

# TWL Introduction

2009/07/06

**The content of this document is highly confidential  
and should be handled accordingly.**

**Confidential**

These coded instructions, statements, and computer programs contain proprietary information of Nintendo and/or its licensed developers and are protected by national and international copyright laws. They may not be disclosed to third parties or copied or duplicated in any form, in whole or in part, without the prior written consent of Nintendo.

## Table of Contents

---

1	Introduction .....	6
2	DSi Features .....	7
2.1	New Style of Play Using Two Cameras .....	7
2.2	Improved Processing Capacity for Images and Sound with DSP Implementation .....	7
2.3	Saving Downloaded Software on the DSi .....	7
2.4	Restricting the Launching of Applications .....	7
2.4.1	Region Controls Added .....	7
2.4.2	Parental Controls Added .....	8
2.5	Support for Commercial SD Memory Cards .....	8
3	Hardware Changes .....	9
3.1	CPU .....	9
3.1.1	Improved Operation Speed .....	9
3.2	Memory .....	9
3.2.1	Increased Main Memory Size .....	9
3.2.2	Increased Internal Work RAM Size .....	9
3.3	DMA .....	9
3.3.1	DMA Controller Added .....	9
3.4	Sound and Microphone .....	9
3.4.1	Improved Sound and Microphone Performance .....	9
3.4.2	Auto Sampling Hardware Processing Implemented .....	10
3.5	Wireless Communication .....	11
3.5.1	Wi-Fi Module Specifications Changed .....	11
3.5.2	Prohibition of Wireless Communication Added .....	11
3.5.3	LED Indicating Wireless Communication Status Added .....	11
3.6	Other Changes .....	12
3.6.1	Thinner Profile .....	12
3.6.2	Larger LCD Size .....	12
3.6.3	GBA Slot Removed .....	12
4	Software Changes .....	13
4.1	Types of Software .....	13
4.1.1	Compatible Hardware .....	13
4.1.2	Media Access from Applications .....	14
4.2	Nintendo DS Software .....	14
4.3	Nintendo DSi Enhanced Software .....	14
4.3.1	Nintendo DSi Exclusive Features: Improvements Over the DS/DS Lite .....	15
4.4	Nintendo DSi Exclusive Software .....	16

4.4.1	Features Unique To NAND Applications .....	16
4.4.2	Size of NAND Applications .....	17
5	Development Environment .....	18
5.1	Hardware Configuration.....	18
5.1.1	IS-TWL-DEBUGGER .....	18
5.1.2	IS-TWL-CAPTURE .....	19
5.1.3	TWL Test Unit / TWL Flash Card .....	20
5.1.4	Flash Writer.....	20
5.2	Software Configuration .....	21
5.2.1	Compiler.....	21
5.2.2	TWL-SDK.....	21
5.2.3	TWL-System .....	21
5.2.4	Middleware for TWL.....	22
6	Additional Documents to Read .....	23

## Tables

Table 2-1	Configurable Languages for Each Market Region .....	8
Table 2-2	Markets and Rating Organizations .....	8
Table 3-1	DS/DS Lite Power LED and DSi Wireless LED Blinking Specifications .....	11
Table 4-1	List of Supported Software Types.....	13
Table 4-2	Media Access According to Application Type .....	14

## Figures

Figure 3-1	CODEC and Peripheral Module Block Diagrams .....	10
Figure 3-2	Nintendo DSi Microphone Position .....	10
Figure 5-1	Development Tools Connection Diagram .....	18
Figure 5-2	IS-TWL-DEBUGGER .....	19
Figure 5-3	IS-TWL-CAPTURE .....	20
Figure 5-4	TWL Test Unit / TWL Flash Card.....	20
Figure 5-5	Hierarchical Structure of Libraries and Middleware .....	21

## Revision History

Revision Date	Description
2009/07/06	Revised notations, text, graphics, and tables overall to make them easier to understand.
2009/06/09	Initial version.

# 1 Introduction

This document is intended for experienced Nintendo DS/DS Lite software planners and developers. It provides information about Nintendo DSi (named *TWL* during development) features, content additions, and changes from Nintendo DS/DS Lite, and an overview of the development environment.

## 2 DSi Features

The following sections introduce the DSi features.

### 2.1 New Style of Play Using Two Cameras

---

The DSi includes two 640x480 pixel cameras (300,000 pixels maximum). One faces outward and the other inward. The two cannot be used at the same time, but by switching between the two, you can photograph what you see or yourself. The resulting photograph data can be accessed through the TWL-SDK library. The system NAND application's DSi cameras enhance fun by allowing users to distort photographs, change the colors, and add graffiti.

### 2.2 Improved Processing Capacity for Images and Sound with DSP Implementation

---

The DSi uses a digital signal processor (DSP) to process image and sound signals. Image or sound data can be encoded and decoded, sounds can be generated, and the generated sounds can be mixed for output.

Use the DSP via the TWL-SDK libraries. The TWL-SDK also provides components for signal processing and image conversion.

### 2.3 Saving Downloaded Software on the DSi

---

The system NAND memory consists of 256 MB of flash memory. This can store the system menu (DSi Menu), built-in software (system NAND applications), downloaded Nintendo DSiWare, and any associated Save Data.

### 2.4 Restricting the Launching of Applications

#### 2.4.1 Region Controls Added

---

Unlike the DS/DS Lite, the Nintendo DSi has market region settings. There are four market regions—Japan (JP), North America (US), Europe (EU), and Australia (AU). The languages that can be selected differ by market region setting.

**Table 2-1 Configurable Languages for Each Market Region**

Market Region	Configurable Languages
Japan (JP)	Japanese
North America (US)	English, French, Spanish
Europe (EU)	English, French, Spanish, German, Italian
Australia (AU)	English

There are restrictions on software startup when the market region for the DSi differs from that of the software. These restrictions apply to Nintendo DSi enhanced software and Nintendo DSi exclusive software. (With the exception of software made for China, the restriction does not apply to DS software.) To read about these different types of software, see section 4.1 Types of Software.

## 2.4.2 Parental Controls Added

The features of the DSi can be restricted, for example when a guardian does not want a minor to use inappropriate features.

The booting of Nintendo DSi enhanced software and Nintendo DSi exclusive software is restricted based on the Ratings Information set in the software and the way the Parental Controls are set for the DSi. To read about these different types of software, see section 4.1 Types of Software.

The ratings for software are determined by different organizations in the different market regions.

**Table 2-2 Markets and Rating Organizations**

Market	Rating Organization
Japan (JP)	CERO
North America (US)	ESRB
Europe (EU)	USK, PEGI, BBFC (varies by country)
Australia (AU)	AGCB

In addition, the wireless exchange of photo data and user-created content can be restricted when a wireless-communication partner cannot be identified.

## 2.5 Support for Commercial SD Memory Cards

The DSi includes an SD Memory Card slot to support SD/SDHC memory cards. These cards can be used as backup for system NAND memory. In addition, they can be used from applications stored in system NAND memory. However, restrictions for accessing SD memory cards exist. See section 4.1.2 Media Access from Applications for more information.



## 3 Hardware Changes

This section describes the major hardware changes from the DS/DS Lite. For details, including recently fixed hardware bugs, see the “Differences with NITRO” section in the *Nintendo DS/TWL Programming Guidelines*. That document also describes hardware bugs that have been fixed in TWL.

### 3.1 CPU

#### 3.1.1 Improved Operation Speed

---

The clock frequency was doubled to 134 MHz from 67 MHz for the DS/DS Lite.

**Note:** Because the system clock did not change, this does not necessarily convert to twice the operation speed.

### 3.2 Memory

#### 3.2.1 Increased Main Memory Size

---

The main memory's size is 16 MB, which is four times the memory size of 4 MB for DS/DS Lite.

#### 3.2.2 Increased Internal Work RAM Size

---

The DSi includes three new 256KB shared memory (WRAM-A/B/C) modules. These memory modules are shared by all the processors. By switching master processors (accessible processors), data exchange can be performed quickly between processors. However, WRAM-A is dedicated for system use, so the memory cannot be allocated freely by applications.

### 3.3 DMA

#### 3.3.1 DMA Controller Added

---

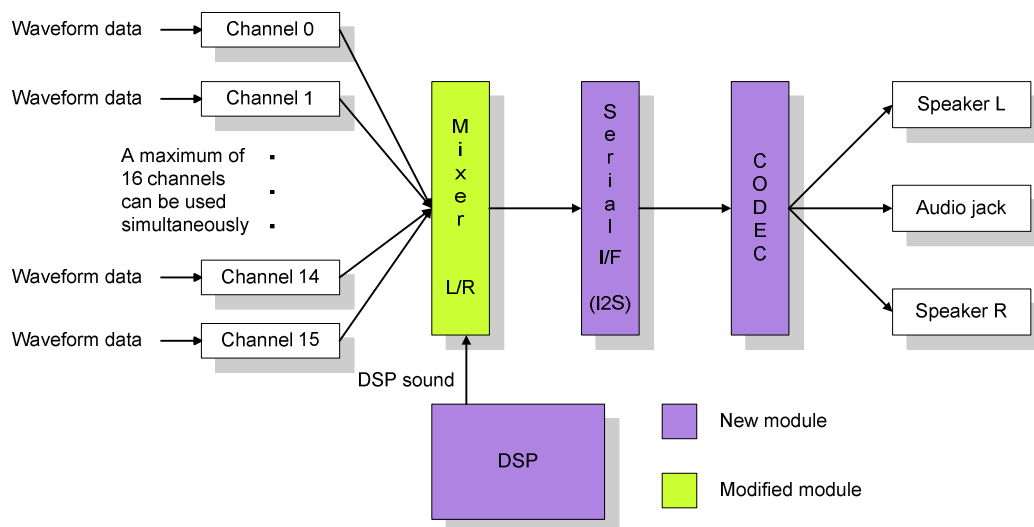
In addition to the DS/DS Lite DMA, the DMA implementation supports block transfer and arbiter type selection. Data transfer without passing through the CPU is performed quickly between memories or devices.

### 3.4 Sound and Microphone

#### 3.4.1 Improved Sound and Microphone Performance

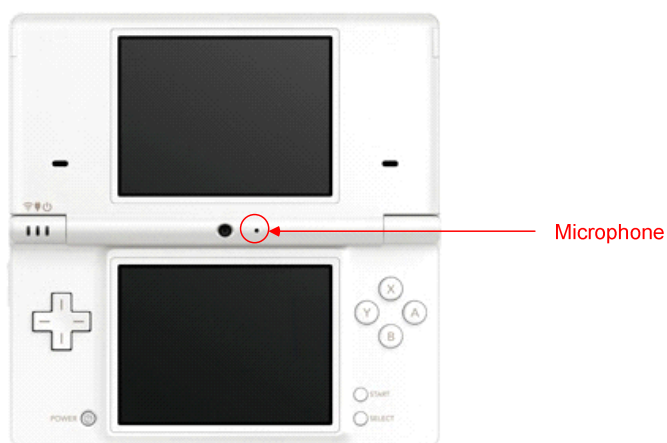
---

Changes were made to the specifications for both the CODEC module that converts analog and digital signals, and for the peripheral modules, resulting in improved sound and microphone performance.

**Figure 3-1 CODEC and Peripheral Module Block Diagrams**

The CODEC has two types of operational modes. The first is a DS/DS Lite compatible mode and the second is the newly added TWL mode. In TWL mode, you can select the microphone input sampling frequency and fine-tune the gain.

The microphone position was changed to a location a little to the right of the center within the hinge (to the right of the inside camera). For applications that use the microphone, therefore, the conditions for speaking into the microphone (line of sight, how the unit is held, and so on) may differ slightly from the DS/DS Lite.

**Figure 3-2 Nintendo DSi Microphone Position**

### 3.4.2 Auto Sampling Hardware Processing Implemented

With the DS/DS Lite, microphone auto-sampling is processed in software by the sub-processor; with the Nintendo DSi, it can be processed in hardware by the CODEC. This processing only occurs during TWL mode. The sub-processor load can be reduced, as can the loss of performance caused by simultaneously using wireless communications and the microphone.

In addition, auto-sampling of the touch panel can also be processed by the hardware. For this reason, even when microphone sampling is performed at the same time as touch panel sampling, the time lag that occurred as a result of software processing is absent and high-quality sound data can be acquired.

## 3.5 Wireless Communication

### 3.5.1 Wi-Fi Module Specifications Changed

---

The Wi-Fi module specifications were changed and augmented.

- IEEE802.11b/g acceleration
- Lower wireless-module power consumption
- Updated for wireless-security protocols WPA/WPA2

Although the DS/DS Lite only supported the WEP protocol, the Nintendo DSi also supports the more secure WPA and WPA2 protocols. The Wi-Fi module is compatible with DS/DS Lite, so wireless communication with DS/DS Lite users can occur without problems.

### 3.5.2 Prohibition of Wireless Communication Added

---

A wireless-off mode (to prohibit wireless communication use) was added to the wireless communication features. When the user sets the wireless-off mode, no wireless communication features, including those in existing DS software, can be used.

### 3.5.3 LED Indicating Wireless Communication Status Added

---

An LED to indicate the wireless communication status was added. With the DS/DS Lite, the Power LED blinks whenever wireless communications occur, regardless of the wireless signal output state. This new LED enables the signal output status to be determined.

**Table 3-1 DS/DS Lite Power LED and DSi Wireless LED Blinking Specifications**

State		Nintendo DSi <sup>1</sup>	DS/DS Lite
		Wireless LED	Power LED
Wireless Mode	Off	Always Off	Always On <sup>1</sup>
	On	Always On	Always On <sup>1</sup>
During Wireless Communication	No signal output	Lit	Varied Blinking
	During signal output	Blinking	Varied Blinking

1. Because the DS/DS Lite does not have a wireless on/off mode, the Power LED is always in the lit state.

## **3.6 Other Changes**

### **3.6.1 Thinner Profile**

---

The Nintendo DSi is thinner than the DS/DS Lite. When the DSi is closed it has a thickness of 18.9 mm, compared to 21.5 mm for the DS Lite.

### **3.6.2 Larger LCD Size**

---

The LCD is larger than that of the DS/DS Lite; the size increased from 3.0 to 3.25 inches. However, there is no change in the number of dots that can be displayed.

### **3.6.3 GBA Slot Removed**

---

The GBA Game Pak slot was removed. When in DS/DS Lite compatible mode (NITRO-compatible mode), a determination that no Game Pak has been inserted is made.

## 4 Software Changes

This section describes the types of software that run on the DSi and the major changes from the DS/DS Lite. For more information, see the *TWL-SDK Application Development Guide*.

### 4.1 Types of Software

---

There are three types of software that can operate on the Nintendo DSi, including existing software that runs on Nintendo DS/DS Lite.

- Nintendo DS Software

This is existing DS/DS Lite software. The DS Game Card is the only format that can be used for these types of applications. This type of software is referred to as *DS software*.

- Nintendo DSi Enhanced Software (TWL Hybrid Software)

This is software that has features for the Nintendo DSi but also is compatible with Nintendo DS/DS Lite. The software operates as if it were Nintendo DS software when running on the Nintendo DS/DS Lite, but makes use of the special features of the Nintendo DSi when running on the Nintendo DSi. Applications can be in the form of both DS Game Cards and NAND applications. However, NAND applications are designed for the purpose of using the clone boot feature of DS Download Play. This type of software is referred to as *Nintendo DSi Enhanced software*.

- Nintendo DSi Exclusive Software (TWL Limited Software)

This is software designed for the Nintendo DSi, and it will only operate on the DSi. Applications can be in the form of both DS Game Cards and NAND applications. This type of software is referred to as *Nintendo DSi Exclusive software*.

#### 4.1.1 Compatible Hardware

---

Hardware compatibility depends on the software type.

**Table 4-1 List of Supported Software Types**

Software Type	DS/DS Lite	DSi
Nintendo DS Software	O	O <sup>1</sup>
Nintendo DSi Enhanced Software (Card and NAND Applications) <sup>2</sup>	O	O
Nintendo DSi Exclusive Software (Card and NAND Applications)	X	O

1. Sections of software applications that use the GBA slot will not operate.

2. NAND applications do not run on DS/DS Lite systems.

### 4.1.2 Media Access from Applications

The media that can be accessed differs according to the application (card or NAND).

**Table 4-2 Media Access According to Application Type**

	Accessing Game Cards	Accessing System NAND Memory	Accessing SD Cards
Card Applications	Possible	Prohibited	Prohibited
NAND Applications	Prohibited in principle	Possible	Prohibited in principle

**Note:** Accessing an SD card from a NAND application is prohibited in principle because of the security risk. However, access for debugging purposes is possible for DEBUG and RELEASE builds. For more information specific to media access, see the *Nintendo DS/TWL Programming Guidelines*.

## 4.2 Nintendo DS Software

This is the traditional DS/DS Lite software type. Although the portions of DS software that use the GBA slot do not run, all other portions operate the same as on a DS/DS Lite. It is also possible to identify whether the hardware is a DS or a DSi system. This is also called NITRO-ROM software.

## 4.3 Nintendo DSi Enhanced Software

This software is compatible with the Nintendo DS/DS Lite but has features for the Nintendo DSi. It operates like Nintendo DS software when running on the Nintendo DS/DS Lite, but uses Nintendo DSi features when running on the Nintendo DSi. Another name for this kind of software is HYBRID ROM.

A number of issues must be taken in consideration when developing Nintendo DSi Enhanced software, since it is a hybrid type of software that supports DS/DS Lite. When planning and developing Nintendo DSi Enhanced software, keep the following points in mind.

- Increased Labor for Testing and Debugging

Verification testing for both DS mode and DSi mode is required. In particular, you need to test and debug applications that support wireless communication for both DS mode and DSi mode. To read about these modes, see the *TWL Programming Manual*.

- Requires More Memory Space than DS Software or DSi Exclusive Software

In addition to the DS/DS Lite library, ROM space for storing the DSi library is required. Furthermore, when running applications, you need RAM space to temporarily store these libraries and binary code.

- Requires Rating Information

Region information and Parental Controls settings have been added to the Nintendo DSi. This protects developers and enables guardians to keep harmful information from underage users. You need to provide rating information for Nintendo DSi Enhanced and Nintendo DSi Exclusive software.

### 4.3.1 Nintendo DSi Exclusive Features: Improvements Over the DS/DS Lite

---

This section describes changes to software specifications and the software development process resulting from hardware changes.

#### 4.3.1.1 Copy Protection

The Nintendo DSi Game Card has a different structure than the DS Game Card and uses stronger copy protection. For these reasons, the DSi region on the DSi Game Card cannot be copied using the DS/DS Lite procedure.

**Note:** Copy protection is only performed for the portion that operates as DSi Exclusive. The portion of the code that runs as DS software is recognized as ordinary DS software on the DS/DS Lite. Illegal devices, such as modchips, recognize DS software in the same way, so there is a risk of that portion being copied as DS software.

#### 4.3.1.2 Cameras

The built-in cameras can be used with the TWL-SDK libraries. You can also use the captured images with the libraries.

The cameras have settings and features for flipping images, setting the white balance, exposure time and image sharpness, and implementing various effects. Applications can distort the captured images and make composites of captured images.

#### 4.3.1.3 DSP

The built-in DSP can be used with the TWL-SDK libraries. The device has a variety of components, including components for signal processing and image conversion. Sounds and sound effects can be played from the DSP library.

#### 4.3.1.4 Memory

The main memory's size is 16 MB, which is four times the memory size of 4 MB in the DS/DS Lite. The expanded region can be used for purposes such as the following.

- As a file cache to reduce the number of accesses to the Game Card and accelerate loading
- To permanently store more voice data in memory than for DS software for purposes such as improving sound quality or adding shouting during combat
- To secure more work memory to make smarter artificial intelligence routines
- To increase the number of images used in the VRAM main memory display
- To change 3D model animation patterns to higher precision coordinates

#### 4.3.1.5 DMA

As with the existing DMA, the DMA added with the TWL is also used via the TWL-SDK library. From the DMA library, fast data transfer between memories can be performed without going through the CPU.

**Note:** Due to the priority issues with the existing DMA, we suspect that resource management could become complicated and that the behavior and the timing on the Nintendo DS would be different. Use caution with Nintendo DSi Enhanced software. See the TWL Programming Manual for more information.

#### 4.3.1.6 Sound and Microphone

Microphone auto-sampling can now be processed by the hardware. It will be easier to implement features such as voice chat during Wi-Fi communication, because the combined processing load is less than before.

#### 4.3.1.7 Graphics

By making the VRAM bus width 32 bits, a slight increase in speed can be expected. Also, enabling the writing of 1-byte units makes it easier to write to VRAM.

#### 4.3.1.8 Wireless Communication

The DSi wireless module accelerates communication speed, decreases power consumption, and supports the more secure WPA and WPA2 wireless protocols. Because WPA/WPA2 is supported, we recommend using Nintendo DSi Enhanced software if using Wi-Fi.

Since specialized libraries support most of the processes related to wireless communications, you do not need to prepare a special program in your application for Nintendo DSi Wi-Fi usage.

Wi-Fi supported titles can operate as before on Nintendo DS/DS Lite and use the newly added wireless features on Nintendo DSi systems. See section 3.5 Wireless Communication for more information.

### 4.4 Nintendo DSi Exclusive Software

---

This is software that uses the Nintendo DSi features and will only run on the Nintendo DSi. It is also called LIMITED ROM.

The main changes from the Nintendo DS/DS Lite are the same as those mentioned for Nintendo DS Enhanced software. For details, see section 4.3.1 Nintendo DSi Exclusive Features: Improvements Over the DS/DS Lite

**Note:** Contact Nintendo if you want to sell Nintendo DSi Exclusive software packaged as a card application.

#### 4.4.1 Features Unique To NAND Applications

---

Because NAND applications can be saved to the DSi system NAND memory, they have several unique features not available for card applications.



- There is a sub-banner feature that can be used to alter banner icons from the application.
- The DSi system's built-in fonts can be used as fonts in applications.
- If two NAND applications have the same company code, they can read and write Save Data to and from each other.
- There is a picture database feature that can be used to share JPEG images by NAND applications.

#### **4.4.2 Size of NAND Applications**

---

The size of NAND applications is limited to a maximum of 16 MB, including the Save Data region and manuals. Furthermore, there is no support for the distribution of add-on data. The only feature of Nintendo Wi-Fi Connection that can be used is the download feature (TWL-DWC-DL). Contact Nintendo for more information about the business conditions and size restrictions when planning and developing Nintendo DSiWare.

## 5 Development Environment

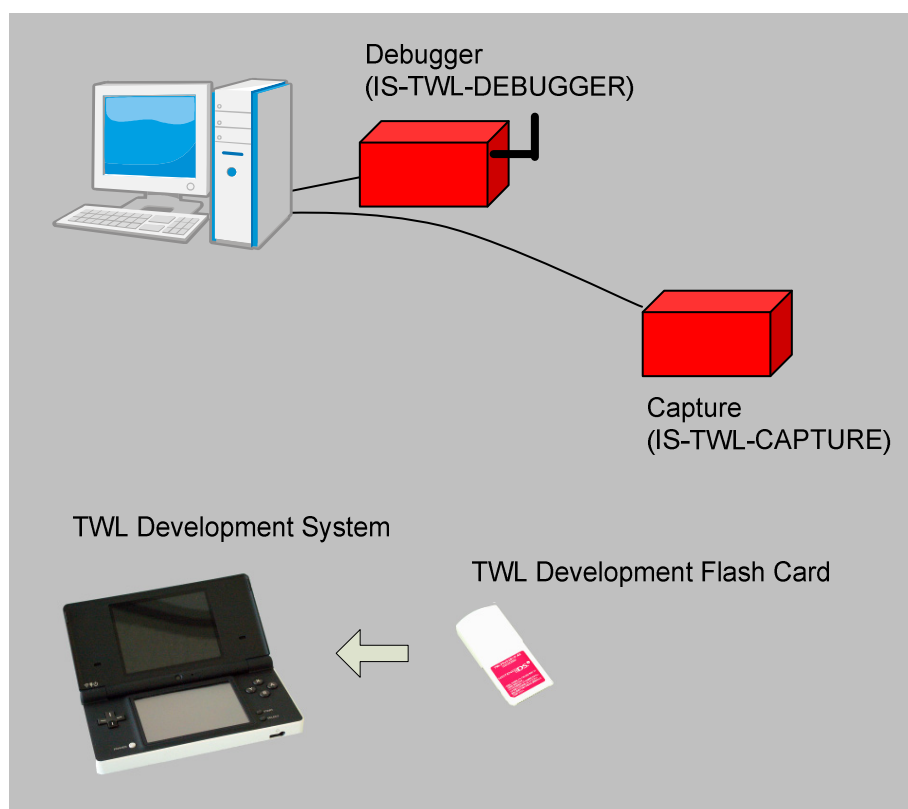
This section describes the Nintendo DSi development environment.

**Note:** The DSi development environment is compatible with DS/DS Lite, and you can make use of the environment that was constructed for the development of DS/DS Lite software. To learn about migrating to this environment in more detail, see the *TWL-SDK Migration Guide*.

### 5.1 Hardware Configuration

This section presents the hardware configuration connection diagrams for the development tools.

**Figure 5-1 Development Tools Connection Diagram**

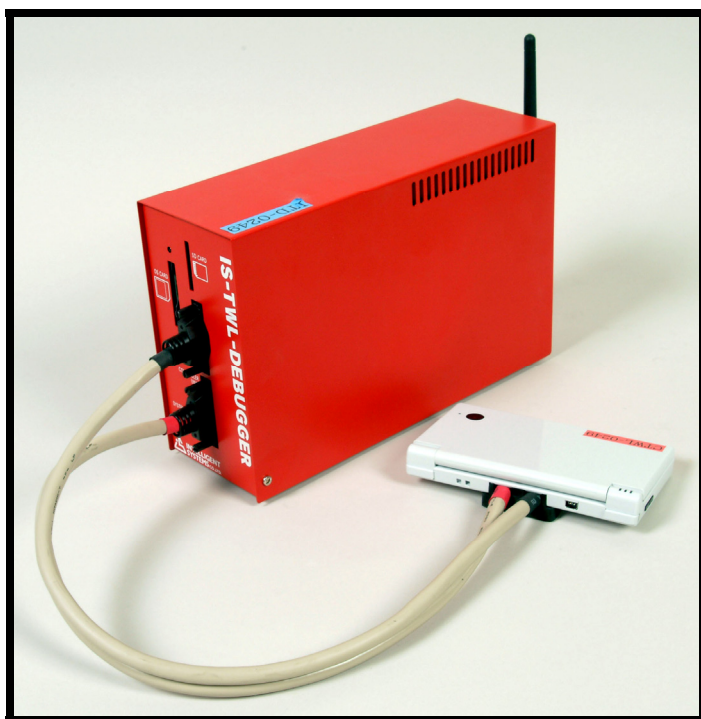


#### 5.1.1 IS-TWL-DEBUGGER

This is the hardware and debugger software for TWL program development. Because this is for the Nintendo DSi, the hardware has no GBA slot. (DS software that does not use the GBA slot can also be developed.)

The development hardware is similar to the IS-NITRO-EMULATOR for the DS/DS Lite, but the wireless communication feature is standard. A wired communication option is available separately.

**Figure 5-2 IS-TWL-DEBUGGER**



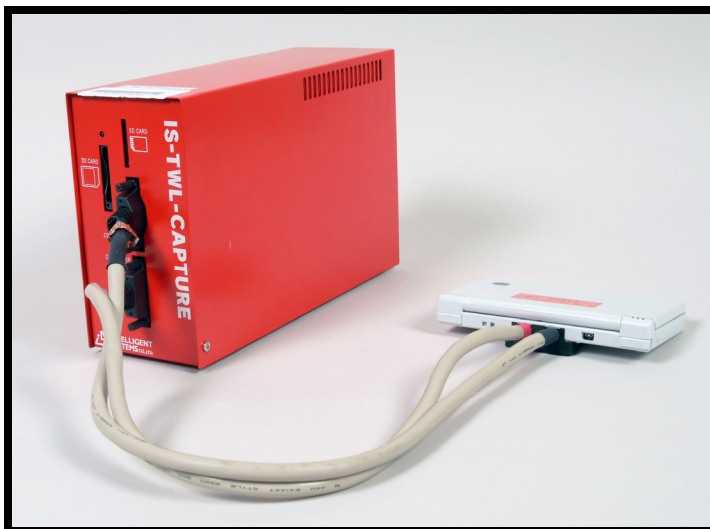
---

### 5.1.2 IS-TWL-CAPTURE

This is the hardware and capture software to output the DSi screen to a PC or TV. There are two types: An IS-TWL-CAPTURE development version (for development cards) and an IS-TWL-CAPTURE commercial-device version that can use commercial game cards.

The development hardware is the same as IS-NITRO-CAPTURE for the DS/DS Lite, but the wireless communication feature is standard.

Figure 5-3 IS-TWL-CAPTURE



### 5.1.3 TWL Test Unit / TWL Flash Card

This is a commercial device and flash card for Nintendo DSi development. Because the flash card used for Nintendo DSi and DS development does not operate on a commercial Nintendo DSi, a TWL Test Unit is required.

**Note:** Non-standard ROMs using illegal devices such as the various “homebrew devices” do not operate on Nintendo DSi retail units, excluding existing DS/DS Lite software that operates in NITRO compatible mode. Also, commercial Nintendo DSi software does not operate on a TWL Test Unit.

Figure 5-4 TWL Test Unit / TWL Flash Card



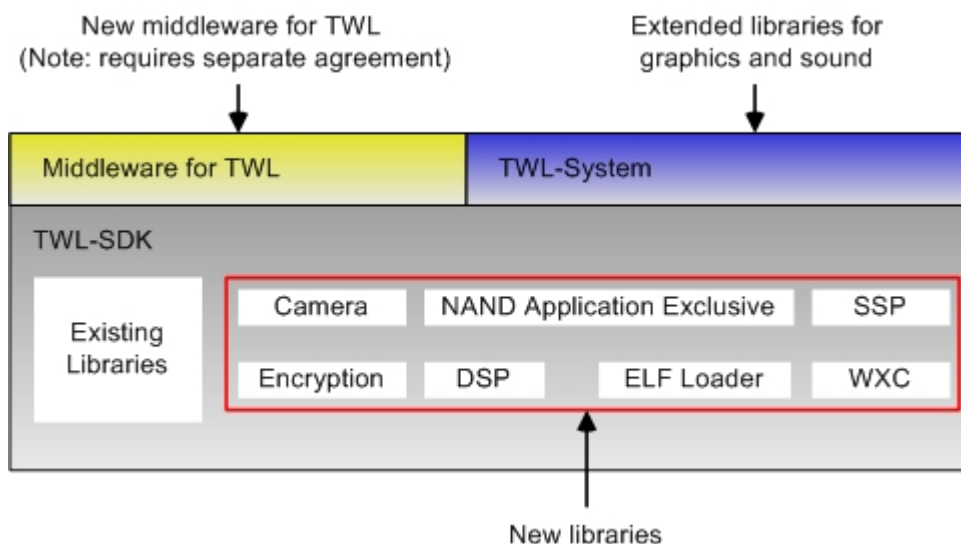
### 5.1.4 Flash Writer

The DS/DS Lite writer (IS-NITRO-WRITER) can be converted, for a fee, to write to TWL flash cards.

## 5.2 Software Configuration

This section presents the hierarchical structure of the libraries and middleware as configured by the software.

**Figure 5-5 Hierarchical Structure of Libraries and Middleware**



### 5.2.1 Compiler

The newly available CodeWarrior for Nintendo DSi integrates support for TWL-SDK features. You can also develop DS/DS Lite software.

### 5.2.2 TWL-SDK

TWL-SDK is an upgrade from the NITRO-SDK. TWL-SDK can also be used to develop DS/DS Lite software because it includes all of the NITRO-SDK libraries.

**Note:** In the future, the NITRO-SDK will no longer be available and support for it will end. All features will be integrated into the TWL-SDK.

### 5.2.3 TWL-System

This is the extended library for graphics and sound that is located on top of the TWL-SDK. NITRO-System has been renamed to TWL-System, but the two basically have the same content. It has also been updated for the TWL-SDK.

### 5.2.4 Middleware for TWL

---

This is new middleware for TWL that is located on top of the TWL-SDK. Separate agreements are required.

- Face Recognition
- Speech Converter (changes sound playback speed and pitch)

**Note:** Contact Nintendo if you would like to enter into an agreement.

## 6 Additional Documents to Read

Finally, we would like to introduce some documents you should review after reading this document.

Each of these documents is in the TWL-SDK package. The path is indicated next to the document name.

### **For those migrating projects to the Nintendo DSi development environment**

- *TWL-SDK Migration Guide* (`docs/TechnicalNotes/AboutNitroToTwl.pdf`)

This provides information for NITRO-SDK developers who are migrating projects to the TWL-SDK development environment.

### **For those who want to know how to incorporate and use TWL-SDK**

- *Quick Start Guide* (`docs/README/QuickStartForSDK.pdf`)

This describes TWL-SDK installation procedures and how to create applications. You can learn basic operations by running the sample programs.

- *TWL-SDK Application Development Guidelines* (`docs/TechnicalNotes/AboutTwlApplication.pdf`)

This describes content related to TWL-SDK. More information about the differences from the NITRO-SDK is included.

In addition, see the function reference (in the `man` directory), the programming manual (programming manual package), and the various guidelines (in each guideline package).

CodeWarrior is a trademark of Freescale Semiconductor, Inc.

All company and product names in this document are the trademarks or registered trademarks of their respective companies.

© 2009 Nintendo

The contents of this document cannot be duplicated, copied, reprinted, transferred, distributed, or loaned in whole or in part without the prior approval of Nintendo.