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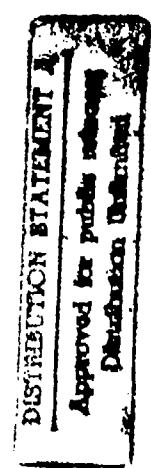


Ada[®] FROM A MANAGEMENT PERSPECTIVE

DTIC QUALITY INSPECTED 3

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1Lt Anthony D. Dominice



Presented by: Ada[®] Software Engineering Education & Training (ASEET) Team

Sponsored by: Ada[®] Joint Program Office

Organized by: Herbert E. Cohen

U.S. Army Materiel Systems Analysis Activity
Aberdeen Proving Ground, Md.



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Overview

Rationale for development

Capabilities and advantages

Life Cycle application

What you may have heard about Ada

It's a cure all for DoD computing problems

It's just another acronym

It's a programming language

It's "just another" programming language

It's a panacea

What you need to hear about Ada

Plain and simple...

Ada is a standardized computer language developed by the DoD for use in embedded computer systems

Ada is the BEST tool available for meeting the software engineering requirements of the DoD

Overview

Rationale for development

Capabilities and advantages

Life Cycle application

Overview

Rationale for development

Capabilities and advantages

Life Cycle application

The criticality of software

Hardware is no longer the dominant factor in the hardware/software relationship

The demand for software is rising quickly

The cost of software is rising quickly

Software maintenance is the dominant software activity

Systems are getting more complex

Life and property are dependent on software

Characteristics of DoD software

Expensive

Incorrect

Unreliable

Unpredictable

Unmaintainable

Not reusable

Factors affecting DoD software

Ignorance of life cycle implications

Lack of standards

Lack of disciplined use of methodologies

Inadequate support environments

Management

Software professionals

Characteristics of DoD software requirements

Large

Complex

Long lived

High reliability

Time constraints

Size constraints

The fundamental problem

Our inability to manage the COMPLEXITY of our software systems (Grady Booch)

Lack of a disciplined, engineering approach

Software Engineering

The establishment and application of sound engineering

Environments

Tools

Methodologies

Models

Principles

Concepts

Software Engineering

Combined with

Standards

Guidelines

Practices

Software Engineering

To support computing which is

Understandable

Efficient

Reliable and safe

Modifiable

Correct

Throughout the life cycle of a system

(C. McKay, 1985)

Programming languages and software engineering

A programming language is a software engineering tool

A programming language EXPRESSES and EXECUTES design methodologies

The quality of a programming language for software engineering is determined by how well it supports a design methodology and its underlying models, principles, and concepts

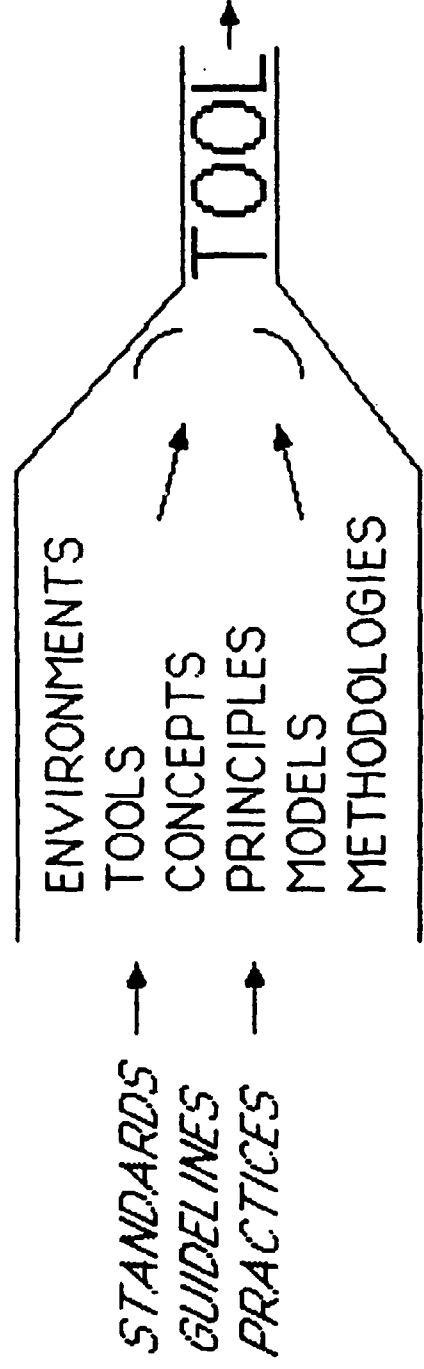
Traditional programming languages and software engineering

Programming Languages

Were not engineered

Have lacked the ability to express
good software engineering

Have acted to constrain software
engineering



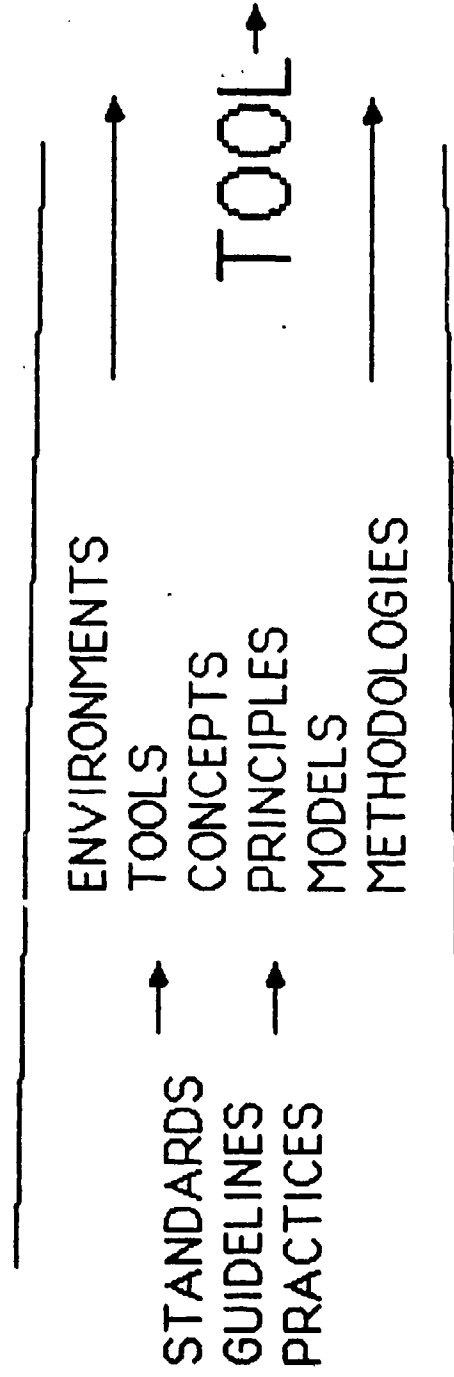
Ada and software engineering

Ada

Was itself engineered to support software engineering

Embodies the same concepts, principles, and models to support methodologies

Is the best tool for software engineering available



Principles of software engineering

Abstraction

Modularity

Localization

Information hiding

Completeness

Confirmability

Uniformity

Abstraction

The process of separating out the important parts of something while ignoring the inessential details

Separates the "what" from the "how"

Reduces the level of complexity

There are levels of abstraction within a system

Modularity

Purposeful structuring of a system into parts which work together

Each part performs some smaller task of the overall system

Can concentrate and develop parts independently as long as interfaces are defined and shared

Can develop hierarchies of management and implementation

Localization

Putting things that logically belong together in the same physical place

Information hiding

Puts a wall around localized details

Prevents reliance upon details and causes focus of attention to interfaces and logical properties

Completeness

Ensuring all important parts are present

Nothing left out

Confirmability

Developing parts that can be effectively tested

Uniformity

No unnecessary differences across a system

Major Features Of Ada

Standardization

Strong Typing

Readability

Typing Structures

Program Units

Data Abstraction

Separate Compilation

Tasks

Subprograms

Exceptions

Packages

Generics

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Standardization

Ada is an exact standard

- ANSI/MIL STD 1815A

- No subsets, no supersets

Conformance to the standard is required

- Ada Compiler Validation Capability (ACVC)

Standardization allows for portability

Standardization promotes reusability

Standardization shifts focus from the mundane to the important

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Readability

Ada was engineered with the understanding that programming is a human activity

Features are provided that allow a maintainer to quickly grasp the meaning of a particular program and to understand its structure

Readability is more than just a language issue

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Systems engineering

Analyze problem

Break into solvable parts

Implement parts

Test parts

Integrate parts to form total system

Test total system

Requirements for effective systems engineering

Ability to express architecture

Ability to define and enforce interfaces

Ability to create independent components

Ability to separate architecture issues from implementation issues

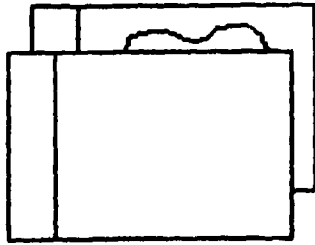
Program Units

Components of Ada which together form a working Ada software system

Express the architecture of a system

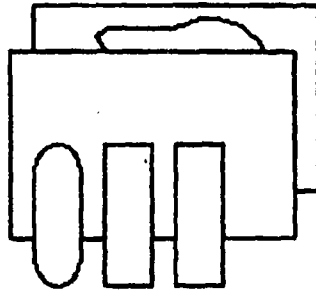
Define and enforce interfaces

Program Units



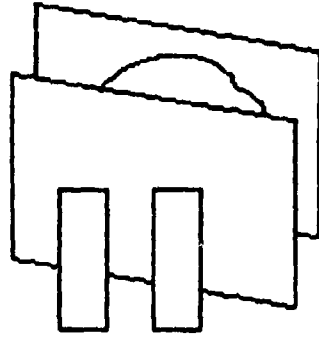
Subprograms

Working components that perform some action



Packages

A mechanism for collecting logically related entities



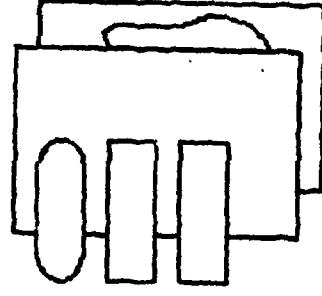
Tasks

Perform actions in parallel with other entities

Program Units

Consist of two parts: specification and body

SPECIFICATION:
Defines the interface
between the unit and
other units (the
WHAT)



BODY: Defines the
implementation of
the unit (the HOW)

Program Units

The specification of program units is the only means of connecting them together

The interface is enforced and shared

The body of a program unit is not accessible to other program units

There is a clear distinction between architecture and implementation

Major Features Of Ada

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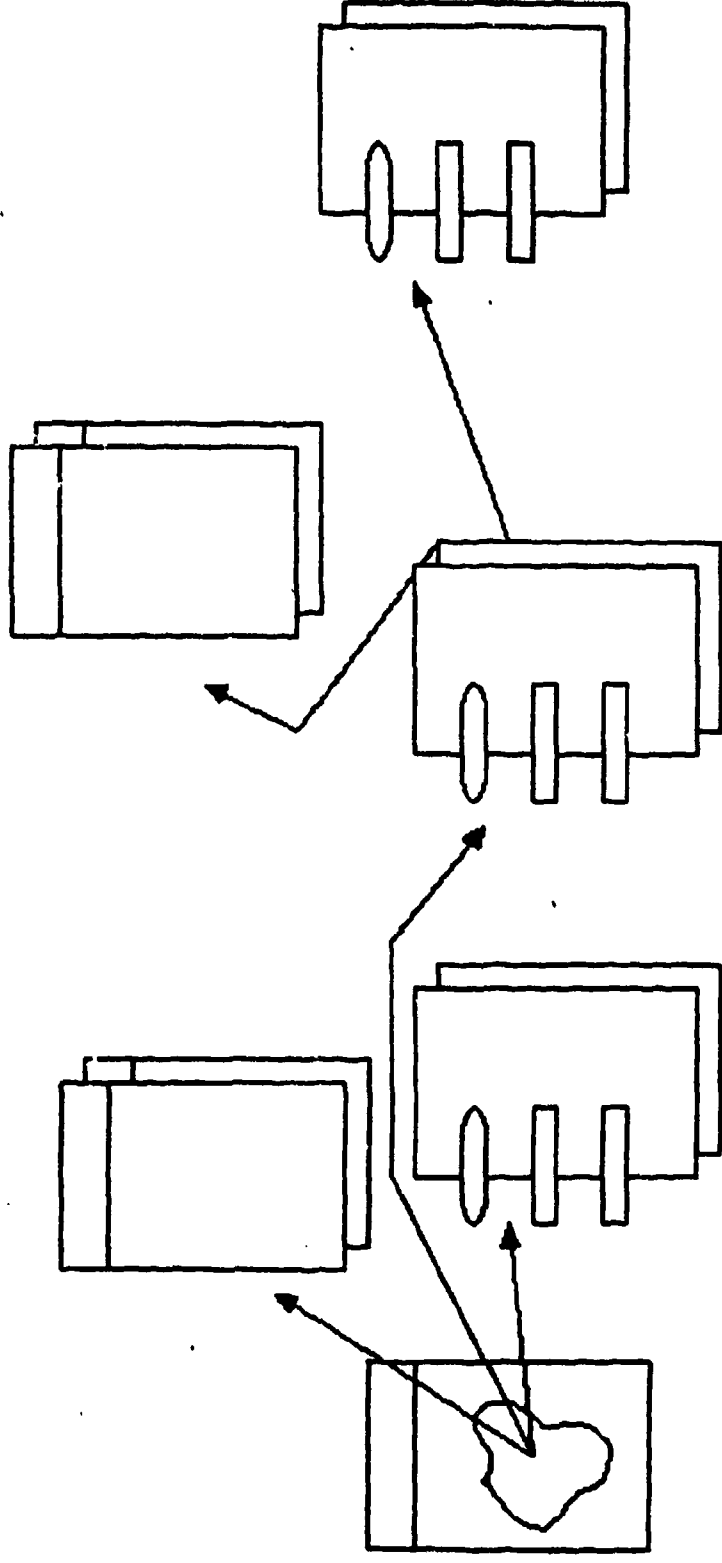
Packages

Generics

Separate compilation

Program units may be separately compiled

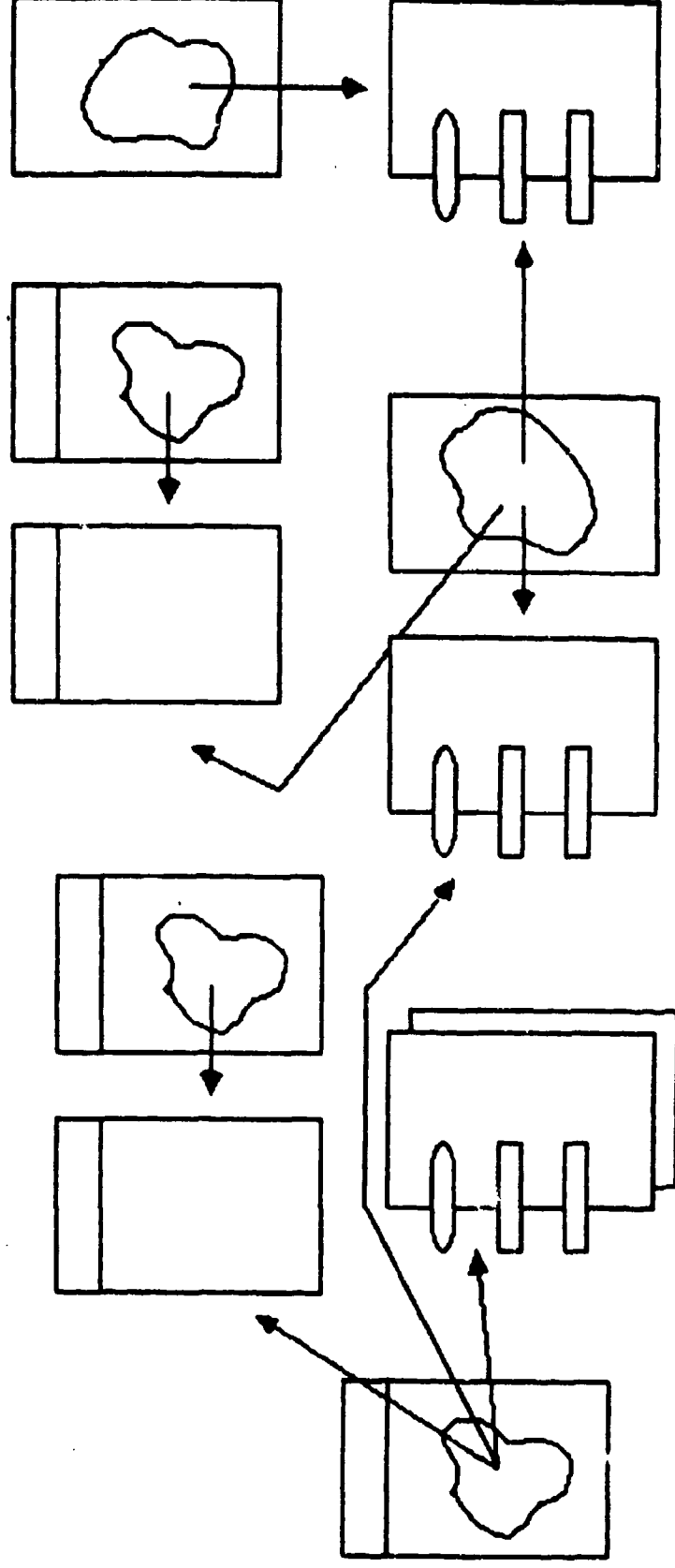
Possible because of separation of specification and body



Separate compilation

A program unit's spec may be compiled separately from its body

Realizes not only a logical distinction between architecture and implementation, but also a physical distinction



Separate compilation

Allows development of independent software components

Currently we lose a tremendous amount of human effort; software is disposable

Separate compilation allows us to reuse components and keep our investment

Major Features Of Ada

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Tasks

Subprograms

Exceptions

Packages

Generics

Discrete components

Allow a system to be composed of black boxes

Provide clear understandable functions

Can be verified and validated more effectively

Prevalent across engineering disciplines

Subprograms

A program unit that performs a particular action

- Procedures
- Functions

Contains an interface (parameter part) mechanism to pass data to and from the subprogram

The basic discrete component which acts like a black box

Gives ability to express abstract actions

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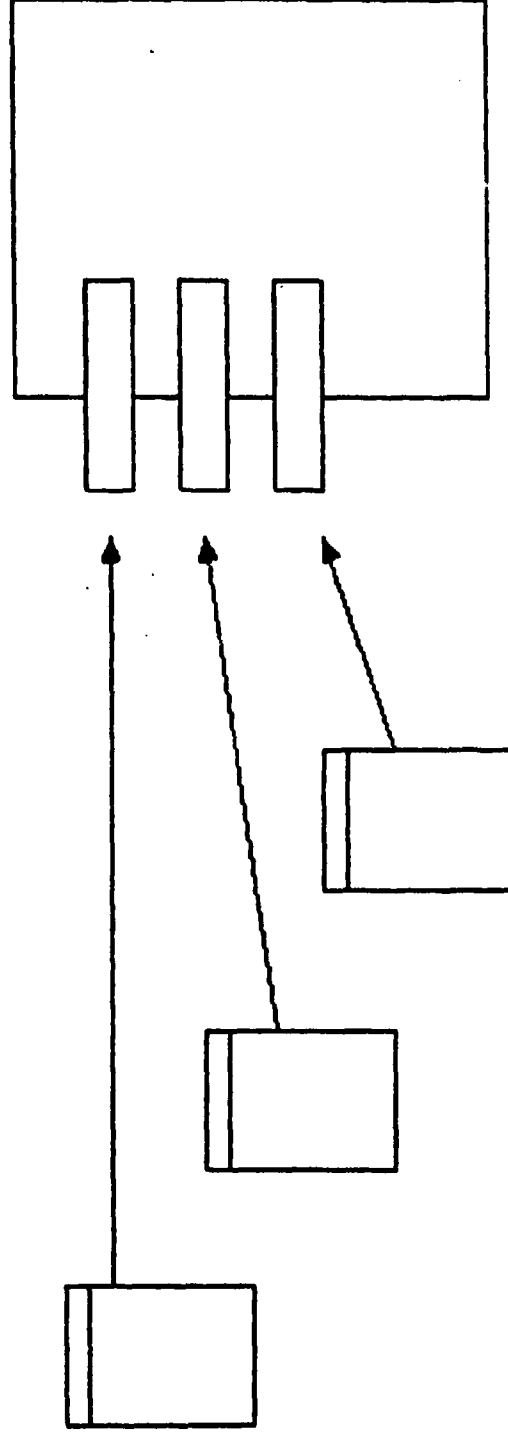
Packages

Program units that allow us to collect logically related entities

Allow the definition of reusable software components

A fundamental feature of Ada which allows a change of mindset

An architecture oriented feature

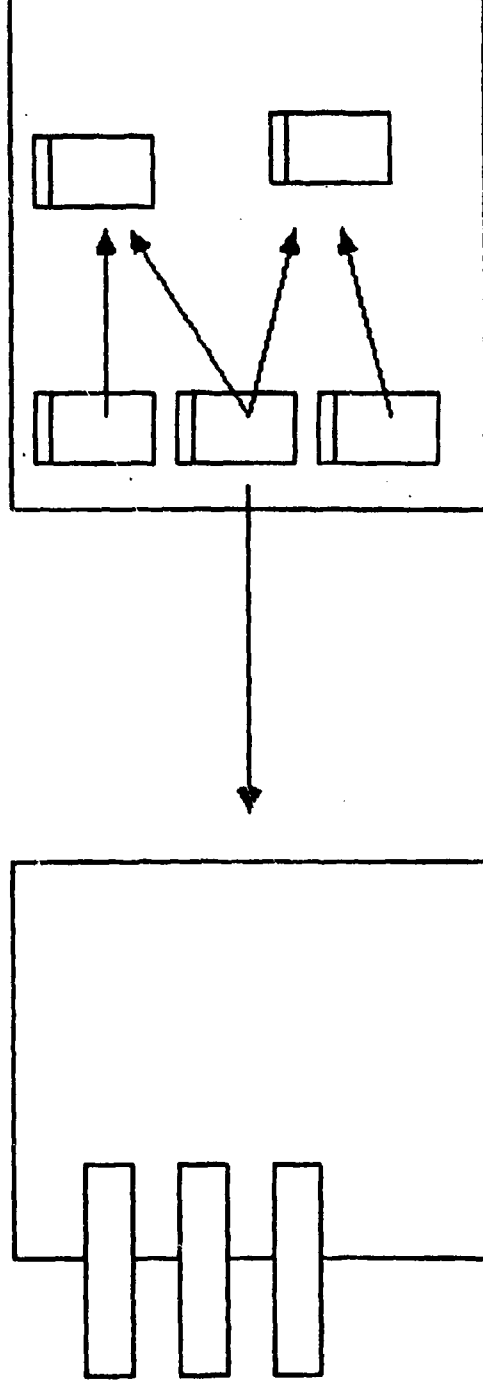


Packages

Place a wall around resources

Export resources to users of a package

May contain local resources hidden from the user



Packages

Directly support:

Abstraction

Information hiding

Modularity

Localization

Understandability, efficiency, reliability, modifiability

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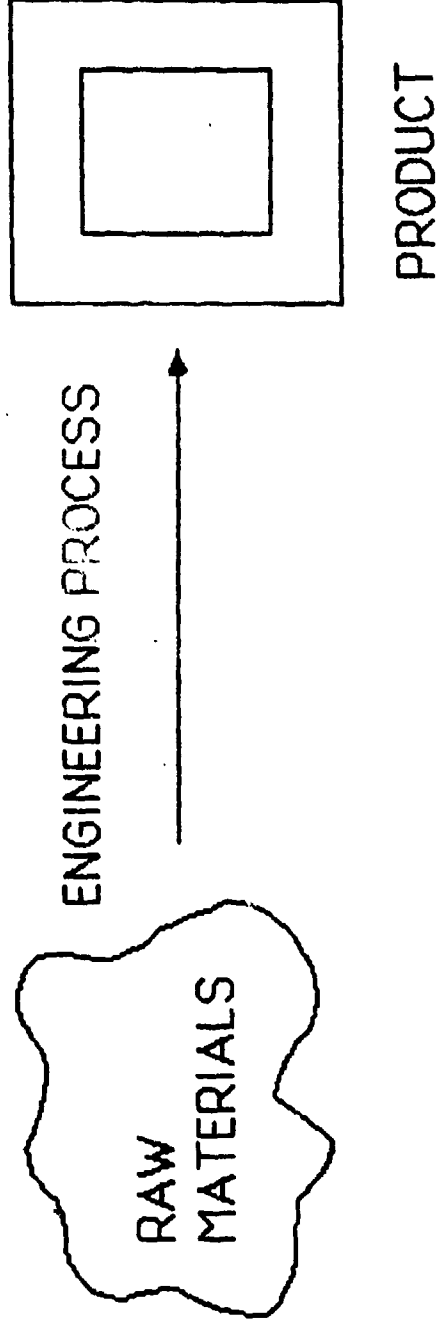
Packages

Generics

The raw materials of engineering

All engineering disciplines shape raw materials into a finished product

The materials and methods combine to define different disciplines



Structuring raw materials

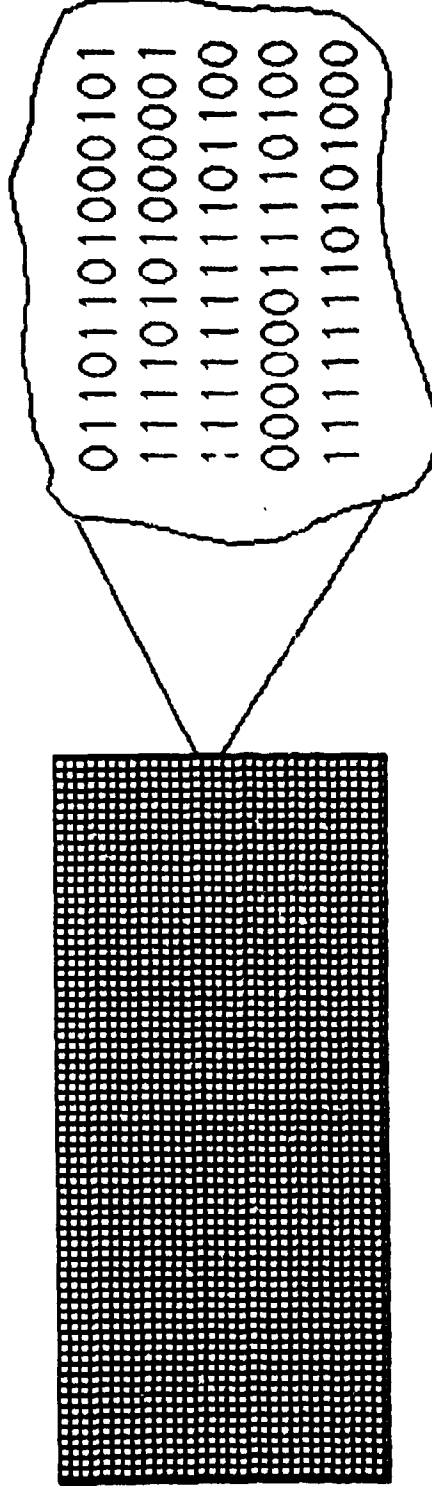
There is a requirement to structure raw materials

- To quantify
- To manage
- To test
- To validate

Methods of structuring vary across disciplines

Some raw materials of software engineering

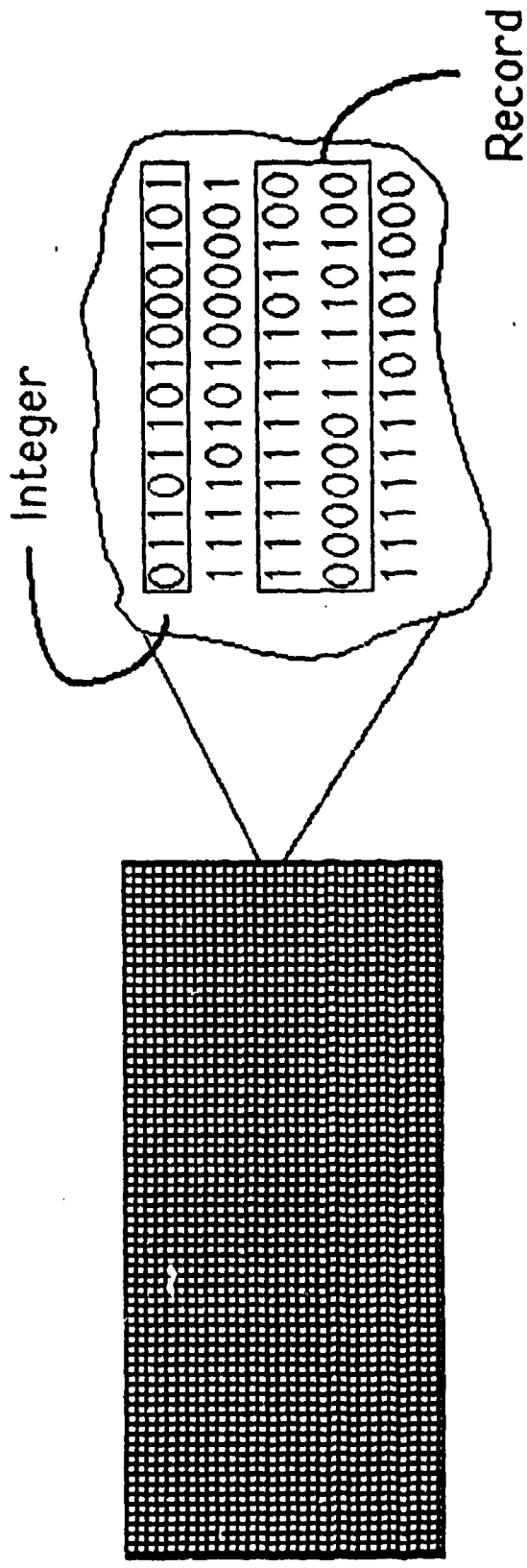
Binary switches
Computer memory locations
Data



Strong typing

Defines structure of data

Enforces structure of data



Strong typing

Enforces abstraction of structure on data

Increases confidence of correctness

Increases reliability and safety

Promotes understandability and maintainability

Major Features Of Ada

Standardization

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Typing Structures

Variety of problems requires a variety of structuring capabilities

Ada provides a rich variety of typing capabilities

Typing structures in Ada

Discrete data

- Enumerated
- Integer

Real data

- Fixed point (absolute error)
- Floating point (relative error)

Composite data

- Arrays (homogeneous)
- Records (heterogeneous)

Dynamic data

- Access types

Major Features Of Ada

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Data Abstraction

Combines primitive raw materials to form higher level structures

Levels of abstraction

Enforces an abstraction on a higher level structure

Prohibits use of implementation details

Promotes understandability

Promotes modifiability

Data abstraction and private types

Private types directly implement data abstraction

Directly implement information hiding

```
package B_R is
```

```
  type NUMBERS is range 0 .. 99;
```

```
  procedure TAKE ( A_NUMBER : out NUMBERS );
```

```
  procedure SERVE ( NUMBER : in NUMBERS );
```

```
  function NOW_SERVING return NUMBERS;
```

```
end B_R;
```

```
with B_R;  
use B_R;  
procedure ICE_CREAM is  
  
    YOUR_NUMBER : NUMBERS;  
  
begin  
  
    TAKE ( YOUR_NUMBER );  
  
    loop  
  
        if NOW_SERVING = YOUR_NUMBER then  
            SERVE ( YOUR_NUMBER );  
            exit;  
        end if;  
  
    end loop;  
  
end ICE_CREAM;
```

```
with B_R;  
use B_R;  
procedure ICE_CREAM is  
  
    YOUR_NUMBER : NUMBERS;  
  
begin  
  
    TAKE ( YOUR_NUMBER );  
  
    loop  
        if NOW_SERVING = YOUR_NUMBER then  
            SERVE ( YOUR_NUMBER );  
            exit;  
        else  
            YOUR_NUMBER := YOUR_NUMBER - 1;  
        end if;  
    end loop;  
  
end ICE_CREAM;
```

```
package B_R is  
    type NUMBERS is private;  
    procedure TAKE ( A_NUMBER : out NUMBERS );  
    procedure SERVE ( NUMBER : in NUMBERS );  
    function NOW_SERVING return NUMBERS;  
private  
    type NUMBERS is range 0 ..99;  
end B_R;
```



```
with B_R;  
use B_R;  
procedure ICE_CREAM is  
  
    YOUR_NUMBER : NUMBERS;  
  
begin  
  
    TAKE ( YOUR_NUMBER );  
  
    loop  
        if NOW_SERVING = YOUR_NUMBER then  
            SERVE ( YOUR_NUMBER );  
            exit;  
        else  
            YOUR_NUMBER := NOW_SERVING;  
        end if;  
    end loop;  
  
end ICE_CREAM;
```

```
package B_R is

  type NUMBERS is limited private;

  procedure TAKE ( A_NUMBER : out NUMBERS );

  procedure SERVE ( NUMBER : in NUMBERS );

  function NOW_SERVING return NUMBERS;

  function "=" ( LEFT, RIGHT : in NUMBERS ) return BOOLEAN;

private

  type NUMBERS is range 0 ..99;

end B_R;
```

```
with B_R;  
use B_R;  
procedure ICE_CREAM is  
  
  YOUR_NUMBER : NUMBERS;  
  procedure GO_TO_DQ is separate;  
  
begin  
  
  TAKE ( YOUR_NUMBER );  
  
  loop  
    if NOW_SERVING = YOUR_NUMBER then  
      SERVE ( YOUR_NUMBER );  
      exit;  
    else  
      GO_TO_DQ;  
    end if;  
  end loop;  
  
end ICE_CREAM;
```

Major Features Of Ada

Standardization

Strong Typing

Readability

Typing Structures

Program Units

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Tasks

Program unit that acts in parallel with other entities

Directly implements those parts of embedded systems which act in parallel

Takes advantage of move toward parallel hardware architectures

- Fault tolerance
- Distributed systems

Eliminates need to introduce additional complexity into a system

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Software reliability and safety

Errors will occur

- Hardware
- Software

Real time systems must be able to operate in a degraded mode

Reliability and safety must be engineered into a system

Traditional languages lack features for dealing with errors and exceptional situations

Exceptions

Deal specifically with errors and exceptional situations

When an exception is raised processing is suspended and control is passed to an appropriate exceptional handler

- Try again
- Fix error
- Propagate exception

Increases reliability

Reduces complexity

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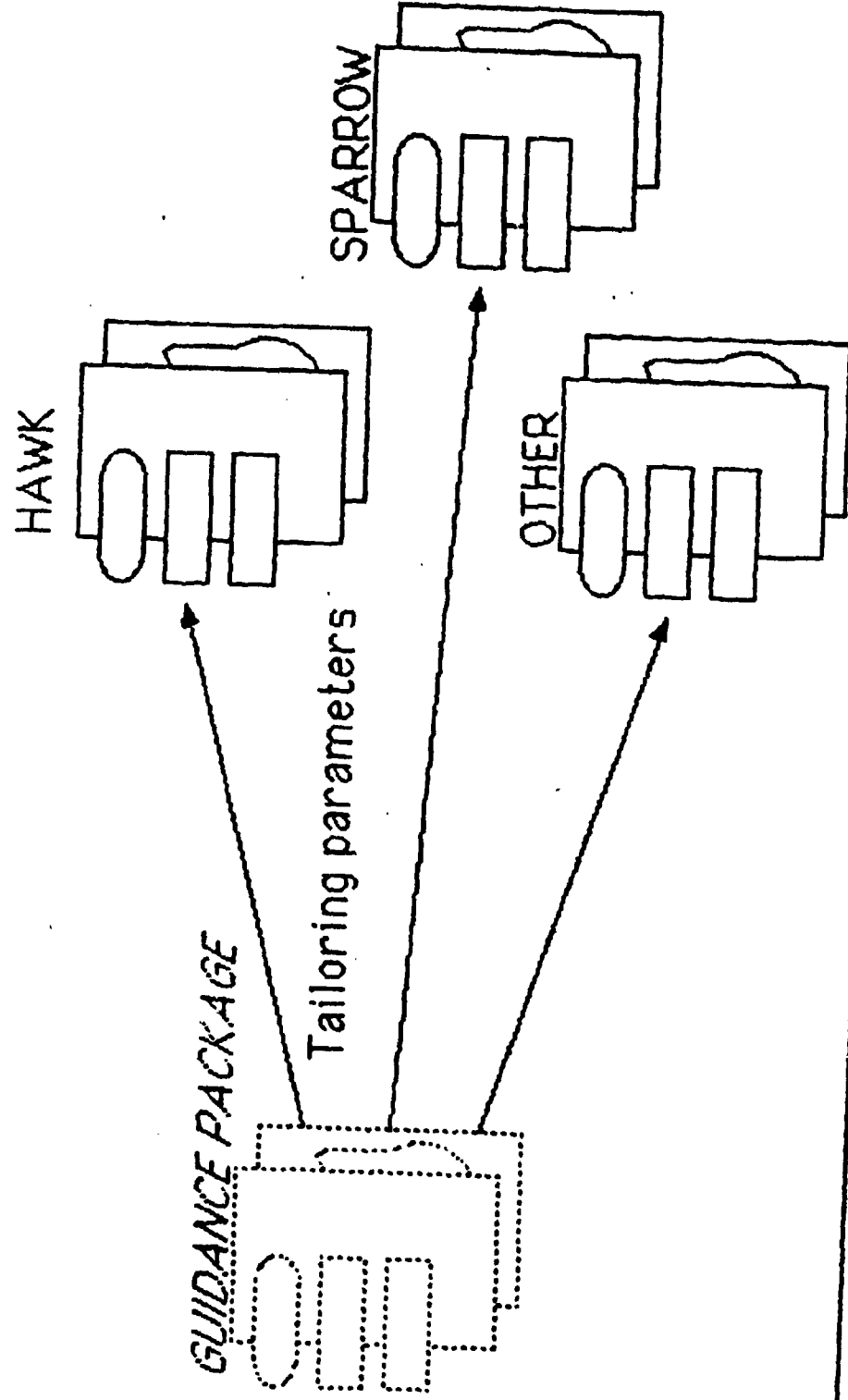
Exceptions

Packages

Generics

Generics

A generic is a tailorable template for a program unit
Increases ability to define reusable software components



Generics

Reduce size of program text

Reduce need to reinvent the wheel

Increase reliability by allowing reuse of known components

Overview

Rationale for development

Capabilities and advantages

Life Cycle application

Software Life Cycle

Requirements analysis

Preliminary design

Detailed design

Coding and unit testing

CSC integration and testing

CSCI testing

Maintenance

Requirements analysis

Standardization brings a much higher level of predictability

- Ada language itself
- Existing Ada software components

Ada supports rapid prototyping very well

Design

Ada features support architectural design

Can actually express design in terms of PDL

- Compileable
- Allows other automated tool support

Can enforce design through compileable PDL

Ada supports varied methodologies

Ada features reduce need to squeeze design into a programming language

Coding

Ada features ensure original design is not violated

Using PDL reduces amount of coding activity

Readability of Ada code promotes productivity

Testing

The ability of Ada to support independent components allows more effective testing

Exceptions allow "built-in" testing facilities

Integration and testing

Ada PDL ensures interfaces are correct

More effective time can be spent testing the system rather than fixing integration errors

Maintenance

Readability makes maintenance much easier

Proper software engineering using Ada will reduce maintenance costs