Reusable Executives for Hard Real-Time Systems in Ada *

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1 Introduction

At the end of 1989 the Subdirección General de Tecnología e Investigación provided funds for an eighteen month research project to investigate the viability of Ada in the development of reusable software components for their use in future projects by the Spanish aerospace industry. A description of the overall project can be found in [6].

The project participants were ISDEFE as the prime contractor, CASA and the Universidad Politécnica of Madrid (UPM) as subcontractors.

The first task of the project was a domain analysis to identify those reusable components that could be used for the development of real-time systems, emphasizing those applied to avionic systems. A main group of the selected components were those related to reusable avionics executive software [4]. This concept can be adapted to the conditions imposed by the Ada programming language and it can be applied to other hard real-time systems. The domain analysis identifies two kinds of executives of interest, that are complementary, in the sense that the special advantages of one of them are the disadvantages of the other one, and vice versa:

- In most avionic applications, the embedded hard real-time software is developed following a cyclic execution model. The advantages of this approach are its deterministic execution scheme, a simple structure, low system overloading and the large experience available. The cyclic executive has been developed following this approach.

- A new approach to avionics software development [11] is based on the rate monotonic scheduling method. Its specific advantages are a higher abstraction level, flexibility and an easier maintenance. The tasking executive is based on this scheduling method.

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Those executives are reusable subsystems that allow users to develop hard real-time systems in Ada. A subsystem, in reusable terminology, is a reusable software component, composed of a set of cooperative (sub)components [3]. Subsystems are needed when the abstraction to be modelized is too complex to be designed with only one component.

It is important to note that these executives are not complete systems on their own, but rather consist of a set of building blocks that allow users to develop hard real-time systems. They rely on Ada features and run-time system. Both executive subsystems are designed in such a way that hard real-time deadlines can be guaranteed for real-time processes. The executives also support aperiodic tasks, mode changes and failure recovery.

2 Cyclic Executive

This executive is intended to be used in safety-critical applications. Since compliance with safe Ada [7] was required, tasks and some other Ada features could not be used.

The executive design is based on the cyclic executive model [2].

It is an iterative procedure which activates, in a sequential way, the application processes in turn. So process execution is fully deterministic and real-time restrictions can be met.

With the cyclic executive approach, all the application processes are periodic. Sporadic processes are implemented by polling servers. Each process’s deadline is at the end of its period. Furthermore, process periods are usually adjusted so that they are harmonic, in order to simplify scheduling.

An application process is defined by:

- The parameterless procedure which is the code it executes.
- Its maximum computation time.
- Its maximum dynamic data space size.

An application execution mode corresponds to an operation mode in the controlled real-time system. Every application execution mode is defined by a subset of processes together with execution profiles for each of them. The execution profile of a process is mode dependent and includes:

- The activation period.
- The phase, i.e. the delay for the first execution.
- The priority, which indicates the relative execution order.

The scheduler is based on the above parameters and is organized in the following way:

- The major cycle is the execution scheme for an application execution mode and it is periodically repeated. Its length is equal to the lowest common multiple of the periods - for this mode - of the processes present in it. This major cycle is divided into one or more minor cycles.