

The Birds Project

The libBirds Library, Software Design Description

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1. Purpose of the SDD Document

This is a standard "Software Design Description" document, corresponding to the guidelines in RTCA DO-178B. In the words of DO-178B, it "is a definition of the software architecture and the low-level requirements that will satisfy the high-level requirements."

This document has been formatted in an attempt to make certification via DO-178B more efficient, essentially by providing a separate document section for each lettered item (a-l) found in DO-178B section 11.10. However, it should be noted that the ordering of the sections is not quite the same.

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2. Fixed-Size Datatypes for External Operations

Traceability: SRD section 2.1 → SDD section 2.

2.1. Description

The library shall provide a set of fixed-size integer datatypes (i.e., in which the datatypes consist of known numbers of bits), so that external interfaces and the internal characteristics of the file-system can be dealt with on a consistent basis. Application software is free in most instances to use the normal C/C++ integer datatypes such as `int`, `long int`, `unsigned int`, and so on, but should use the fixed-size datatypes when accessing files or hardware interfaces, to insure maximum portability.

Fixed-size datatypes supported shall include 8-bit signed and unsigned integers, 16-bit signed and unsigned integers, 32-bit signed and unsigned integers, and 64-bit signed and unsigned integers.

2.2. Hardware-Software Allocation

This functionality is implemented in software.

2.3. Design Data

2.3.1. TBD name of a design-breakdown item

Traceability: SDD section 2.3.1 → SVCP section 2.1.

2.3.1.1. Detailed Description

TBD

3. Endian Conversions

Traceability: SRD section 2.2 → SDD section 3.

3.1. Description

Because the aim of the libBirds library is to provide maximal portability, and yet byte-ordering within multi-byte datatypes differs from CPU type to CPU type, byte-ordering conversion functions are provided. For most coding purposes, byte-ordering preferences of the CPU are unknown and irrelevant, but they become relevant in file operations and when accessing multi-byte hardware interfaces. Therefore, application software should employ the appropriate byte-ordering conversion functions in these circumstances.

The libBirds library shall provide the following functionality: conversion (in either direction) between the CPU's native 16-bit or 32-bit integer datatypes, and 16-bit or 32-bit big-endian integer datatypes. Also, between the CPU's native 16-bit or 32-bit integer datatypes and 16-bit or 32-bit little-endian integer datatypes.

3.2. Hardware-Software Allocation

This functionality is implemented entirely in software.

3.3. Design Data

3.3.1. TBD name of a design-breakdown item

Traceability: SDD section 3.3.1 → SVCP section 2.2.

3.3.1.1. Detailed Description

TBD

4. Timekeeping Functions

Traceability: SRD section 2.3 → SDD section 4.

4.1. Description

The libBirds library shall provide, at a minimum, the ability to determine the amount of time which has passed since system power-up. The granularity of the time measurement is not significant in libBirds, but for design purposes can be regarded as being of the order of magnitude of 10 ms. or smaller.

4.2. Hardware-Software Allocation

This shall be implemented by means of an interrupt service routine based on a hardware timer, such as an integrated CPU timer.

However, only the interrupt-service routine itself shall be provided by libBirds. The low-level details of setting up the interrupt and vectoring to the ISR are handled by a board-support package (not a part of libBirds), and hence this hardware dependence is transparent to libBirds.

4.3. Design Data

4.3.1. TBD name of a design-breakdown item

Traceability: SDD section 4.3.1 → SVCP section 2.3.

4.3.1.1. Detailed Description

TBD

5. String and Memory Manipulations

Traceability: SRD section 2.4 → SDD section 5.

5.1. Description

Operations shall be provided such as comparing or copying strings or memory, case conversions, and so on. The extent of this functionality is not specified in the Requirements Process.

5.2. Hardware-Software Allocation

This functionality shall be implemented entirely in software.

5.3. Design Data

5.3.1. TBD name of a design-breakdown item

Traceability: SDD section 5.3.1 → SVCP section 2.4.

5.3.1.1. Detailed Description

TBD

6. Text-Display Functions

Traceability: SRD section 2.5 → SDD section 6.

6.1. Description

A set of functions shall be provided appropriate for outputting data to a text-oriented display. By a "text-oriented" display is meant a display screen considered as rows and columns of characters, and not accessible other than at integral character cells. This concept is not dependent on the display hardware actually being text-oriented at a hardware level, of course, since a graphical display can also logically be considered as a text-oriented display.

The types of functions provided by libBirds shall include (but not necessarily be limited to) positioning the cursor at arbitrary text cells and displaying a character or string at a given text cell.

Arbitrary 24-bit color mappings shall be provided at the software level, though not necessarily at the hardware level.

6.2. Hardware-Software Allocation

The implementation of this functionality will vary depending on whether the actual display screen is text-oriented or graphically-oriented in hardware. The primary implementation difficulty is the conversion of character data to pixel data.

In the former case, this functionality can be completely provided by a board-support package (separate from libBirds). In the latter case, libBirds must break text operations down into pixel-manipulations, and the board-support package must provide the raw pixel manipulations.

Thus, libBirds is aware of hardware dependence only to the extent of knowing whether the display hardware is text-oriented or pixel-oriented.

6.3. Design Data

6.3.1. TBD name of a design-breakdown item

Traceability: SDD section 6.3.1 → SVCP section 2.5.

6.3.1.1. Detailed Description

TBD

7. Graphical Display-Output Functions

Traceability: SRD section 2.6 → SDD section 7.

7.1. Description

A set of functions shall be provided allowing output to a graphically-oriented display screen.

The functionality provided shall include, but not necessarily be limited to: the ability to output text in various fonts and sizes to arbitrary pixel locations; the ability to draw arbitrary lines or filled areas; the ability to display arbitrary graphics files in BMP format. Both aliased and non-aliased fonts shall be provided.

At a software level, 24-bit colors shall be provided, whatever the actual capabilities of the hardware display.

7.2. Hardware-Software Allocation

This functionality is provided entirely in software, except that the hardware display must have the capability of manipulating arbitrary pixels. The raw-pixel manipulations are provided by a board-support package (separate from libBirds).

7.3. Design Data

7.3.1. TBD name of a design-breakdown item

Traceability: SDD section 7.3.1 → SVCP section 2.6.

7.3.1.1. Detailed Description

TBD

8. Keyboard-Input Functions

Traceability: SRD section 2.7 → SDD section 8.

8.1. Description

Keyboard data is provided to the application software by means of a FIFO buffer and associated functions for adding/removing data to/from the buffer. Separate buffer events shall be generated for key-depression and for key-release.

Keystrokes shall be debounced prior to their press/release events being added to the keyboard FIFO.

8.2. Hardware-Software Allocation

An interrupt-service routine shall scan the keyboard with some (unspecified) degree of regularity, debounce the keystrokes, and insert key-pressed and key-released events into the keyboard buffer.

The physical keyboard, of course, shall be in hardware.

Low-level details of setting up the interrupts, vectoring to the ISR, and fetching raw data from the physical keyboard are handled not by libBirds, but by a board-support package (separate from libBirds).

8.3. Design Data

8.3.1. TBD name of a design-breakdown item

Traceability: SDD section 8.3.1 → SVCP section 2.7.

8.3.1.1. Detailed Description

TBD

9. Filesystem Manipulations

Traceability: SRD section 2.8 → SDD section 9.

9.1. Description

The ability to create or read "files" shall be present. The file-system is intended to be general-purpose, but limited in ways appropriate to embedded systems and to the use of flash-memory as a storage medium.

In particular, the following characteristics of familiar filesystems in Microsoft Windows or UNIX shall be provided: sub-directory structures; long filenames; files up to 2 Gbytes in size; reading and writing files sequentially; reading files randomly.

The following familiar filesystem characteristics shall not be supported: random writing; timestamps; ownership; permissions; sharing.

The filesystem software shall not be reentrant.

Files may be deleted, but their allocated space is not necessarily immediately reclaimed. The reclamation may require "garbage collection", as described in the next section.

9.2. Hardware-Software Allocation

The design criteria assume the use of flash-memory as a storage medium. In other words, the hardware medium must have the following properties: It may be erased in relatively large "erasable blocks", and erasure consists of setting the block to bits that are all 1; any bit which is 1 may be changed at will to 0, but not necessarily vice-versa. Of course, a file-system based on these limitations may also be implemented in other media (EEPROM, RAM, or magnetic disk), as well as flash-memory, though not with maximum efficiency.

All other capabilities are implemented in software.

In accordance with common practice, erasable blocks are sub-divided into smaller blocks ("sectors").

The following low-level functions are to be provided by a board-support package (separate from libBirds): mapping of the erasable blocks by address and size; erasure of blocks; reading sectors; writing sectors.

9.3. Design Data

9.3.1. TBD name of a design-breakdown item

Traceability: SDD section 9.3.1 → SVCP section 2.8.

9.3.1.1. Detailed Description

TBD

10. Filesystem Garbage Collection

Traceability: SRD section 2.9 → SDD section 10.

10.1. Description

Because the file-system is conceptually based on flash-memory as a storage medium, as described above, space which has been used but subsequently deallocated cannot be immediately reclaimed. This is because bits which have been changed from 1 to 0 cannot be returned to 1 unless the entire block containing them is erased.

The libBirds library shall provide a garbage collection facility capable of reclaiming used file-system space by temporarily buffering a block of data within RAM while the associated flash-memory be being erased, and then writing the buffered data back to flash-memory afterward with reclaimed 0-bits changed to 1-bits as appropriate.

10.2. Hardware-Software Allocation

The hardware-software allocation for this functionality is the same as described above under "Filesystem Manipulations".

10.3. Design Data

10.3.1. TBD name of a design-breakdown item

Traceability: SDD section 10.3.1 → SVCP section 2.9.

10.3.1.1. Detailed Description

TBD

11. Audio Playback

Traceability: SRD section 2.10 → SDD section 11.

11.1. Description

Audio clips stored within the file-system as files in the WAV format may be played back through an audio codec, if one exists.

11.2. Hardware-Software Allocation

A compatible audio codec must exist within hardware to use this feature. An interrupt-service routine is used to transfer audio data from the file-system to the audio codec.

The low-level details of setting up the interrupts, vectoring to the ISR, setting up the codec, and outputting data to the codec are handled by a board-support package (separate from libBirds).

11.3. Design Data

11.3.1. TBD name of a design-breakdown item

Traceability: SDD section 11.3.1 → SVCP section 2.10.

11.3.1.1. Detailed Description

TBD

12. Serial I/O

Traceability: SRD section 2.11 → SDD section 12.

12.1. Description

The libBirds library shall provide functions that can be used for simple serial i/o. "Simple" serial i/o is defined as i/o involving only 8-bit data without parity or handshaking, and with loose (or no) timing constraints. This functionality is provided by means of FIFO buffers into which serial data is placed or removed.

This same mechanism shall also be used if ethernet or other network services are provided.

12.2. Hardware-Software Allocation

Providing this functionality is based on the existence of hardware UARTs, and an interrupt-service routine servicing these UARTs. The interrupt-service routine receives data from the UARTs and places the data into a "received data" FIFO from which the application software can remove it. Similarly, the application software can place data

into a "transmitter" FIFO from which the interrupt-service return removes it and gives it to the UARTs.

Low-level details of setting up the interrupts, vectoring to the ISR, and inputting/outputting data from/to the UARTs is handled by a board-support package (separate from libBirds).

12.3. Design Data

12.3.1. TBD name of a design-breakdown item

Traceability: SDD section 12.3.1 → SVCP section 2.11.

12.3.1.1. Detailed Description

TBD

13. Software Architecture

TBD

14. Input/Output Description

TBD

15. Data Flow and Control Flow

TBD

16. Partitioning

TBD

16.1. Means of Preventing Partition Breaches

TBD

17. Description of the Software Components

TBD

18. Design Methods

18.1. Software Data Loading

TBD

18.2. User-Modifiable Software

TBD

18.3. Multiple-Version Dissimilar Software

Not used by libBirds.

18.4. TBD name of other design method

TBD

19. Software Timing and Scheduling Strategies

The libBirds library assumes that libBirds functions and all other code for the system (such as application code) run in a single foreground execution thread. Thus, application code passes control to libBirds functions when it wants to do so, and receives control back when the libBirds function has terminated.

However, libBirds functions can only provide certain functionality by depending on some underlying interrupt-service routines, as follows:

- 1) The libBirds "kernel" ISR executes at regular intervals by means of a CPU timer or other hardware timer. This ISR handles the following tasks: updating the master system clock; scanning/debouncing the keyboard; transferring audio data from the file-system to the audio codec; user-defined operations via a function call reserved for this purpose.
- 2) Interrupt-service routines for each supported UART.

While libBirds provides the ISR, low-level details of setting up the hardware (interrupts, timers, UARTs) and vectoring to the ISR are handled not by libBirds, but by a board-support package (separate from libBirds).

19.1. Scheduling Procedures

TBD

19.2. Inter-Processor/Inter-Task Communications

TBD

20. Derived Requirements

TBD

21. Deactivated Code

TBD

22. Design Decisions Traceable to Safety Requirements

TBD

23. Software Characteristics and Constraints

23.1. Executable Object Code Size

23.1.1. Limitations

TBD

23.1.2. Strategy for Management

TBD

23.1.3. Margins

TBD

23.1.4. Method for Measuring Margins

TBD

23.2. Timing Requirements and Constraints

23.2.1. Limitations

TBD

23.2.2. Strategy for Management

TBD

23.2.3. Margins

TBD

23.2.4. Method for Measuring Margins

TBD

23.3. Memory Size Constraints

23.3.1. Limitations

TBD

23.3.2. Strategy for Management

TBD

23.3.3. Margins

TBD

23.3.4. Method for Measuring Margins

TBD

23.4. TBD Name of additional limited system resource

23.4.1. Limitations

TBD

23.4.2. Strategy for Measurement

TBD

23.4.3. Margins

TBD

23.4.4. Method for Measuring Margins

TBD

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