INTERNATIONAL STANDARD

ISO/IEC 8652

Fourth edition
2023-05

Information technology — Programming languages — Ada

Technologies de l'information — Langages de programmation — Ada

Reference number
ISO/IEC 8652:2023(E)

Contents

Foreword

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html. In the IEC, see www.iec.ch/understanding-standards.

This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 22, *Programming languages, their environments and system software interfaces*.

This fourth edition cancels and replaces the third edition (ISO/IEC 8652:2012), which has been technically revised. It also incorporates the Technical Corrigendum ISO/IEC 8652:2012/Cor.1:2016.

The main changes are as follows:

— improved support for parallel execution is provided via the introduction of parallel loops, parallel blocks, parallel container iteration, and parallel reduction;

— more precise specification of subprogram interfaces is supported via the new aspects Global, Global'Class, and Nonblocking. The Global aspects, in particular, help to determine whether two constructs can safely execute in parallel;

— Pre and Post aspects can now be specified for access-to-subprogram types and for generic formal subprograms; a postcondition for the default initialization of a type can be specified using the new Default_Initial_Condition aspect;

— the behavior of many predefined container operations is now more precisely specified by using pre- and postcondition specifications instead of English descriptions; a restricted (“stable”) view for most containers is introduced to support more efficient iteration;

— more flexible uses of static expressions are supported via the introduction of static expression functions along with fewer restrictions on static strings;

— the Image attribute is supported for nonscalar types, and a user-specifiable attribute Put_Image is provided, which determines the value of the Image attribute for a user-defined type;

— the use of numeric and string literals is generalized to allow their use with other categories of types, via the new aspects Integer_Literal, Real_Literal, and String_Literal;

— array and record aggregates are made more flexible: index parameters are allowed in an array aggregate to define the components as a function of their array index; discriminants can be defined more flexibly within an aggregate for a variant record type;

— new types of aggregates are provided: delta aggregates to allow the construction of a new object by incremental updates to an existing object; container aggregates to allow construction of an object of a container type by directly specifying its elements;

— a shorthand is provided, using the token '@', to refer to the target of an assignment statement in the expression defining its new value;

— declare expressions are provided that permit the definition and use of local constants or renamings, to allow a large expression to be simplified by defining common parts as named entities;

— support for lightweight iteration is added via the introduction of procedural iterators;

— support for the map-reduce programming strategy is added via the introduction of reduction expressions;

— for constructs that use iterators of any sort, a filter can be specified that restricts the elements produced by the iteration to those that satisfy the condition of the filter;

— predefined packages supporting arbitrary-precision integer and real arithmetic are provided;

— the Jorvik profile is introduced to support hard real-time applications that want to go beyond the restrictions of the Ravenscar profile.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

Introduction

Design Goals

Ada was originally designed with three overriding concerns: program reliability and maintenance, programming as a human activity, and efficiency. The 1995 revision to the language was designed to provide greater flexibility and extensibility, additional control over storage management and synchronization, and standardized packages oriented toward supporting important application areas, while at the same time retaining the original emphasis on reliability, maintainability, and efficiency. Subsequent editions, including this fourth edition, have provided further flexibility and added more standardized packages within the framework provided by the 1995 revision.

The need for languages that promote reliability and simplify maintenance is well established. Hence emphasis was placed on program readability over ease of writing. For example, the rules of the language require that program variables be explicitly declared and that their type be specified. Since the type of a variable is invariant, compilers can ensure that operations on variables are compatible with the properties intended for objects of the type. Furthermore, error-prone notations have been avoided, and the syntax of the language avoids the use of encoded forms in favor of more English-like constructs. Finally, the language offers support for separate compilation of program units in a way that facilitates program development and maintenance, and which provides the same degree of checking between units as within a unit.

Concern for the human programmer was also stressed during the design. Above all, an attempt was made to keep to a relatively small number of underlying concepts integrated in a consistent and systematic way while continuing to avoid the pitfalls of excessive involution. The design especially aims to provide language constructs that correspond intuitively to the normal expectations of users.

Like many other human activities, the development of programs is becoming ever more decentralized and distributed. Consequently, the ability to assemble a program from independently produced software components continues to be a central idea in the design. The concepts of packages, of private types, and of generic units are directly related to this idea, which has ramifications in many other aspects of the language. An allied concern is the maintenance of programs to match changing requirements; type extension and the hierarchical library enable a program to be modified while minimizing disturbance to existing tested and trusted components.

No language can avoid the problem of efficiency. Languages that require over-elaborate compilers, or that lead to the inefficient use of storage or execution time, force these inefficiencies on all machines and on all programs. Every construct of the language was examined in the light of present implementation techniques. Any proposed construct whose implementation was unclear or that required excessive machine resources was rejected. Parallel constructs were introduced to simplify making safe and efficient use of modern multicore architectures.

Language Summary

An Ada program is composed of one or more program units. Program units can be subprograms (which define executable algorithms), packages (which define collections of entities), task units (which define concurrent computations), protected units (which define operations for the coordinated sharing of data between tasks), or generic units (which define parameterized forms of packages and subprograms). Each program unit normally consists of two parts: a specification, containing the information that is visible to other units, and a body, containing the implementation details, which are not visible to other units. Most program units can be compiled separately.

This distinction of the specification and body, and the ability to compile units separately, allows a program to be designed, written, and tested as a set of largely independent software components.

An Ada program will normally make use of a library of program units of general utility. The language provides means whereby individual organizations can construct their own libraries. All libraries are structured in a hierarchical manner; this enables the logical decomposition of a subsystem into