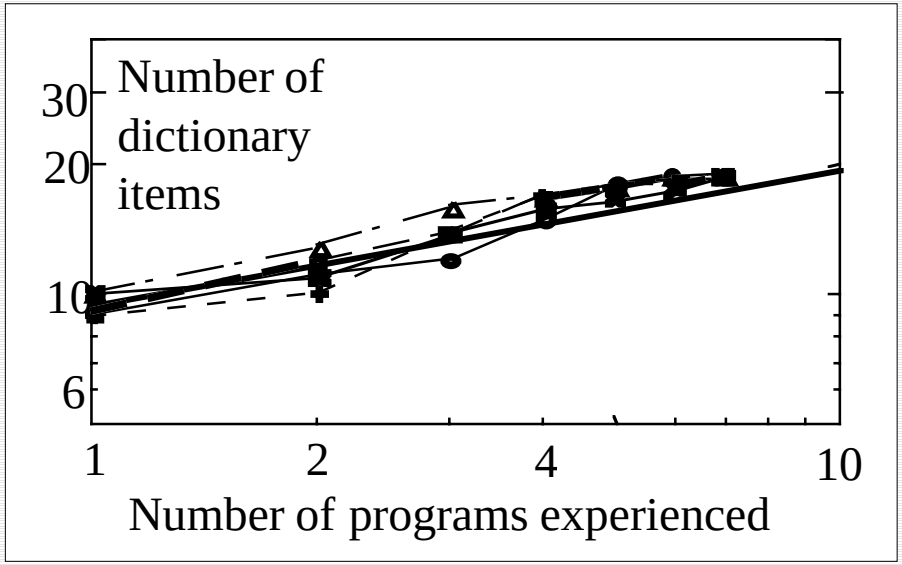
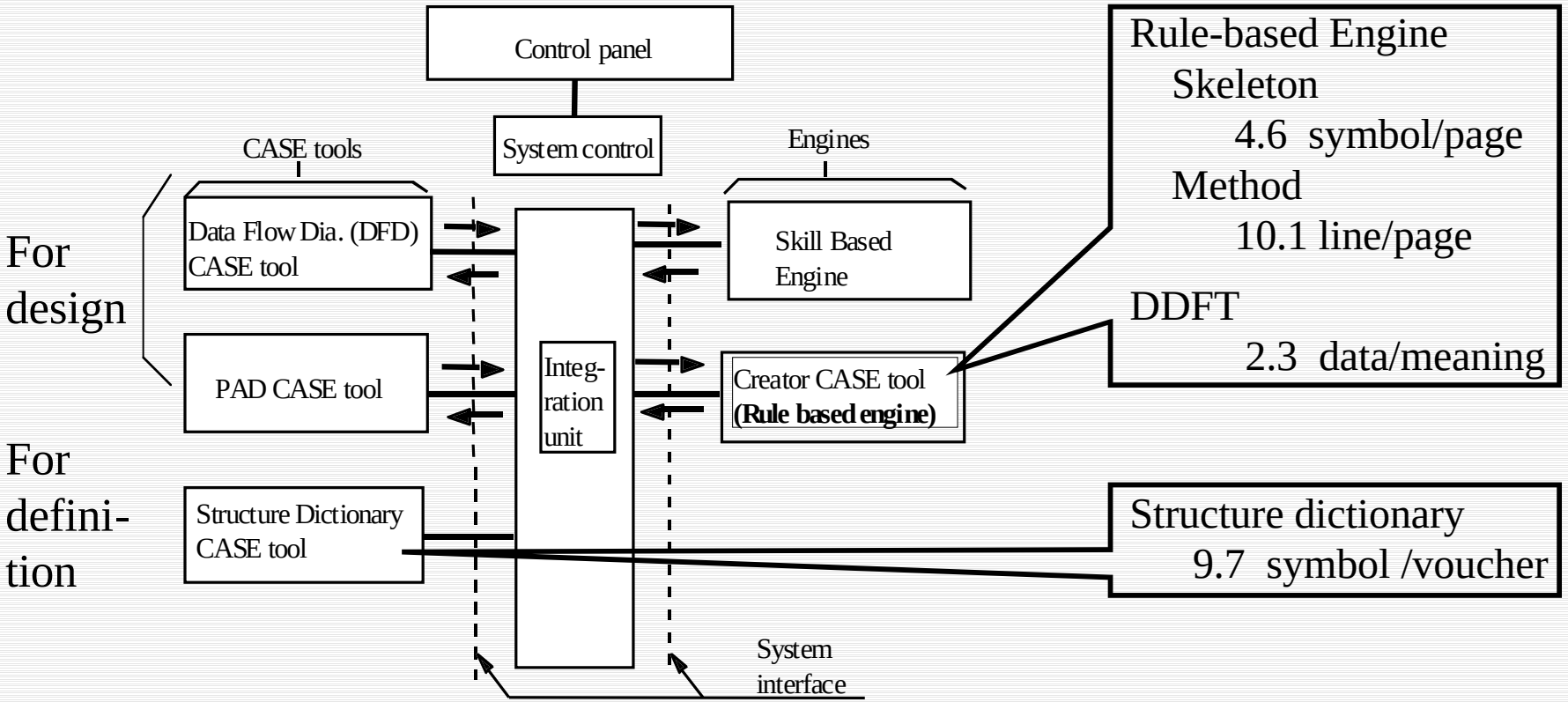


Knowledge-based is used where all rule-based operations fail.
It works by its control logic using definition in BCD.



- If **hr hand** is defined as a **short hand**, The pair may not be identified.
- If Basic Concept Dictionary has ['short hand' = hour hand], and the pair search is extended to translate 'short hand',it may be automatically Designed.

Evaluation (cost)



Development efforts of the design knowledge, shown in balloons, are small.
It has been brought by following factors.

1. A small step of hierarchical decomposition of concept is taken.
2. Graphic operation substitutes design.

Concluding remarks

Software Creation Project

○An automatic design system, a human intelligence simulator

- ·Reproduction of human design (skill, rule and knowledge)
- ·Highly cost effective like a designer

  Dictionary (human memory structure) oriented

  Graphic operation like human design

  Learning system

○Future works ….Evolution to be a human simulator

○ Applications

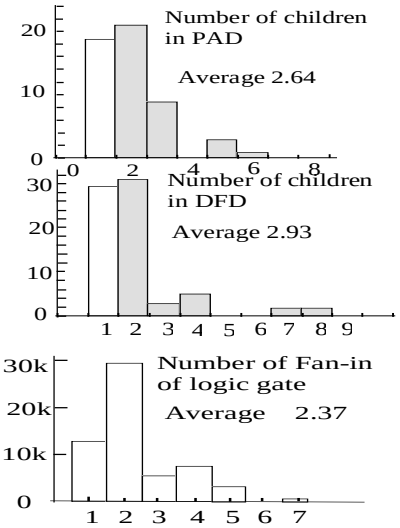
Humanoid robot, intelligent control like human

Quantitative, rational and scientific S/W Engineering

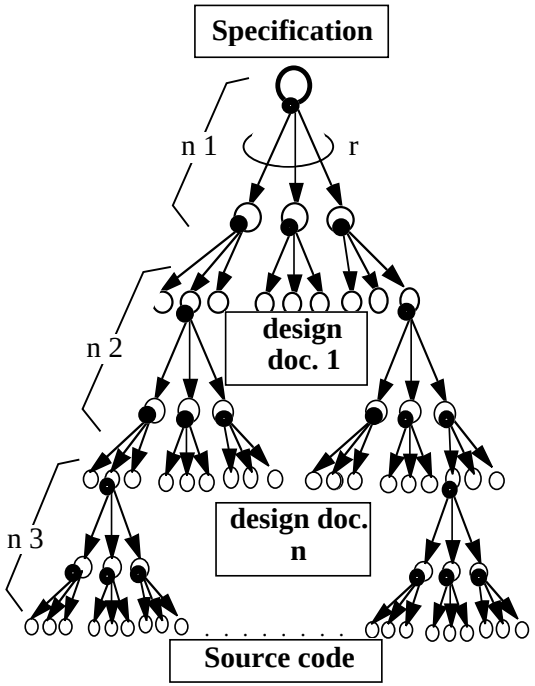
Research tool for research of Human Intelligence

Applications to Software Engineering

○Quantitative, rational and scientific Software Engineering like those for hardware production

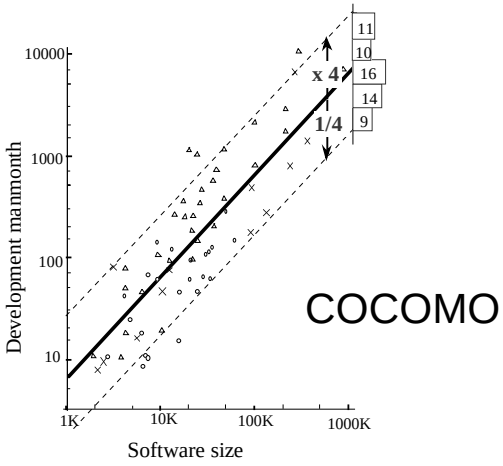


Small step detailing is taken expansion rate is constant (e ?)



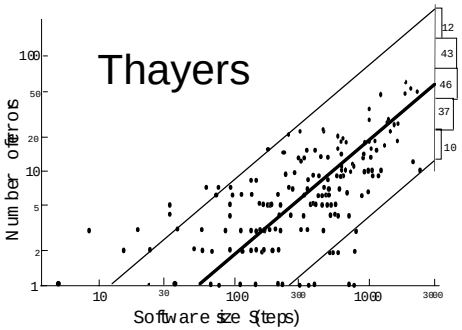
Work process is a linear system, enabling both integration and decomposition

Theoretical Actual Man-hours ∽ S/W size



COCOMO

Nr.of Errors ∽ S/W size



The same as H/W works

Concluding remarks

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Quantitative, rational and scientific S/W Engineering

Research tool for research of Human Intelligence

Proof of linear nature

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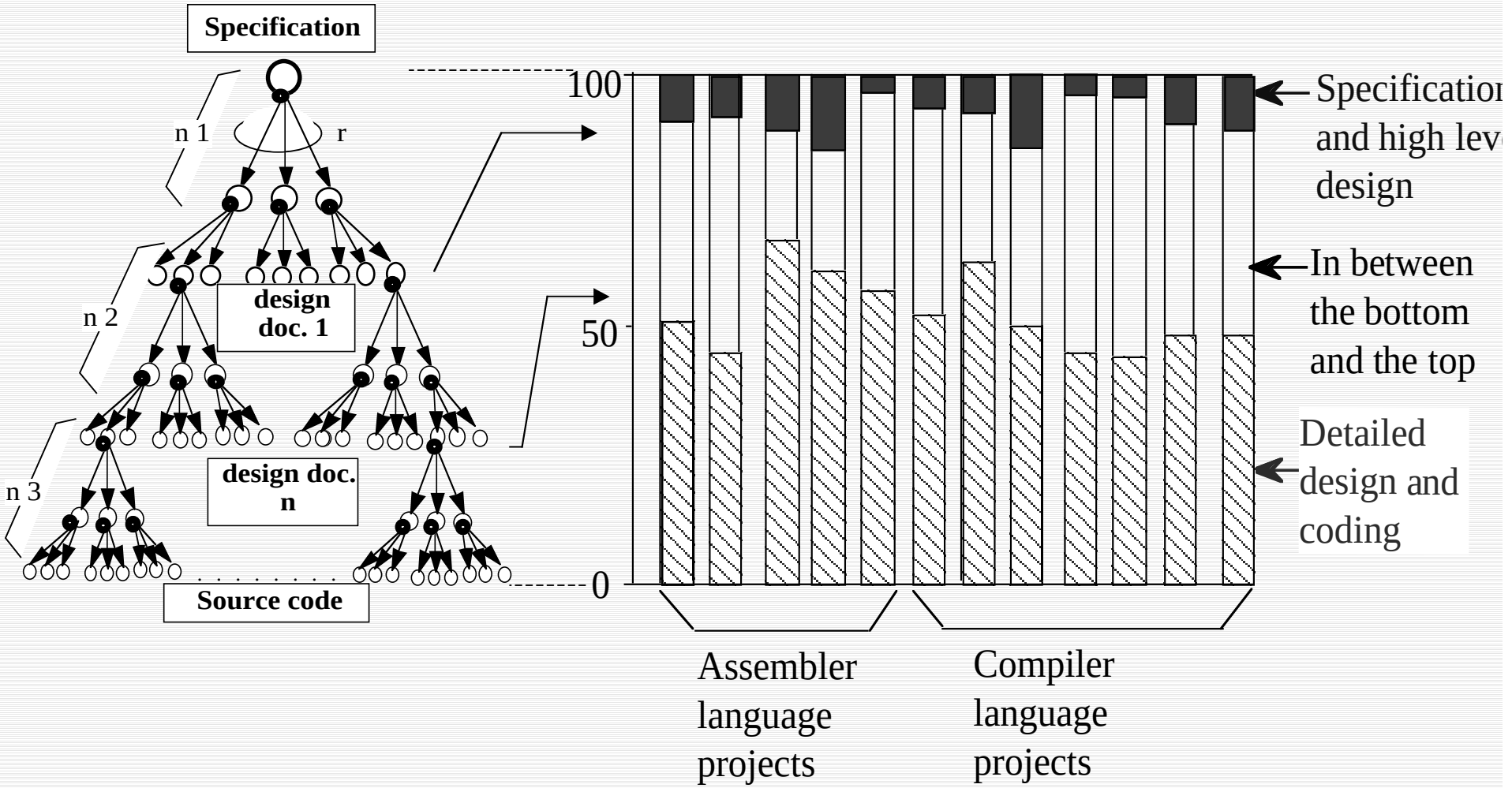

Attenuation rate by test

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