XSR v1.5.2

Porting Guide

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Preface

SEC XSR POG-001

This Document is a Porting Guide for XSR (eXtended Sector Remapper) developed by Samsung Electronics.

Purpose

This document is XSR Porting Guide. This document explains the definition, architecture, system requirement, and porting tutorial of XSR. This document also provides the features and API of each module - OAM, PAM, LLD – that a user should know well to port XSR.

Scope

This document is for Project Manager, Project Leader, Application Programmers, etc.

Definitions and Acronyms

FTL (Flash Translation Layer)	A software module which maps between logical addresses and physical addresses when accessing to flash memory
XSR	eXtended Sector Remapper
STL	Sector Translation Layer
BML	Block Management Layer
LLD	Low Level Device Driver
Initial bad block	Invalid blocks upon arrival from the manufacturers
Run-time bad block	Additional invalid blocks may occur during the life of NAND flash usage
Sector	The file system performs read/write operations in a 512-byte unit called sector.
Page	NAND flash memory is partitioned into fixed-sized pages. A page is (512+16) bytes or (2048 + 64) bytes.
Block	NAND flash memory is partitioned into fixed-sized blocks. A block is 16K bytes or 128K bytes.
Wear-Leveling algorithm	Wear-leveling algorithm is an algorithm for increasing lifetime of NAND flash memory
NAND flash device	NAND flash device is a device that contains NAND flash memory or NAND flash controller.
NAND flash memory	NAND-type flash memory
Deferred Check Operation	The method that can increase time and device operation performance. Every operation function of LLD defers the check routine to the next operation.
OneNAND	Samsung NAND flash device that includes NAND flash memory and NAND flash controller.

Related Documents

- SEC, XSR v1.5.2 Part 1. Sector Translation Layer Programmer's Guide, Samsung Electronics, Co., LTD, JUN-2006
- SEC, XSR v1.5.2 Part 2. Block Management Layer Programmer's Guide, Samsung Electronics, Co., LTD, JUN-2006

History

Version	Date	Comment	Author	Approval

0.1	JULY-05-2004	Initial version	Seungeun Lee	
0.2	JULY-09-2004	Updated version - Delete FIL ; Some of FIL functionalities is shifted to BML or LLD. - Add a synchronous feature - Add chapater 7.5. “Byte Alignment Restriction” - Add MRead/MWrite function - Modify the figure of XSR system architecture. XSR consists of XSR Core (STL and BML), OAM, PAM, and LLD. In the previous verion, XSR has only STL and BML	Seungeun Lee	
1.0	JULY-09-2004	Released version	Seungeun Lee	Kwangyoon Lee
1.1	OCT-18-2004	Updated version - Add MErase/ EraseVerify function - Add ECC Policy	Min Young Kim Se Wook Na Seungeun Lee	
2.0	OCT-19-2004	Released version	Seungeun Lee	Kwangyoon Lee
2.1	NOV-26-2004	Updated version - Add PAM interrupt functions - Modify OAM interrupt functions and timer functions - Modify Interrupt and Timer	Min Young Kim Se Wook Na Seungeun Lee	
3.0	DEC-09-2004	XSR v1.3.1 Release	Seungeun Lee	Kwangyoon Lee
3.1	JAN-14-2005	Modify ECC Policy	Min Young Kim Se Wook Na Seungeun Lee	
4.0	JUN-24-2005	Updated version for XSR v1.4.0 - Add PAM_Memcpy - Modify ECC policy - Modify interrupt and timer	Min Young Kim Se Wook Na	Song Ho Yoon
5.0 RC5	FEB-20-2006	XSR v1.5.0 RC5 Release	Byoung Young Ahn	
5.1	APR-07-2006	XSR v1.5.1 Release	Byoung Young Ahn	
5.2	JUN-2007	XSR v1.5.2 Release	Byoung Young Ahn	

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1. Introduction

This document is a Porting Guide of XSR (eXtended Sector Remapper). This chapter first introduces the definition, system architecture, and features of XSR.

1.1. XSR Overview

☐ **Flash Memory**

Flash memory is an electronically programmable nonvolatile memory. It is used in laptop computer, PDA, or cell phone as storage. It is divided into two types, NOR and NAND, according to its cell composition at manufacturing. NAND flash memory has higher capacity and is cheaper than NOR flash memory. It has many benefits and widely used as storage of portable device.

☐ **NAND Flash Memory**

Unlike a hard disk, a user cannot rewrite data on NAND flash memory. It means user cannot overwrite existing data on it without first executing an erase operation. A user needs to erase the current data to write new data. Additionally, erase operation is performed by a block, which is larger than other operation unit; read and write operation is performed by a page on NAND flash memory. This prolongs working time, because unrelated data must also be erased and then rewritten to complete updating.

NAND flash memory is also limited in the number of times it can be written to and then erased (erase cycles). Flash device writes data sporadically, not in its address order. Specific sector can be written more frequently and the entire flash device becomes unusable eventually. Lastly, NAND flash memory can have an initial bad block[1] when it is manufactured and a run time bad block or bit-flipping[2] when it is used.

☐ **XSR development background**

As the above reason, a user cannot manage data on NAND flash memory like block devices[3]. Therefore, data management of NAND flash memory is very important issue. To cover that, Samsung Electronics develops the flash management software XSR (eXtended Sector Remapper) to use NAND flash memory as a regular block device. XSR has same functionalities with well-known FTL (Flash Translation Layer). Basically, it is a software layer or device driver, that resides between the OS file system and the NAND flash memory. XSR can be used separately and is independent of Operating system as a common component itself. It provides the OS with full block-device functionality so that NAND flash memory appears to the OS as a regular hard disk drive, while it transparently manages the flash data.

[1] Bad block is a block on which data cannot be read, written, or erased. There are two types of bad blocks: Initial bad block and Run-time bad block. Initial bad block occurs from manufacturer and runtime bad block occurs during using of NAND flash memory.
[2] Bad block is a block on which data cannot be read, written, or erased. When 1 bit error happens, XSR corrects the error itself, called bit-flipping.
[3] Block devices include all disk drives and other mass-storage devices on the computer.

1.2. XSR System Architecture

As mentioned in chapter 1.1. XSR Overview, XSR exists between the file system and NAND flash memory. It works in conjunction with an existing Operating system or in some embedded applications.

Figure 1-1 shows the system architecture of XSR.

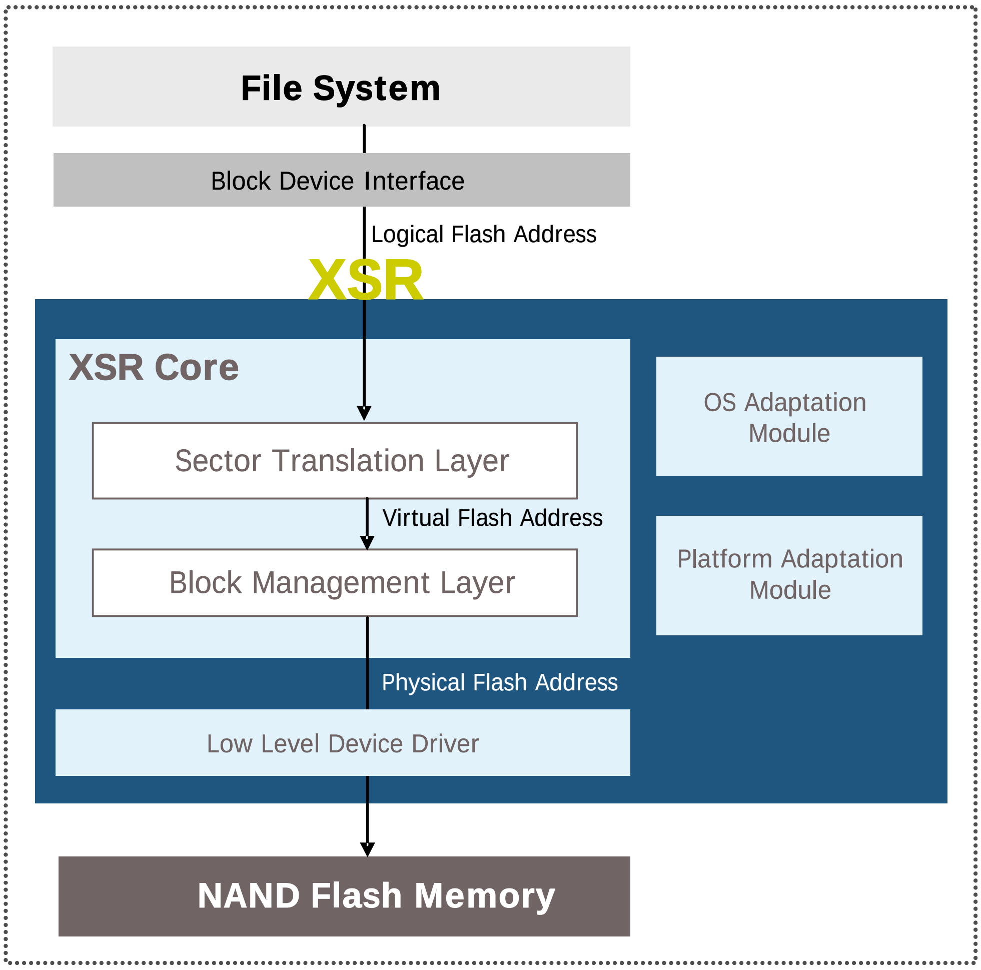


Figure 1-1. XSR System Architecture

There is a file system at the top of the figure. Block device interface exists between the file system and XSR. Block device interface is a kind of driver layer, which provides a file system with block device services. Block device interface code is ported for each OS.

There is XSR at the middle of the figure and it consists of four parts: XSR core, OAM (OS Adaptation Module, PAM (platform adaptation module), and LLD (Low Level Device Driver). The following briefly explains each of them.

☐ **XSR core:** XSR core is composed of two layers: STL (Sector Translation Layer) and BML (Block Management Layer). STL is a top layer of XSR. BML is below the STL. The layers specifically have different features with each other, but all they are to perform the basic functionalities of XSR as block device emulation and flash memory management. The main features of each layer are as follows.

- **STL** (Sector Translation Layer): translates a logical address from the file system into the virtual flash address. It internally has wear-leveling[4] during the address translation.

- **BML** (Block Management Layer): translates the virtual address from the upper layer into the physical address. At this time, BML does the address translation in consideration of bad block and the number of NAND device in use. BML accesses LLD[5], which actually performs read, write, or erase operation, with the physical address.

☞ **Note**

Each layer of XSR can be operated separately as a module. Thus, STL can be used with other layer, which has same functionalities with BML.

☐ **OAM:** OAM is at the right of the figure. OAM connects XSR with the OS. OAM needs to be configured according to your OS environment to use NAND flash memory.

☐ **PAM:** PAM is below OAM. PAM connects XSR with the platform. PAM also needs to be configured according to your platform to use NAND flash memory.

☐ **LLD:** There is a low level device driver between BML and NAND flash memory. It reads, writes, or erases data on the physical sector address received from XSR and is controlled by BML.

1.3. XSR Features

The following describes the main benefits and features of XSR implementation.

☐ It emulates a block device and manages data on NAND flash memory efficiently.
☐ It extends the life span of NAND flash memory by enhancing Wear- leveling.
☐ It can be embedded in any kind of OS using NAND flash memory.
☐ It enhances data integrity by managing a bad block and performing error detection or correction.
☐ It reduces data loss in case of sudden power failure with the advanced algorithms, and guarantees data stability.

In the next chapter, XSR build and installation procedures are covered in detail.

[4] Wear-leveling is an internal operation to use every block of NAND flash memory evenly through the algorithm. It extends NAND flash memory life span.
[5] LLD is an abbreviation of Low Level Device Driver. It performs actual read/write/erase operation to NAND flash memory as a device driver.

2. Development Environment

This chapter describes the system requirement and the directory structure.

2.1. System Requirement

Table 2-1 shows the system requirement to install XSR and use it.

Table 2-1. System Requirement

System Requirement	
Host OS	Windows 2K/XP
Target CPU	50 mips
Source Disk Space	About 8 MB
NAND Flash Chip	Samsung NAND Chip Emulator using RAM
Target Disk Space	Minimum 50 MB

2.2. Directory Structure

Figure 2-1 shows the XSR and Platform Directory Structure. Depending on type of released package, detail structure of directories can be different from Figure 2-1.

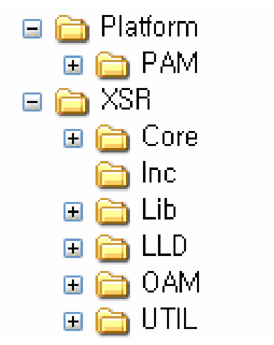


Figure 2-1. XSR and Platform Directory Structure

Table 2-2 describes the components of XSR and Platform directory structure in Figure 2-1. The following table only refers to porting related components of XSR and Platform directory.

Table 2-2. Component of XSR and Platform Directory

Directory		Description
XSR		This folder is a base directory when XSR is installed.
	Core	This folder has XSR source code. (STL and BML)
	Inc	This folder has XSR header files.
	Lib	This folder has XSR libraries (STL and BML).

	`LLD`	This folder has LLD source code.
	`OAM`	This folder has OAM source code.
`Platform`		This folder is a base directory for platform dependent code.
	`PAM`	This folder has platform source code.

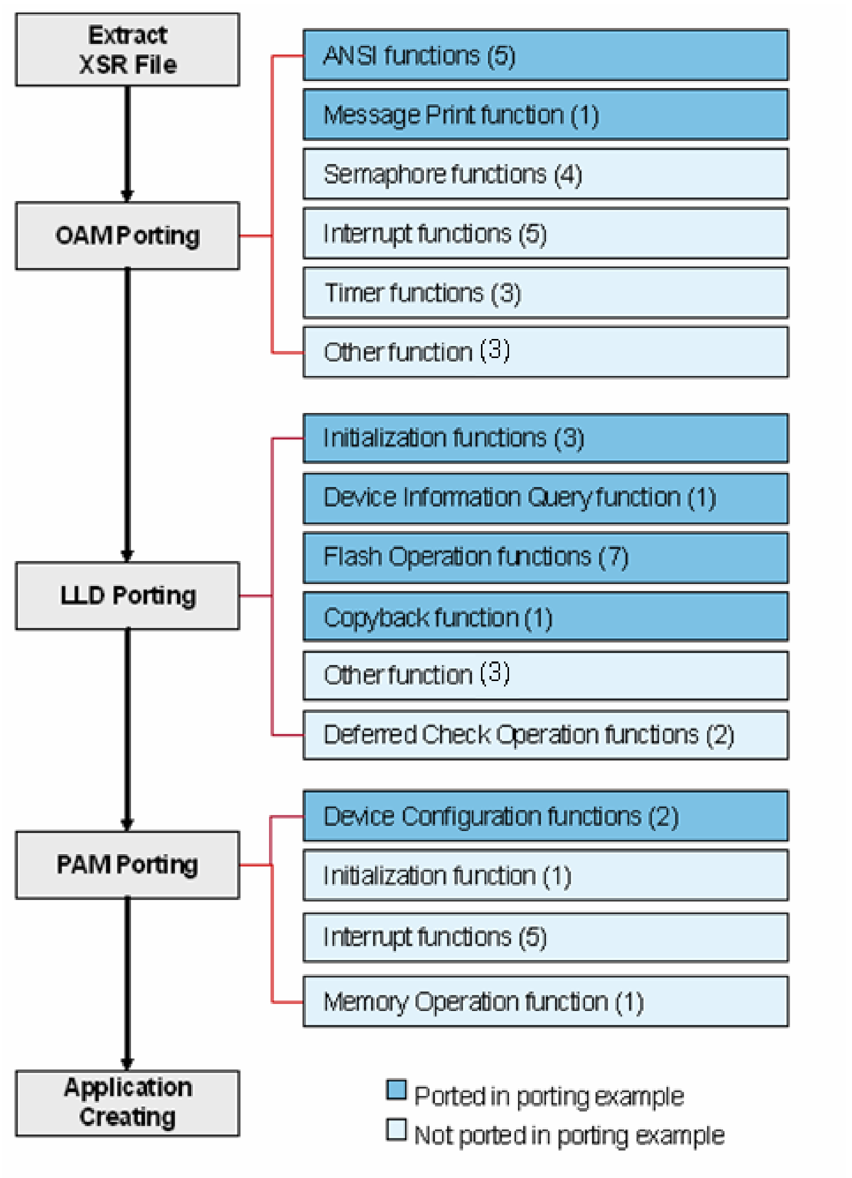
3. Porting Tutorial

This chapter describes a porting example of XSR. First of all, you should read the prerequisite and check points. Then, follow the steps of the porting example.

3.1. Prerequisite

3.1.1. Porting Outline

The procedure of the porting example is as follows.



Extract XSR File
OAM Porting
LLD Porting
PAM Porting
Application Creating
ANSI functions (5)
Message Print function (1)
Semaphore functions (4)
Interrupt functions (5)
Timer functions (3)
Other function (3)
Initialization functions (3)
Device Information Query function (1)
Flash Operation functions (7)
Copyback function (1)
Other function (3)
Deferred Check Operation functions (2)
Device Configuration functions (2)
Initialization function (1)
Interrupt functions (5)
Memory Operation function (1)
Ported in porting example
Not ported in porting example

Figure 3-1. XSR Porting Flowchart

This document shows you the process to port XSR on a PC. So, you port OAM(OS Adaptation Module) to Win32. You implement ANSI functions, and Message print functions. You do not implement the semaphore functions, because you use the single process. Also, you do not implement both interrupt functions and timer functions, because you do not use real NAND flash memory.

In porting LLD, you do not use a real device or NAND flash memory. This document shows you the process to make a simple NAND emulator including small block NAND flash memory functionality. You do not implement functions related to Deferred Check Operation.

In porting PAM, you use the simple NAND emulator that is made in implementing LLD. You implement the device and driver configuration functions

After implementing OAM, LLD and PAM, you create the application in Visual Studio and check that XSR is normally operated. Therefore, XSR porting example will be completed.

3.1.2. Condition Check

Before you start the porting example, you should check the files to use in porting. The following figure shows XSR and Platform directory structure to check.

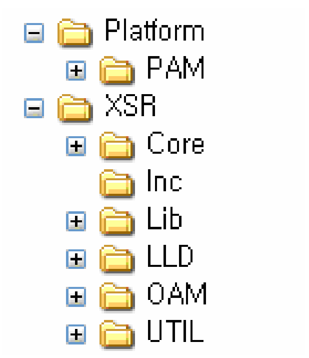


Figure 3-2. XSR and Platform Directory

The following description only refers to porting related files in XSR and Platform directory.

☐ In **PAM** folder, there is a template file in **Template** folder: MyPAM.cpp
☐ In **Inc** folder, there are XSR library files: BML.h, LLD.h, OAM.h, PAM.h, STL.h, XSR.h, and XsrTypes.h.
☐ In **Lib** folder, there is a XSR library file in **Generic\VS60\Retail** folder: XsrEmul.lib.
☐ In **LLD** folder, there are template files in **Template** folder: MyLLD.h and MyLLD.cpp.
☐ In **OAM** folder, there is a template file in **Template** folder: MyOAM.cpp.

Now, you fulfill all prerequisite for the porting example.

3.2. Porting Example

Follow the next porting example step by step.

3.2.1. Extract XSR File

At first, extract the provided XSR file.

1) Create a folder named as **XSR** in any location to port.

2) Extract **XSR_1.5.2_xxx.zip** in a newly created folder **XSR.**
Then, you can see the directory structure as follows.

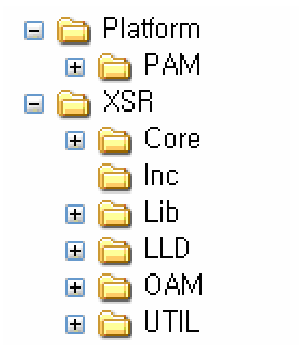


Figure 3-3. XSR and Platform Directory

3.2.2. OAM Porting

Among three modules (OAM, LLD, and PAM), you port OAM at first.

OAM, an OS-dependent module, links XSR to OS. In this porting example, you exercise OAM porting to Win32 because you port XSR on a PC.

In **\XSR\OAM** folder, there is a template file **MyOAM.cpp** in **Template** folder. This template file contains 21 functions that are classified into 6 categories as follows.

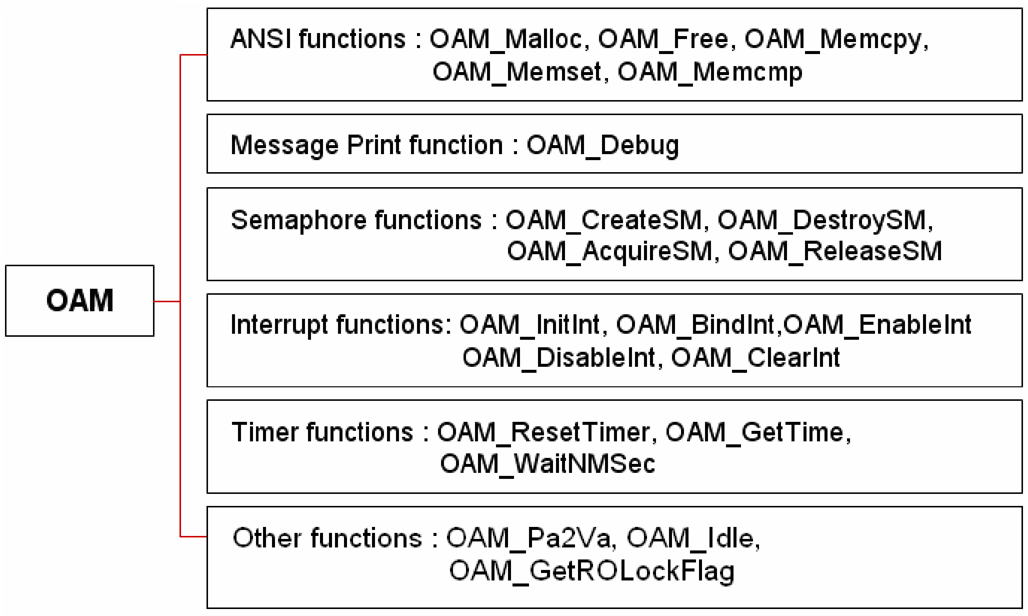

OAM
ANSI functions : OAM_Malloc, OAM_Free, OAM_Memcpy, OAM_Memset, OAM_Memcmp
Message Print function : OAM_Debug
Semaphore functions : OAM_CreateSM, OAM_DestroySM, OAM_AcquireSM, OAM_ReleaseSM
Interrupt functions: OAM_InitInt, OAM_BindInt,OAM_EnableInt OAM_DisableInt, OAM_ClearInt
Timer functions : OAM_ResetTimer, OAM_GetTime, OAM_WaitNMSec
Other functions : OAM_Pa2Va, OAM_Idle, OAM_GetROLockFlag

Figure 3-4. OAM Function Classification

The following explains the classification of OAM functions.

☐ ANSI functions

ANSI functions are the mandatory functions that XSR library uses. You must implement these functions at all times.

```
        OAM_Malloc()
        OAM_Free()
        OAM_Memcpy()
        OAM_Memset()
        OAM_Memcmp()
```

☐ Message print function

Message print function is the functions to print all XSR messages, including an error or debug message. If you do not implement this function, you cannot see XSR debug messages.

```
        OAM_Debug()
```

☐ Semaphore functions

The semaphore functions are the functions to protect codes or devices using XSR in multi-task or multi-process environment. For more information about the semaphore functions, refer to Chapter 오류! 참조 원본을 찾을 수 없습니다.. 오류! 참조 원본을 찾을 수 없습니다..

```
        OAM_CreateSM()
        OAM_DestroySM()
        OAM_AcquireSM()
        OAM_ReleaseSM()
```

☐ Interrupt functions

The interrupt functions are the functions for Asynchronous functionality of XSR. For more information about the interrupt, refer to Chapter 오류! 참조 원본을 찾을 수 없습니다.. 오류! 참조 원본을 찾을 수 없습니다..

```
        OAM_InitInt()
        OAM_BindInt()
        OAM_EnableInt()
        OAM_DisableInt()
        OAM_ClearInt()
```

☐ **Timer functions**
Timer functions are the functions to check the time flow for Asynchronous functionality of XSR or handle the time-related errors. For more information about timer, refer to Chapter 오류! 참조 원본을 찾을 수 없습니다. Timer and 오류! 참조 원본을 찾을 수 없습니다. Power-Off Recovery

```
        OAM_ResetTimer()
        OAM_GetTime()
        OAM_WaitNMSec()
```

☐ **Other functions**
These functions does not correspond to any category above.

```
        OAM_Pa2Va()
        OAM_Idle()
        OAM_GetROLockFlag()
```

Now, port OAM to Win32.

1) Make a duplicate of the existing **Template** folder in `\XSR\OAM`, and name the new folder as **MyOAM**.

   Check there is a file **MyOAM.cpp** in the newly named folder **MyOAM**.

2) Open the existing file MyOAM.cpp in an editor.

3) Add the followings to include the header files.

```
#include <windows.h>
#include <stdio.h>
#include <stdarg.h>
#include <string.h>
```

4) Add the following code in bold to implement ANSI functions.

```
VOID *
OAM_Malloc(UINT32 nSize)
{
    return malloc(nSize);
}

VOID
OAM_Free(VOID  *pMem)
{
    free(pMem);
}

VOID
OAM_Memcpy(VOID *pDst, VOID *pSrc, UINT32 nLen)
{
    memcpy((void *) pDst,(void *) pSrc, nLen);
}

VOID
OAM_Memset(VOID *pDst, UINT8 nData, UINT32 nLen)
{
    memset((void *) pDst, (int) nData, nLen);
}

INT32
OAM_Memcmp(VOID  *pCmp1, VOID  *pCmp2, UINT32 nLen)
{
    return memcmp((void *) pCmp1, (void *) pCmp2, nLen);
}
```

ANSI functions are implemented to map one-to-one with the standard ANSI function. Each six functions execute the general memory operation: memory allocation, memory release, memory copy, memory set, and memory comparison. You must implement these mandatory functions.

5) Add the following code in bold to implement Message print function.

```
VOID
OAM_Debug(VOID  *pFmt, ...)
{
    static char   aStr[4096];
    va_list       ap;

    va_start(ap, pFmt);
    vsprintf(aStr, (char *) pFmt, ap);
    printf(aStr);

    va_end(ap);
}
```

Message print function prints messages on XSR. If you want to see an error or debug message of XSR, you should implement this function.

6) Do not modify the semaphore functions because you use a single process, not a multi-process. The current template always returns `TRUE32.`

```
BOOL32
OAM_CreateSM(SM32 *pHandle)
{
    *pHandle = 1;
    return TRUE32;
}

BOOL32
OAM_DestroySM(SM32 nHandle)
{
    return TRUE32;
}

BOOL32
```

```
OAM_AcquireSM(SM32 nHandle)
{
   return TRUE32;
}

BOOL32
OAM_ReleaseSM(SM32 nHandle)
{
   return TRUE32;
}
```

For detailed information about the semaphore functions, refer to Chapter 4.2. OAM APIs. For detailed information about the semaphore functionality, refer to Chapter **오류! 참조 원본을 찾을 수 없습니다.**. **오류! 참조 원본을 찾을 수 없습니다.**.

7) Do not modify the interrupt functions because you do not use real NAND flash memory.

```
VOID
OAM_InitInt(UINT32 nLogIntId)
{
}

VOID
OAM_BindInt(UINT32 nLogIntId, UINT32 nPhyIntId)
{
}

VOID
OAM_EnableInt(UINT32 nLogIntId, UINT32 nPhyIntId)
{
}

VOID
OAM_DisableInt(UINT32 nLogIntId, UINT32 nPhyIntId)
{
}

VOID
OAM_ClearInt(UINT32 nLogIntId, UINT32 nPhyIntId)
{
}
```

For detailed information about the interrupt functions, refer to Chapter 4.2. OAM APIs.

8) Do not modify timer functions because you do not real NAND flash memory.

```
VOID
OAM_ResetTimer(VOID)
{
}

UINT32
OAM_GetTime(VOID)
{
   return 0;
}

VOID
OAM_WaitNMSec(UINT32 nNMSec)
{
}
```

For detailed information about timer functions, refer to Chapter 4.2. OAM APIs. For detailed information about timer functionality, refer to Chapter 오류! 참조 원본을 찾을 수 없습니다. Timer and 오류! 참조 원본을 찾을 수 없습니다. Power-Off Recovery.

9) The function OAM_Pa2Va is used for the address translation: from Physical address to Virtual address. Do not modify this function, because you do not use real NAND flash memory.

```
UINT32
OAM_Pa2Va(UINT32 nPAddr)
{
    return nPAddr;
}
```

If it is needed to the address translation for accessing to hardware, you should implement this function.

10) The function OAM_Idle is called when XSR is at idle time. For example, if XSR is polling on the device status, this function is called. Do not modify this function for now.

```
VOID
OAM_Idle(VOID)
{
}
```

At idle, other operations can be done by implementing this function.

11) The function OAM_GetROLockFlag is called when XSR determines whether certain block is in Read-Only partition or not. If XSR finds it is in range of RO partition, this function is called. If it is necessary to regard blocks in RO partition as RW under certain condition, implement this function. Do not modify this function unless you deeply understand internal implementation of XSR. Default implementation of this function just returns TRUE.

```
BOOL32
OAM_GetROLockFlag(VOID)
{
    return TRUE32;
}
```

After editing MyOAM.cpp, save the file and close it.

By far, you implement an OAM file, MyOAM.cpp, operating on Win32. Next, you implement LLD files.

3.2.3. LLD Porting

XSR sends a request to a device driver LLD, and then LLD accesses to the real device. This porting example shows you the process to make a simple NAND emulator as RAM, because you do not use real NAND flash memory.

Suppose that the simple NAND emulator is as follows;

☐ `pNANDArray,` a general pointer variable, points to the start address of the simple NAND emulator.

☐ Supposing that using large block, so 1 page = 4 sector.

☐ 1 page = (512 * 4) bytes main array + (16 * 4) bytes spare array .

☐ 1 block = 64 pages.

☐ The total number of blocks = 1024.

☐ The total memory of the simple NAND emulator
= the number of total blocks * (the number of pages in a block * the size of a page)
= 1024 * (64 * (512 * 4 + 16 * 4)) bytes.

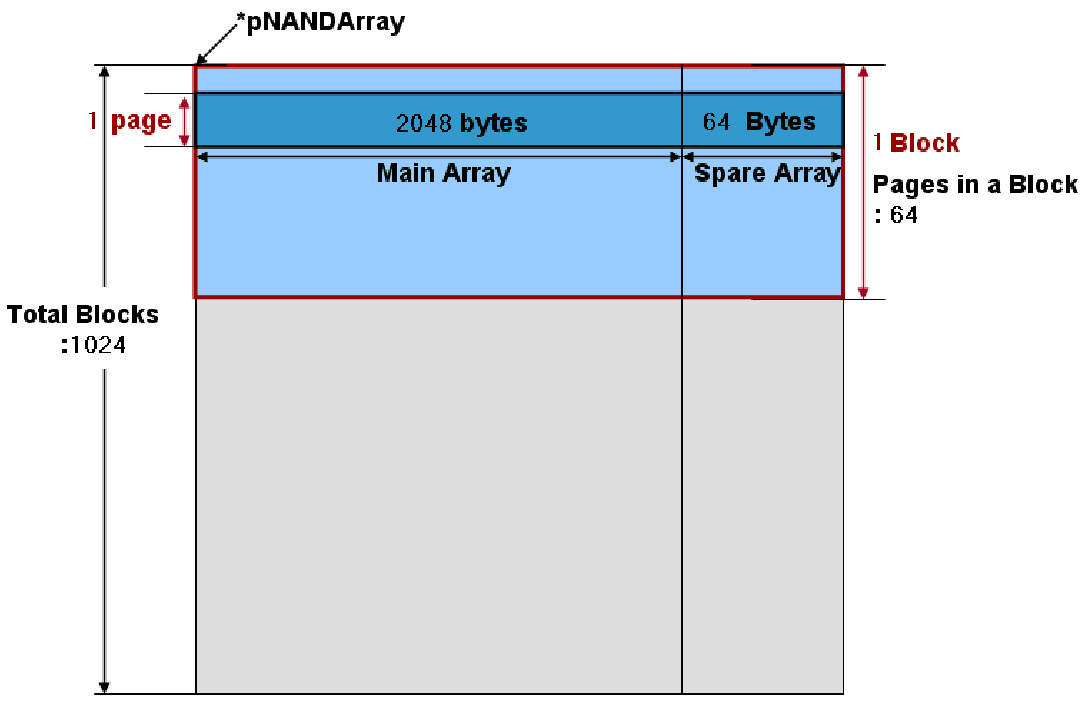


Figure 3-5. Simple NAND Emulator Design

In `\XSR\LLD` folder, there are two template files in **Template** folder: **MyLLD.h** and **MyLLD.cpp**. A template file **MyLLD.cpp** contains 17 functions that are classified into 6 categories.

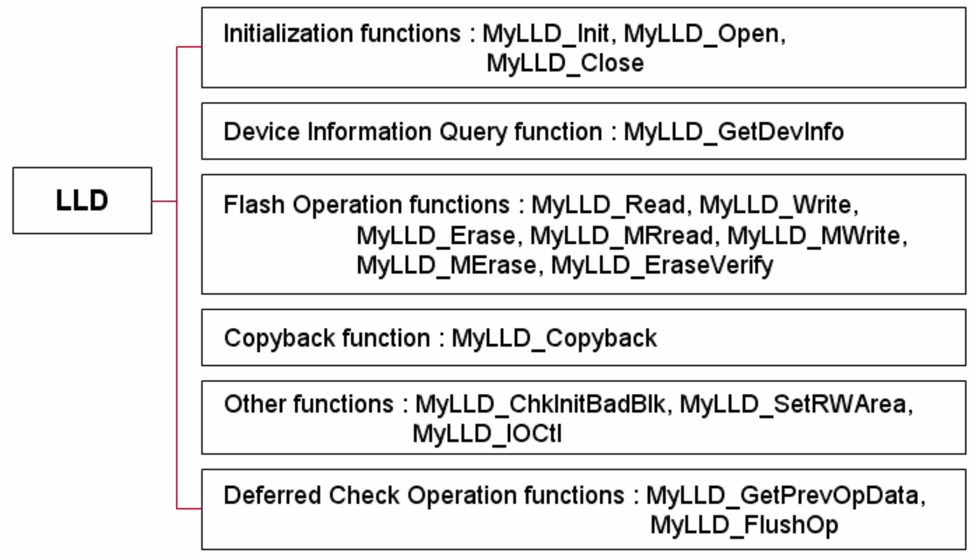

LLD
Initialization functions : MyLLD_Init, MyLLD_Open, MyLLD_Close
Device Information Query function : MyLLD_GetDevInfo
Flash Operation functions : MyLLD_Read, MyLLD_Write, MyLLD_Erase, MyLLD_MRead, MyLLD_MWrite, MyLLD_MErase, MyLLD_EraseVerify
Copyback function : MyLLD_Copyback
Other functions : MyLLD_ChkInitBadBlk, MyLLD_SetRWArea, MyLLD_IOCtl
Deferred Check Operation functions : MyLLD_GetPrevOpData, MyLLD_FlushOp

Figure 3-6. LLD Function Classification

Now, make a simple NAND emulator and port LLD to that simple NAND emulator.

1) Make a duplicate of the existing **Template** folder in `\XSR\LLD`, and name the new folder as **MyLLD**.

   Check there are two files **MyLLD.cpp** and **MyLLD.h** in the newly named folder **MyLLD**.

2) Open the existing file MyLLD.h in an editor and check it.
   Do not modify MyLLD.h and use it as it is.

```
#ifndef __MY_LLD_H__
#define __MY_LLD_H__

#ifdef __cplusplus
extern "C" {
#endif /* __cplusplus */

INT32 MyLLD_Init (VOID  *pParm);
INT32 MyLLD_Open (UINT32 nDev);
INT32 MyLLD_Close (UINT32 nDev);
INT32 MyLLD_ChkInitBadBlk (UINT32 nDev,  UINT32 nPbn);
INT32 MyLLD_Read (UINT32 nDev,  UINT32 nPsn,  UINT32 nNumOfScts,
                 UINT8 *pMBuf, UINT8 *pSBuf, UINT32 nFlag);
INT32 MyLLD_Write (UINT32 nDev,  UINT32 nPsn,  UINT32 nNumOfScts,
                  UINT8 *pMBuf, UINT8 *pSBuf, UINT32 nFlag);
INT32 MyLLD_Erase (UINT32 nDev,  UINT32 nPbn, UINT32 nFlag);
INT32 MyLLD_CopyBack (UINT32 nDev,  CpBkArg *pstCpArg,
                      UINT32 nFlag);
INT32 MyLLD_GetDevInfo (UINT32 nDev,  LLDSpec* pstLLDDev);
INT32 MyLLD_GetPrevOpData (UINT32 nDev,  UINT8 *pMBuf,
                           UINT8 *pSBuf);
INT32 MyLLD_FlushOp (UINT32 nDev);
INT32 MyLLD_SetRWArea (UINT32 nDev,  UINT32 n1stUB,
                      UINT32 nNumOfUBs);
INT32 MyLLD_IOCtl (UINT32 nDev,  UINT32 nCode, UINT8 *pBufI,
                   UINT32 nLenI, UINT8 *pBufO, UINT32 nLenO,
                   UINT32 *pByteRet);
INT32 MyLLD_MRead (UINT32 nDev,  UINT32 nPsn, UINT32 nNumOfScts,
                   SGL *pstSGL, UINT8 *pSBuf,UINT32 nFlag);
INT32 MyLLD_MWrite (UINT32 nDev, UINT32 nPsn, UINT32 nNumOfScts,
                   SGL *pstSGL, UINT8 *pSBuf,   UINT32 nFlag,
                   UINT32 *pErrPsn);
INT32 MyLLD_MErase (UINT32 nDev, LLDMEArg *pstMEArg,
                    UINT32 nFlag);
INT32 MyLLD_EraseVerify (UINT32 nDev,  LLDMEArg *pstMEArg,
                         UINT32 nFlag);

#ifdef __cplusplus
}
#endif /* __cplusplus */

#endif /* __MY_LLD_H__ */
```

If necessary, you can rename the prefix (MyLLD_) of LLD function suitable for the device. If you change the function name, save the file MyLLD.h and close it.

3) Open the existing file MyLLD.cpp in an editor.

4) Add the following code to make a simple NAND emulator.
First, define the number of blocks and the size of total blocks to use. Then, define a general pointer variable pointing to the start address of the buffer for the simple NAND emulator.

```
#define NUM_BLK         1024
#define PGS_PER_BLK     64
#define SCTS_PER_PG     4
#define SCTS_PER_BLK    (64 * 4)
#define PG_SIZE         (512 * 4 + 16 * 4)
#define BLK_SIZE        (64 * PG_SIZE)

UINT8  *pNANDArray;
```

NUM_BLK is the number of the total blocks. It is defined as 1024.

BLK_SIZE is the size of a block. The formula to decide the size of a block is the number of pages in a block * the size of a page = 64 * (512 * 4 + 16 * 4).

pNANDArray is a general pointer variable pointing to the start address of the simple NAND emulator.

5) Add the following code in bold to implement Device initialization related functions: Init, Open and Close.

```
INT32
MyLLD_Init(VOID *pParm)
{
   XsrVolParm  *pstParm = (XsrVolParm*)pParm;
```

```
    pNANDArray = (UINT8 *)OAM_Malloc(NUM_BLK * BLK_SIZE);
    if (pNANDArray == NULL)
    {
        LLD_RTL_PRINT((TEXT("Memory Allocation Error!!\n")));
        return LLD_INIT_FAILURE;
    }
    OAM_Memset(pNANDArray, 0xff, NUM_BLK * BLK_SIZE);

    return LLD_SUCCESS;
}

INT32
MyLLD_Open(UINT32 nDev)
{
    return LLD_SUCCESS;
}

INT32
MyLLD_Close(UINT32 nDev)
{
    return LLD_SUCCESS;
}
```

`Init` initializes data structure required to the device operating. `Init` called first and once when the driver is loaded.
This example allocates a buffer for the simple NAND emulator calling a function `OAM_Malloc`, and initializes the buffer as `0xff`. In general, you can implement this function suitable for real NAND device.

`Open` initializes the device to be used.
Do not modify the template. In general, you can implement this function that makes the real device be ready to use.

`Close` , in opposite to **`Open`**, unlinks XSR and the device.
Do not modify the template. In general, you can implement this function that makes the real device be released.

6) Add the following code in bold to implement Device information query function `GetDevInfo`.

```
INT32
MyLLD_GetDevInfo(UINT32 nDev, LLDSpec* pstDevInfo)
{
    pstDevInfo->nMCode              = 0xEC;
    pstDevInfo->nDCode              = 0x11;

    pstDevInfo->nNumOfBlks          = NUM_BLK;
    pstDevInfo->nPgsPerBlk          = 64;
    pstDevInfo->nSctsPerPg          = 4;
    pstDevInfo->nBlksInRsv          = 20;
    pstDevInfo->nNumOfPlane         = 1;

    pstDevInfo->nBadPos             = 0;
    pstDevInfo->nLsnPos             = 2;
    pstDevInfo->nEccPos             = 8;
    pstDevInfo->nMEFlag             = LLD_ME_NO;
    pstDevInfo->nBWidth           = 0;

    pstDevInfo->aUID[ 0]          = 0;
    pstDevInfo->aUID[ 1]          = 0;
    pstDevInfo->aUID[ 2]          = 0;
    pstDevInfo->aUID[ 3]          = 0;
    pstDevInfo->aUID[ 4]          = 0;
    pstDevInfo->aUID[ 5]          = 0;
    pstDevInfo->aUID[ 6]          = 0;
    pstDevInfo->aUID[ 7]          = 0;
    pstDevInfo->aUID[ 8]          = 0;
    pstDevInfo->aUID[ 9]          = 0;
    pstDevInfo->aUID[10]          = 0;
    pstDevInfo->aUID[11]          = 0;
    pstDevInfo->aUID[12]          = 0;
    pstDevInfo->aUID[13]          = 0;
    pstDevInfo->aUID[14]          = 0;
    pstDevInfo->aUID[15]          = 0;

    pstDevInfo->nTrTime           = 500000;
    pstDevInfo->nTwTime           = 3500000;
    pstDevInfo->nTeTime           = 20000000;
    pstDevInfo->nTfTime           = 50;

    return LLD_SUCCESS;
}
```

GetDevInfo returns the device information to BML.

☐ **nMCode** and **nDCode** are Device IDs.
This example gives random code as 0xEC and 0x11 because you do not use a real device.

☐ **nNumOfBlks** is the number of blocks, **nPgsPerBlk** is the number of pages in a block,

☐ **nSctsPerPg** is the number of sectors in a page, and **nBlksInRsv** is the number of the reserved blocks.

☐ **nMEFlag** is a flag which indicates whether multi-block erase is supported or not.

☐ **aUID** is Unique ID of a device.
This example gives random code as 0 because you do not use a real device.

☐ **nTrTime** is the time for page reading, **nTwTime** is the time for page writing, **nTeTime** is the time for block erasing, **nTfTime** is the time for data transmitting (512 bytes). These values are referred as XSR mapping.
These time values are the standard to calculate the performance cost for the internal algorithm. The time values should be suitable for the real operation time approximately, although it is not exactly same. The unit of the operation time is ns.

For more information about the device information to BML, refer to LLD API, `XXX_GetDevInfo`.

7) Add the following code in bold to implement Flash operation functions: `Read, Write, Erase, MRead, MWrite, MErase and EraseVerify.`

```
INT32
MyLLD_Read(UINT32 nDev,  UINT32 nPsn,  UINT32 nNumOfScts,
           UINT8 *pMBuf, UINT8 *pSBuf, UINT32 nFlag)
{
   UINT32 nBlkOff;
   UINT32 nPgOff;
   UINT32 nSctOff;
   UINT32 nPos;

   nBlkOff = nPsn / SCTS_PER_BLK;
   nPgOff = (nPsn - nBlkOff * SCTS_PER_BLK) / SCTS_PER_PG;
   nSctOff = nPsn - (nBlkOff * SCTS_PER_BLK + nPgOff * SCTS_PER_PG);

   nPos = nBlkOff * BLK_SIZE + nPgOff * PG_SIZE;

   if (pMBuf != NULL)
   {
      PAM_Memcpy(pMBuf, pNANDArray + nPos + 512 * nSctOff,
                 512 * nNumOfScts);
   }

   if (pSBuf != NULL)
   {
      PAM_Memcpy(pSBuf, pNANDArray + nPos + 512 * 4 + 16 * nSctOff,
                 16 * nNumOfScts);
   }

   return LLD_SUCCESS;
}
```

Read is to read data as a unit of a sector from NAND flash memory.
The parameters nPsn and nNumOfScts read data as a unit of a sector. The number of sectors does not exceed the sector-included page because you can read/write as a unit of a page. That is, this function reads data as a unit of a page; else the argument of the function is received as a unit of a sector. So, the number of sectors is limited by the number of a page.
This example calculates the start address of memory using pNANDArray, and copies data to the using buffer. This function handles the main array and spare array separately when reading data of NAND flash memory page.

```
INT32
MyLLD_Write(UINT32 nDev,  UINT32 nPsn,  UINT32 nNumOfScts,
            UINT8 *pMBuf, UINT8 *pSBuf, UINT32 nFlag)
{
   UINT32 nIdx;
   UINT32 nSctIdx;

   UINT32 nBlkOff;
   UINT32 nPgOff;
   UINT32 nSctOff;
   UINT32 nPos;

   nBlkOff = nPsn / SCTS_PER_BLK;
   nPgOff = (nPsn - nBlkOff * SCTS_PER_BLK) / SCTS_PER_PG;
   nSctOff = nPsn - (nBlkOff * SCTS_PER_BLK + nPgOff * SCTS_PER_PG);
```

```
    nPos = nBlkOff * BLK_SIZE + nPgOff * PG_SIZE;

    if (pMBuf != NULL)
    {
        for (nSctIdx = 0; nSctIdx < nNumOfScts ; nSctIdx++)
        {
            for (nIdx = 0; nIdx < 512; nIdx++)
            {
                pNANDArray[nPos + 512 * (nSctOff + nSctIdx) + nIdx]
                            &= pMBuf[512 * nSctIdx + nIdx];
            }
        }
    }

    if (pSBuf != NULL)
    {
        for (nSctIdx = 0; nSctIdx < nNumOfScts ; nSctIdx++)
        {
            for (nIdx = 0; nIdx < 16; nIdx++)
            {
                pNANDArray[nPos + 512 * 4 + 16 * (nSctOff + nSctIdx)
                            + nIdx] &= pSBuf[16 * nSctIdx + nIdx];
            }
        }
    }

    return LLD_SUCCESS;
}
```

Write is to write data as a unit of a page or sector to NAND flash memory.
The parameters nPsn and nNumOfScts read data as a unit of a sector. The number of sectors does not exceed the sector-included page because you can read/write as a unit of a page. That is, this function writes data as a unit of a page, else the argument of the function is received as a unit of a sector. So, the number of sectors is limited by the number of a page.
This example calculates the start address of memory using pNANDArray, and writes data. This function always handles main array and spare array separately when it reads data of NAND flash memory page. You use an AND operator to emulate the real writing to NAND flash memory in this function.

```
INT32
MyLLD_Erase(UINT32 nDev, UINT32 nPbn, UINT32 nFlag)
{
    OAM_Memset(pNANDArray + nPbn * BLK_SIZE, 0xff, BLK_SIZE);

    return LLD_SUCCESS;
}
```

Erase is to erase a block of NAND flash memory.
This example calculates the start address of memory using pNANDArray, and erases data. This example handles as a unit of a block. You fill memory buffer with 0xff. In general, you can implement this function that accesses to the real NAND device.

```
INT32
MyLLD_MRead(UINT32 nDev,  UINT32 nPsn, UINT32 nNumOfScts,
            SGL *pstSGL, UINT8 *pSBuf, UINT32 nFlag)
{
    UINT32 nBlkOff;
    UINT32 nPgOff;
    UINT32 nSctOff;
    UINT32 nPos;
    UINT32 nCnt;
    UINT32 nReadScts;
    UINT32 nSctIdx;
    UINT32 nCurPos;

    nBlkOff = nPsn / SCTS_PER_BLK;
    nPgOff = (nPsn - nBlkOff * SCTS_PER_BLK) / SCTS_PER_PG;
    nSctOff = nPsn - (nBlkOff * SCTS_PER_BLK + nPgOff * SCTS_PER_PG);

    nPos = nBlkOff * BLK_SIZE + nPgOff * PG_SIZE;
    nCurPos = nPos;
    nSctIdx = nSctOff;

    if (pstSGL != NULL)
    {
        for (nCnt = 0;nCnt < pstSGL->nElements;nCnt++)
        {
            nReadScts = 0;
            while (nReadScts < pstSGL->stSGLEntry[nCnt].nSectors)
            {
                PAM_Memcpy(
                    pstSGL->stSGLEntry[nCnt].pBuf + 512*nReadScts,
                    pNANDArray + nCurPos + 512 * nSctIdx, 512);

                nReadScts++;
                nSctIdx++;
                if (nSctIdx == 4)
                {
                    nCurPos += PG_SIZE;
                    nSctIdx = 0;
                }
            }
        }
    }

    if (pSBuf != NULL)
    {
        PAM_Memcpy(pSBuf, pNANDArray + nPos + 512 * 4 + 16 * nSctOff,
                   16 * nNumOfScts);
    }

    return LLD_SUCCESS;
}
```

MRead reads pages and sectors within a block boundary, while **Read** reads data within a page. This function can be optimized by not reading sectors one by one. But, for simplicity, the above scheme shows how to handle SGL argument.

```
INT32
MyLLD_MWrite(UINT32 nDev,  UINT32 nPsn,  UINT32 nNumOfScts,
              SGL *pstSGL, UINT8 *pSBuf, UINT32 nFlag,
              UINT32 *pErrPsn)
{
    UINT32 nIdx;
    UINT32 nBlkOff;
    UINT32 nPgOff;
    UINT32 nSctOff;
    UINT32 nPos;
    UINT32 nCnt;
    UINT32 nWriteScts;
    UINT32 nSctIdx;
    UINT32 nCurPos;
    UINT8 *pSrcBuf;

    nBlkOff = nPsn / SCTS_PER_BLK;
    nPgOff = (nPsn - nBlkOff * SCTS_PER_BLK) / SCTS_PER_PG;
    nSctOff=nPsn-(nBlkOff*SCTS_PER_BLK+nPgOff*SCTS_PER_PG);

    nPos = nBlkOff * BLK_SIZE + nPgOff * PG_SIZE;

    nCurPos = nPos;
    nSctIdx = nSctOff;

    if (pstSGL != NULL)
    {
        for (nCnt = 0;nCnt < pstSGL->nElements;nCnt++)
        {
            nWriteScts = 0;
            pSrcBuf = pstSGL->stSGLEntry[nCnt].pBuf;
            while(nWriteScts<pstSGL->stSGLEntry[nCnt].nSectors)
            {
                for (nIdx = 0; nIdx < 512; nIdx++)
                {
                 pNANDArray[nCurPos + 512*nSctIdx + nIdx]
                           &=  pSrcBuf[512*nWriteScts + nIdx];
                }

                nWriteScts++;
                nSctIdx++;
                if (nSctIdx == 4)
                {
                    nCurPos += PG_SIZE;
                    nSctIdx = 0;
                }
            }
        }
    }

    if (pSBuf != NULL)
    {
        for (nSctIdx = 0; nSctIdx < nNumOfScts ; nSctIdx++)
        {
            for (nIdx = 0; nIdx < 16; nIdx++)
            {
               pNANDArray[nPos+512*4+16*(nSctOff+nSctIdx)+nIdx]
                      &= pSBuf[16 * nSctIdx + nIdx];
            }
        }
    }

    return LLD_SUCCESS;
}
```

`MWrite` writes pages and sectors within a block boundary, while **`Write`** writes data within a page. This function can be optimized by not writing sectors one by one. But, for simplicity, the above scheme shows how to handle SGL argument.

```
INT32
MyLLD_MErase(UINT32 nDev, LLDMEArg *pstMEArg, UINT32 nFlag)
{
    return LLD_SUCCESS;
}
```

`MErase` erases multiple blocks of NAND flash memory simultaneously, while **`Erase`** erases only one block of NAND flash memory. In this example, we assume that NAND emulator does not support an erase operation for multiple blocks, thus `MErase` is not provided.

```
INT32
MyLLD_EraseVerify(UINT32 nDev, LLDMEArg *pstMEArg, UINT32 nFlag)
{
    return LLD_SUCCESS;
}
```

`EraseVerify` verifies an erase operation whether it checks blocks are properly erased. Do not modify the template. In this example, we assume that NAND emulator does not support an erase operation for multiple blocks, thus `EraseVerify` is not provided.

8) Add the following code in bold to implement CopyBack function. CopyBack function supports a page copy functionality using the internal buffer in a NAND device.

```
INT32
MyLLD_CopyBack(UINT32 nDev, CpBkArg *pstCpArg, UINT32 nFlag)
{
    UINT8  aBuf[2112];
    UINT32 nIdx;
    UINT32 nBlkOff;
    UINT32 nPgOff;
    UINT32 nSctNum;
    UINT32 nOffset;
    UINT32 nPos;

    nBlkOff = pstCpArg->nSrcSn / SCTS_PER_BLK;
    nPgOff = (pstCpArg->nSrcSn – nBlkOff * SCTS_PER_BLK)
              / SCTS_PER_PG;

    nPos = nBlkOff * BLK_SIZE + nPgOff * PG_SIZE;

    PAM_Memcpy(aBuf, pNANDArray + nPos, 2112);

    for (nIdx = 0; nIdx < pstCpArg->nRndInCnt; nIdx++)
    {
        nSctNum = pstCpArg->pstRndInArg[nIdx].nOffset / 1024;
        nOffset = pstCpArg->pstRndInArg[nIdx].nOffset % 1024;

        if (nOffset < 512)
        {
            PAM_Memcpy(aBuf + 512 * nSctNum + nOffset,
                    pstCpArg->pstRndInArg[nIdx].pBuf,
                    pstCpArg->pstRndInArg[nIdx].nNumOfBytes);
        }
        else
        {
            PAM_Memcpy(aBuf + 512 * 4 + 16 * nSctNum + nOffset,
                    pstCpArg->pstRndInArg[nIdx].pBuf,
                    pstCpArg->pstRndInArg[nIdx].nNumOfBytes);
        }
    }

    nBlkOff = pstCpArg->nDstSn / SCTS_PER_BLK;
    nPgOff = (pstCpArg->nDstSn - nBlkOff * SCTS_PER_BLK)
             / SCTS_PER_PG;

    nPos = nBlkOff * BLK_SIZE + nPgOff * PG_SIZE;

    for (nIdx = 0; nIdx < 2112; nIdx++)
    {
        pNANDArray[nPos + nIdx] &= aBuf[nIdx];
    }

    return LLD_SUCCESS;
}
```

☞ **Reference**

`CopyBack` means the operation method to copy pages using the internal buffer in a NAND device.
This copyback method improves the performance by cutting the transfer time and operation procedure, because this method does not use the external memory. When copying a page using the copyback method, a part of data can be brought the outside device; this is called **Random-in**.
To implement CopyBack function, you must understand a `CpBkArg` structure. For more information about `CpBkArg`, refer to LLD function `XXX_CopyBack`.

9) Do not modify `ChkInitBadBlk`, `SetRWArea`, and `IOCtl` functions, because you use the simple NAND emulator.

```
INT32
MyLLD_ChkInitBadBlk(UINT32 nDev, UINT32 nPbn)
{
    return LLD_INIT_GOODBLOCK;
}

INT32
MyLLD_SetRWArea(UINT32 nDev, UINT32 n1stUB, UINT32 nNumOfUBs)
{
    return LLD_SUCCESS;
}

INT32
MyLLD_IOCtl(UINT32 nDev, UINT32 nCode, UINT8 *pBufI,
            UINT32 nLenI, UINT8 *pBufO, UINT32 nLenO,
            UINT32 *pByteRet)
{
   return LLD_SUCCESS;
}
```

`ChkInitBadBlk` is to check whether a block is an initial bad block or not.
If the value of the bad mark position in the first or second page of a block is not `0xff`(a normal statement), the block is the initial bad block.
This function is implemented to read the first or second page of a block and check it bad or not. In general, you implement this function using `Read` function in real NAND device.

`SetRWArea` is used when NAND device supports the hardware write protection.

10) Do not modify Deferred Check Operation functions. The current template always returns `LLD_SUCCESS`.

```
INT32
MyLLD_GetPrevOpData(UINT32 nDev, UINT8 *pMBuf, UINT8 *pSBuf)
{
   return LLD_SUCCESS;
}

INT32
MyLLD_FlushOp(UINT32 nDev)
{
   return LLD_SUCCESS;
}
```

For detailed information about the function related to Deferred Check Operation, refer to Chapter 5.2. LLD APIs. For detailed information about the functionality of Deferred Check Operation, refer to Chapter 오류! 참조 원본을 찾을 수 없습니다.. 오류! 참조 원본을 찾을 수 없습니다..

After editing MyLLD.cpp, save the file and close it.

By far, you make a simple NAND emulator and port the device driver file MyLLD.cpp operating to the simple NAND emulator. Next, you implement a PAM file.

3.2.4. PAM Porting

PAM, a platform-dependent module, links XSR to the platform. This document shows you the process to port OAM to Win32 and port LLD by making a simple NAND emulator. You implement PAM based on that porting environment.

In `\Platform\PAM` directory, there is a template file **MyPAM.cpp** in **Template** folder. This template file contains 9 functions as follows.

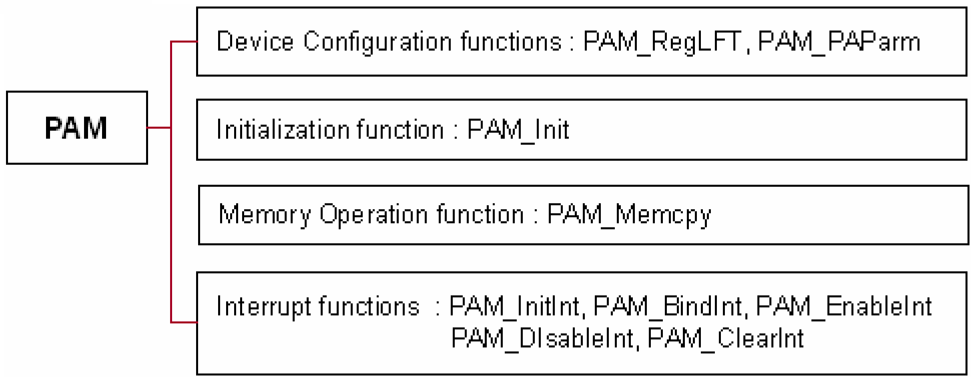

PAM
Device Configuration functions : PAM_RegLFT, PAM_PAParm
Initialization function : PAM_Init
Memory Operation function : PAM_Memcpy
Interrupt functions : PAM_InitInt, PAM_BindInt, PAM_EnableInt PAM_DIsableInt, PAM_ClearInt

Figure 3-7. PAM Function Classification

Now, port PAM to the simple NAND emulator made by LLD.

1) Make a duplicate of the existing **Template** folder in `\Platform\PAM`, and name the new folder as **MyPAM**.

   Check that there is a file **MyPAM.cpp** in the newly named folder **MyPAM**.

2) Open the existing file MyPAM.cpp in an editor.

3) Update the path of a LLD header file as follows.

   ☐ **Before Modification**

```
#include "../../../XSR/LLD/Template/MyLLD.h"
```

   ☐ **After Modification**

```
#include "../../../XSR/LLD/MyLLD/MyLLD.h"
```

   Depending on the type of the released package, the proper path of LLD header files can be different from above.

4) Do not modify initialization functions because you do not real NAND flash memory.

```
VOID
PAM_Init(VOID)
{
}
```

5) Add the following code in bold to implement a function `RegLFT`, which registers LLD to XSR.

```
VOID
PAM_RegLFT(VOID *pstFunc)
{
    LowFuncTbl *pstLFT;

    pstLFT                          = (LowFuncTbl*)pstFunc;
    pstLFT[0].Init              = MyLLD_Init;
    pstLFT[0].Open              = MyLLD_Open;
    pstLFT[0].Close             = MyLLD_Close;
    pstLFT[0].Read              = MyLLD_Read;
    pstLFT[0].Write             = MyLLD_Write;
    pstLFT[0].CopyBack          = MyLLD_CopyBack;
    pstLFT[0].Erase             = MyLLD_Erase;
    pstLFT[0].GetDevInfo        = MyLLD_GetDevInfo;
    pstLFT[0].ChkInitBadBlk     = MyLLD_ChkInitBadBlk;
    pstLFT[0].FlushOp           = MyLLD_FlushOp;
    pstLFT[0].SetRWArea         = MyLLD_SetRWArea;
    pstLFT[0].GetPrevOpData     = MyLLD_GetPrevOpData;
    pstLFT[0].IOCtl             = MyLLD_IOCtl;
    pstLFT[0].MRead             = MyLLD_MRead;
    pstLFT[0].MWrite            = MyLLD_MWrite;
    pstLFT[0].MErase            = MyLLD_MErase;
    pstLFT[0].EraseVerify       = MyLLD_EraseVerify;

}
```

RegLFT registers LLD to BML.
If you change LLD function name in MyLLD.cpp and MyLLD h, you must rename LLD function name in this function.

6) Add the following code in bold to implement a function `GetPAParm`, which configures the platform and device.

```
#define   VOL0   0
#define   VOL1   1

#define   DEV0   0
#define   DEV1   1
#define   DEV2   2
#define   DEV3   3

VOID*
PAM_GetPAParm(VOID)
{

    gstParm[VOL0].nBaseAddr[DEV0] = 0x20000000;
    gstParm[VOL0].nBaseAddr[DEV1] = NOT_MAPPED;
    gstParm[VOL0].nBaseAddr[DEV2] = NOT_MAPPED;
    gstParm[VOL0].nBaseAddr[DEV3] = NOT_MAPPED;

    gstParm[VOL0].nEccPol         = SW_ECC;
    gstParm[VOL0].nLSchemePol     = SW_LOCK_SCHEME;
    gstParm[VOL0].bByteAlign      = FALSE32;
    gstParm[VOL0].nDevsInVol      = 1;
    gstParm[VOL0].pExInfo         = NULL;

    return (VOID *) gstParm;
}
```

GetPAParm returns the information to XSR and LLD.
This example only implements **[VOL0]** and **[DEV0]** because this example uses only one device. The value **NOT_MAPPED** means that the device is not used for that device slot. In

this example, only **`[DEV0]`** is used.

`[VOL0]` has the following functionalities: it uses software ECC, it uses the software lock scheme, and it does not use byte aligning. In general, you must implement the total setting about `nBaseAddr[ ]`as many as the device number per a volume.

7) Do not modify the interrupt functions because you do not use real NAND flash memory.

```
VOID
PAM_InitInt(UINT32 nLogIntId)
{
}

VOID
PAM_BindInt(UINT32 nLogIntId)
{
}

VOID
PAM_EnableInt(UINT32 nLogIntId)
{
}

VOID
PAM_DisableInt(UINT32 nLogIntId)
{
}

VOID
PAM_ClearInt(UINT32 nLogIntId)
{
}
```

For detailed information about the interrupt functionality, refer to Chapter **오류! 참조 원본을 찾을 수 없습니다.. 오류! 참조 원본을 찾을 수 없습니다.**.

8) Do not modify the memory copy function because you do not use real NAND flash memory.

```
VOID
PAM_Memcpy(VOID *pDst, VOID *pSrc, UINT32 nLen)
{
   OAM_Memcpy(pDst, pSrc, nLen);
}
```

`PAM_Memcpy` copies data from source to destination using system supported function. In this porting example, `PAM_Memcpy` just calls `OAM_Memcpy` because you do not use real platform.

After editing MyPAM.cpp, save the file and close it.

By far, you implement MyPAM.cpp. You implement all required porting files, so create the application to execute XSR.

3.2.5. Application Creating

Now, create the application using the implemented files and test that XSR operates well.

1) To make a main file of the project, add the following code in an editor and name it as **XSRHello.cpp** in **XSR** folder.

```
#include <XSR.h>
#include <stdio.h>

#define NUM_OF_VOLS 2

#define VOL0        0
#define VOL1        1


UINT8 aRWBuf[512];

INT32
SeqWrite(UINT32 nTotalLogScts)
{
   UINT32       nIdx;
   UINT32       nIdx2;
   INT32        nErr;

   printf("       ");
   for (nIdx = 0; nIdx < nTotalLogScts; nIdx++)
   {
      printf("\b\b\b\b\b\b\b\b%-8d", nTotalLogScts - nIdx);
      for (nIdx2 = 0; nIdx2 < 512; nIdx2++)
      {
         aRWBuf[nIdx2] = (UINT8)(nIdx + nIdx2);
      }
      nErr = STL_Write(VOL0 , PARTITION_ID_FILESYSTEM,
                       nIdx, 1, aRWBuf);
      if (nErr != STL_SUCCESS) break;
   }
   printf("\b\b\b\b\b\b\b\b");

   return nErr;
}

INT32
SeqVerify(UINT32 nTotalLogScts)
{
   UINT32       nIdx;
   UINT32       nIdx2;
   INT32        nErr;

   for (nIdx = 0; nIdx < nTotalLogScts; nIdx++)
   {
      nErr = STL_Read(VOL0 , PARTITION_ID_FILESYSTEM,
                      nIdx, 1, aRWBuf);
      if (nErr != STL_SUCCESS) break;

      for (nIdx2 = 0; nIdx2 < 512; nIdx2++)
      {
         if (aRWBuf[nIdx2] != (UINT8)(nIdx + nIdx2)) break;
```

```
        }
        if (nIdx2 < 512)
        {
           nErr = 1;
           break;
        }
     }

     return nErr;
  }

  VOID
  main(VOID)
  {
     STLInfo    stSTLinfo;
     STLConfig     stSTLconfig;
     XSRPartI   stPart[NUM_OF_VOLS];
     INT32      nErr;
     UINT32     nTotalLogScts;
     UINT32     nIdx;

     printf("### Hello XSR ###\r\n");

     do
     {
        STL_Init();

        OAM_Memcpy(&stPart[VOL0].aSig, "XSRPARTI",
                     BML_MAX_PART_SIG);

        stPart[VOL0].nVer                   = 0x00010000;
        stPart[VOL0].nNumOfPartEntry        = 1;

        stPart[VOL0].stPEntry[0].nID        =
                                PARTITION_ID_FILESYSTEM;
        stPart[VOL0].stPEntry[0].nAttr      = BML_PI_ATTR_RW;
        stPart[VOL0].stPEntry[0].n1stVbn    = 0;
        stPart[VOL0].stPEntry[0].nNumOfBlks = 100;

        nErr = BML_Format(VOL0,  &stPart[VOL0],
                          BML_INIT_FORMAT);
        if (nErr != BML_SUCCESS)
        {
           printf("[:ERR] BML_Format() returns ERROR : %x\r\n",
                                                   nErr);
           break;
        }

        stSTLconfig.nFillFactor       = 100;
        stSTLconfig.nNumOfRsvUnits    = 2;
        stSTLconfig.nBlksPerUnit      = 1;
        stSTLconfig.nSnapshots        = 4;

        nErr = STL_Format(VOL0, PARTITION_ID_FILESYSTEM,
                          &stSTLconfig , 0);
        if (nErr != STL_SUCCESS)
        {
          printf("[:ERR] STL_Format() returns ERROR : %x\r\n",
                 nErr);
            break;
        }

        stSTLinfo.nSamBufFactor      = 100;
        stSTLinfo.bASyncMode         = FALSE32;

        nErr = STL_Open(VOL0, PARTITION_ID_FILESYSTEM,
                        &stSTLinfo);
        if (nErr != STL_SUCCESS)
        {
            printf("[:ERR] STL_Open() returns ERROR : %x\r\n",
                   nErr);
            break;
        }

        nTotalLogScts = stSTLinfo.nTotalLogScts;

        printf("* Simple Test()\r\n");
        for (nIdx = 0; nIdx < 10; nIdx++)
        {
            printf("\t(%2d) Write  : ", nIdx + 1);
            if (SeqWrite(nTotalLogScts) == STL_SUCCESS)
            {
                printf("OK\r\n");
            }
            else
            {
                printf("ERROR\r\n");
                break;
            }

            printf("\t    Verify : ", nIdx + 1);
            if (SeqVerify(nTotalLogScts) == STL_SUCCESS)
            {
                printf("OK\r\n");
            }
            else
            {
                printf("ERROR\r\n");
                break;
            }
        }
    } while (0);

    STL_Close(VOL0, PARTITION_ID_FILESYSTEM);

    printf("### Bye XSR ###\r\n");
}
```

2) Execute Visual Studio, and create a new Win32 Console project.
   This is an example to name the new project as **XSRHello.**

3) Include the following files in the new project **XSRHello**.
   Then, you can see the project structure as the following figure.

☐ XSR**XSRHello.cpp**
☐ XSR\OAM\MyOAM\MyOAM.cpp
☐ XSR\LLD\MyLLD\MyLLD.cpp
MyLLD.h
☐ XSR\Inc\BML.h
LLD.h
OAM.h
PAM.h
STL.h
XSR.h
XsrTypes.h
☐ XSR\lib\Generic\VS60\Retail\XSREmul.lib
☐ Platform\PAM\MyPAM\MyPAM.cpp

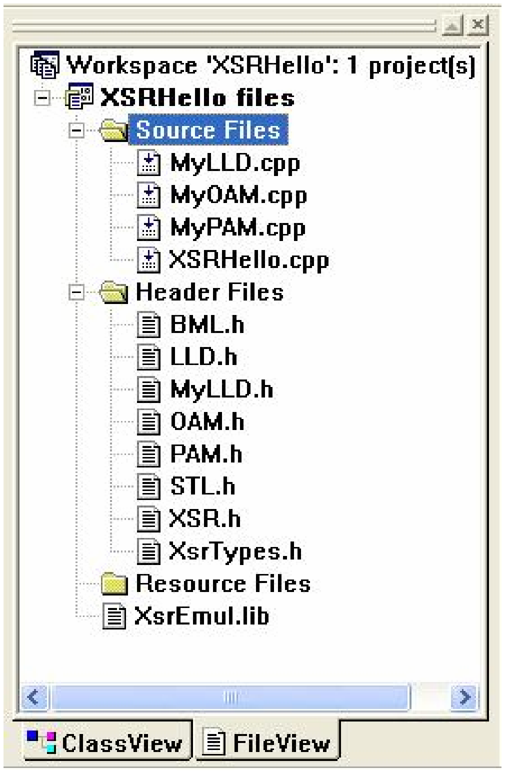

```
Workspace 'XSRHello': 1 project(s)
XSRHello files
    Source Files
        MyLLD.cpp
        MyOAM.cpp
        MyPAM.cpp
        XSRHello.cpp
    Header Files
        BML.h
        LLD.h
        MyLLD.h
        OAM.h
        PAM.h
        STL.h
        XSR.h
        XsrTypes.h
    Resource Files
    XsrEmul.lib
```

Figure 3-8. XSRHello Project Structure

4) On **Project** menu, click **Setting**, and then **Project Setting** pop-up window is opened. On **Project Setting** pop-up window, set as follows.

☐ On C/C++ tap, click General in Category list.
Add "**, OAM_RTLMSG_ENABLE**" in Preprocessor definitions text box.

☞ **Reference**

If you declare **OAM_RTLMSG_ENABLE**, XSR_RTL_PRINT() function is linked to OAM_Debug() function.
If you declare **OAM_DBGMSG_ENABLE**, XSR_DBG_PRINT() function is linked to OAM_Debug() function.

☐ On **C/C++** tap, click **Preprocesso**r in **Category** list.
Add “`../../inc`” in **Additional include directories** text box.

Now, all preparation for executing XSRHello project is done.

5) Click **Execute XSRHello.cpp** on Build menu, or press **Ctrl + F5** key, or click button on menu toolbar. Then, the project is executed.

The project is compiled and built if there is no error, and the project is performed.
The command window is opened, so you can XSRHello project is working.

```
### Hello XSR ###
* Simple Test()
       ( 1) Write  : OK
            Verify : OK
       ( 2) Write  : OK
            Verify : OK
       ( 3) Write  : OK
            Verify : OK
       ( 4) Write  : OK
            Verify : OK
       ( 5) Write  : OK
            Verify : OK
       ( 6) Write  : OK
            Verify : OK
       ( 7) Write  : OK
            Verify : OK
       ( 8) Write  : OK
            Verify : OK
       ( 9) Write  : OK
            Verify : OK
       (10) Write  : OK
            Verify : OK
### Bye XSR ###
Press any key to continue
```

Figure 3-9. XSRHello Project Working Screen

XSRHello project working process is as follows;

1. First, call STL_Init,
2. Format BML
3. Format STL
4. Open STL,
5. Then, repeat Sequential Write and Sequential Verify 10 times.

☞ **Remark**

The preceding API calling sequence is for the NAND device that is called for the first time. `BML_Format()` should be called just one time to initialize NAND device. And `STL_Format()` should be called for each RW partitions. If `BML_Format()` and `STL_Format()` are called for the NAND device before, `STL_Init()` and

`STL_Open()` are enough to next opening the NAND device.

☞ **Reference**

Sequential Write means writing data from the sector 0 to the last as many as defined sequentially.
Sequential Verify means verifying the written data from the sector 0 to the last as many as defined sequentially.

Once all working is finished, it shows "**`### Bye XSR ###`**". Press any key to close XSRHello command window.

You follow XSR porting example and execute it. Now, you can port XSR in various environments by implementing OAM, LLD and PAM.

4. OAM (OS Adaptation Module)

This chapter describes the definition, system architecture, features, and APIs of OAM.

4.1. Description & Architecture

OAM is an abbreviation of OS Adaptation Module. OAM is to receive the services that OS provides. OAM is responsible for OS-dependent part of XSR layers (STL and BML). If OS is changed, a user only changes OAM.

For example, a layer of XSR wants to write memory. The memory request service is dependent on OS. Each layer calls an adaptation module OAM to use OS functionalities. Therefore a user must implement OAM suitable for the OS when a user ports XSR.

Figure 4-1 shows OAM in XSR system architecture.

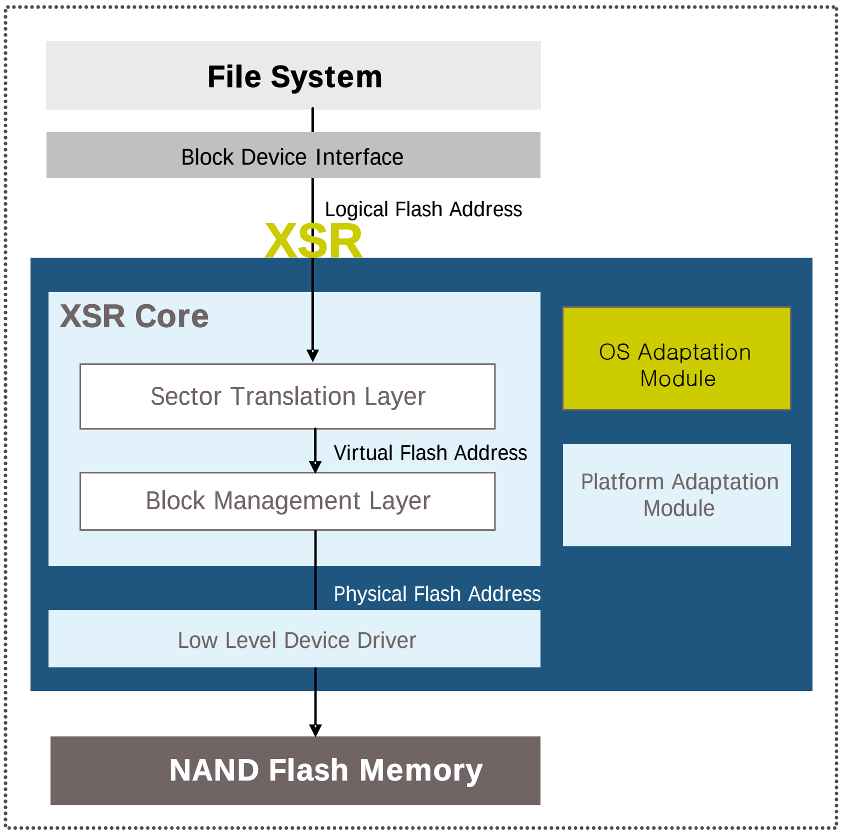


Figure 4-1. OAM in XSR System Architecture

OAM has 21 functions that are classified into 6 categories as follows.

☐ **ANSI functions** : memory allocation, memory free, memory copy, memory setting, and memory comparison

☐ **Message print function :** message print

☐ **Semaphore functions:** semaphore creation, semaphore destroy, semaphore acquire, and semaphore release

☐ **Interrupt functions:** interrupt initialization, interrupt bind, interrupt enable, interrupt disable, and interrupt clear

☐ **Timer functions :** timer setting, timer return, and time waiting

☐ **Other functions :** address translation, idle operation, RO partition check

In the next chapter, OAM APIs are covered in detail.

4.2. API

This chapter describes OAM APIs. .

☞ **Reference**

All the OAM function has a prefix "`OAM_`" on each function name.

Table 4-1 shows the lists of OAM APIs.
The right row in table shows that the function is **M**andatory or **O**ptional or **R**ecommended. Optional functions should be existed, but contents of the functions does not need to be implemented.

Table 4-1. OAM API

Function	Description	
`OAM_Malloc`	This function allocates memory for XSR.	**M**
`OAM_Free`	This function frees memory that XSR allocates.	**M**
`OAM_Memcpy`	This function copies from the source data to the destination data.	**M**
`OAM_Memset`	This function sets data of a specific buffer.	**M**
`OAM_Memcmp`	This function compares data of two buffers.	**M**
`OAM_Debug`	This function is called when XSR prints message.	**R**
`OAM_CreateSM`	This function creates the semaphore.	**O**
`OAM_DestroySM`	This function destroys the semaphore.	**O**
`OAM_AcquireSM`	This function acquires the semaphore.	**O**
`OAM_ReleaseSM`	This function releases the semaphore.	**O**
`OAM_InitInt`	This function initializes the specified logical interrupt for NAND device.	**O**
`OAM_BindInt`	This function binds the specified interrupt for NAND device.	**O**
`OAM_EnableInt`	This function enables the specified interrupt for NAND device.	**O**
`OAM_DisableInt`	This function disables the specified interrupt for NAND device.	**O**
`OAM_ClearInt`	This function clears the specified interrupt for NAND device.	**O**
`OAM_ResetTimer`	This function resets timer.	**O**
`OAM_GetTime`	This function returns the current time value.	**O**
`OAM_WaitNMSec`	This function is called for delaying as a unit of milliseconds.	**R**
`OAM_Pa2Va`	This function is called for the address translation to access to the hardware from the system using virtual memory.	**R**
`OAM_Idle`	This function is called at idle time.	**O**
`OAM_GetROLockFlag`	This function is called when XSR determines whether Partition is RO or not.	**O**

OAM_Malloc

DESCRIPTION

This function allocates memory for XSR.

SYNTAX

```
VOID *
OAM_MallocC(UINT32 nSize)
```

PARAMETERS

Parameter	Type	In/Out	Description
nSize	UINT32	In	Size to be allocated

RETURN VALUE

Return Value	Description
VOID	allocated memory buffer pointer If this function fails, the return value is NULL.

REMARKS

This function is a mandatory ANSI function. ANSI function is implemented to map one-to-one with the standard ANSI function.

This function is called by the function that wants to use memory.

EXAMPLE

(1) Example to call the function

```
#include <OAM.h>
#include <XSRTypes.h>

VOID
Example(VOID)
{
   UINT8 *MainBuf = (UINT8 *)OAM_Malloc(512);

   OAM_Free(MainBuf);
}
```

(2) Example to implement the function in Symbian

```
void *
OAM_Malloc(UINT32 nSize)
{
   return Kern::Alloc(nSize);
}
```

SEE ALSO

OAM_Free

OAM_Free

DESCRIPTION

This function frees memory that XSR allocates.

SYNTAX

```
VOID
OAM_Free(VOID  *pMem)
```

PARAMETERS

Parameter	Type	In/Out	Description
`pMem`	`VOID *`	`In`	Pointer to be free

RETURN VALUE

None

REMARKS

This function is a mandatory ANSI function. ANSI function is implemented to map one-to-one with the standard ANSI function.

This function is called by the function that wants to free memory.

EXAMPLE

(1) Example to call the function

```
#include <OAM.h>
#include <XSRTypes.h>

VOID
Example(VOID)
{
    UINT8 *MainBuf = (UINT8 *)OAM_Malloc(512);

    OAM_Free(MainBuf);
}
```

(2) Example to implement the function in Symbian

```
VOID
OAM_Free(VOID  *pMem)
{
    Kern::Free(pMem);
    return ;
}
```

SEE ALSO

`OAM_Malloc`

OAM_Memcpy

DESCRIPTION

This function copies from the source data to the destination data.

SYNTAX

```
VOID
OAM_Memcpy(VOID *pDst, VOID *pSrc, UINT32 nLen)
```

PARAMETERS

Parameter	Type	In/Out	Description
pDst	VOID *	Out	Array Pointer of destination data to be copied
pSrc	VOID *	In	Array Pointer of source data to be copied
nLen	UINT32	In	Length to be copied

RETURN VALUE

None

REMARKS

This function is a mandatory ANSI function. ANSI function is implemented to map one-to-one with the standard ANSI function.

This function is called by the function that wants to copy data in the source buffer to data in the destination buffer.

EXAMPLE

(1) Example to call the function

```
#include <OAM.h>
#include <XSRTypes.h>

VOID
Example(VOID)
{
    UINT8 *SrcBuf = (UINT8 *)OAM_Malloc(512);
    UINT8 *DstBuf = (UINT8 *)OAM_Malloc(512);

    OAM_Memcpy(DstBuf, SrcBuf, (512));
}
```

(2) Example to implement the function in Symbian

```
VOID
OAM_Memcpy(VOID *pDst, VOID *pSrc, UINT32 nLen)
{
    memcpy((TAny*)(pDst), (const TAny*)(pSrc),
            (unsigned int)nLen);
}
```

SEE ALSO

`OAM_Memset, OAM_Memcmp`

OAM_Memset

DESCRIPTION

This function sets data of a specific buffer.

SYNTAX

```
VOID
OAM_Memset(VOID *pDst, UINT8 nV, UINT32 nLen)
```

PARAMETERS

Parameter	Type	In/Out	Description
`pDst`	`VOID *`	`Out`	Array Pointer of destination data to be copied
`nV`	`UINT8`	`In`	Value to be set
`nLen`	`UINT32`	`In`	Length to be set

RETURN VALUE

None

REMARKS

This function is a mandatory ANSI function. ANSI function is implemented to map one-to-one with the standard ANSI function.

This function is called by the function that wants to set the source buffer's own data.

EXAMPLE

(1) Example to call the function

```
#include <OAM.h>
#include <XSRTypes.h>

VOID
Example(VOID)
{
    UINT8 *pBuf = (UINT8 *)OAM_Malloc(512);

    OAM_Memset(pBuf, 0xFF, (512));
}
```

(2) Example to implement the function in Symbian

```
VOID
OAM_Memset(VOID *pSrc, UINT8 nV, UINT32 nLen)
{
    memset((TAny*)(pSrc),(TInt)(nV), (unsigned int)(nLen));
}
```

SEE ALSO

`OAM_Memcpy, OAM_Memcmp`

OAM_Memcmp

DESCRIPTION

This function compares data of two buffers.

SYNTAX

```
INT32
OAM_Memcmp(VOID  *pBuf1, VOID  *pBuf2, UINT32 nLen)
```

PARAMETERS

Parameter	Type	In/Out	Description
`pBuf1`	`VOID *`	`In`	Pointer of Buffer1
`pBuf2`	`VOID *`	`In`	Pointer of Buffer2
`nLen`	`UINT32`	`In`	Length to be compared

RETURN VALUE

Return Value	Description
Negative number	When `pBuf1` is smaller than `pBuf2.`
`0`	When `pBuf1` is the same as `pBuf2.`
Positive number	When `pBuf1` is bigger than `pBuf2.`

REMARKS

This function is a mandatory ANSI function. ANSI function is implemented to map one-to-one with the standard ANSI function.

This function is called by the function that wants to compare data of two buffers.

EXAMPLE

(1) Example to call the function

```
#include <OAM.h>
#include <XSRTypes.h>

VOID
Example(VOID)
{
   UINT8 Re;
   UINT8 *pBuf1 = (UINT8 *)OAM_Malloc(512);
   UINT8 *pBuf2 = (UINT8 *)OAM_Malloc(512);

   Re = OAM_Memcmp(pBuf1, pBuf2);

   if (Re != 0)
   {
      printf(" Compare fail(%x)\n", Re);
   }
}
```

(2) Example to implement the function in Symbian

```
INT32
```

```
OAM_Memcmp(VOID  *pSrc, VOID  *pDst, UINT32 nLen)
{
    INT8 *pS1 = (UINT8 *)pSrc;
    INT8 *pD1 = (UINT8 *)pDst;

    while (nLen--)
    {
        if (*pS1 != *pD1)
            return (*pS1 - *pD1);
        pS1++;
        pD1++;
    }

    return 0;
}
```

SEE ALSO

`OAM_Memcpy, OAM_Memset`

OAM_Debug

DESCRIPTION

This function is called when XSR prints messages such as error or debug or etc.

SYNTAX

```
VOID
OAM_Debug(VOID  *pFmt, ...)
```

PARAMETERS

Parameter	Type	In/Out	Description
`pFmt`	`VOID *`	`In`	Data to be printed

RETURN VALUE

None

REMARKS

This function is recommended.

EXAMPLE

(1) Example to call the function

```
#include <OAM.h>
#include <XSRTypes.h>

VOID
Example(VOID)
{
    OAM_Debug(“Print debug message”);
}
```

(2) Example to implement the fuinction in Win32

```
VOID
OAM_Debug(VOID  *pFmt, ...)
{
    static char   aStr[4096];
    va_list       ap;

    va_start(ap, pFmt);
    vsprintf(aStr, (char *) pFmt, ap);
    printf(aStr);

    va_end(ap);
}
```

SEE ALSO

OAM_CreateSM

DESCRIPTION

This function creates the semaphore.

SYNTAX

```
BOOL32
OAM_CreateSM(SM32 *pHandle)
```

PARAMETERS

Parameter	Type	In/Out	Description
pHandle	SM32 *	Out	Handle of the semaphore to be created

RETURN VALUE

Return Value	Description
TRUE32	If this function creates the semaphore successfully, it returns TRUE32.
FALSE32	Else it returns FALSE32.

REMARKS

This function is an optional semaphore function.

This function is called by the function that wants to create the semaphore.

XSR regards the number of the semaphore token as 0 after calling OAM_CreateSM().Thus, when a user implements OAM_CreateSM(), a user should set the initial value of the semaphore token as 0.

EXAMPLE

(1) Example to call the function

```
#include <OAM.h>
#include <XSRTypes.h>

VOID
Example(VOID)
{
    SM32        nSm;

    if (OAM_CreateSM (&(nSm)) == FALSE32)
    {
        FVM_DBG_PRINT((TEXT("OAM_CreateSM Error\r\n")));
    }
}
```

(2) Example to implement the function in pSOS

```
BOOL32
OAM_CreateSM(SM32 *pHandle)
{
    BOOL32 bRet = TRUE32;
    if (sm_create("XSRS",
                  0,
                  SM_LOCAL | SM_FIFO | SM_UNBOUNDED,
                  (ULONG *)pHandle) != 0)
    {
        bRet = FALSE32;
    }

    return bRet;
}
```

SEE ALSO

`OAM_DestroySM, OAM_AcquireSM, OAM_ReleaseSM`

OAM_DestroySM

DESCRIPTION

This function destroys the semaphore.

SYNTAX

```
BOOL32
OAM_DestroySM(SM32 nHandle)
```

PARAMETERS

Parameter	Type	In/Out	Description
`nHandle`	`SM32`	`In`	Handle of the semaphore to be destroyed

RETURN VALUE

Return Value	Description
`TRUE32`	If this function destroys the semaphore successfully, it returns `TRUE32`.
`FALSE32`	Else it returns `FALSE32`.

REMARKS

This function is an optional semaphore function.

This function is called by the function that wants to destroy the semaphore.

EXAMPLE

(1) Example to call the function

```
#include <OAM.h>
#include <XSRTypes.h>

VOID
Example(VOID)
{
    SM32        nSm;

    if (OAM_CreateSM (&(nSm)) == FALSE32)
    {
        FVM_DBG_PRINT((TEXT("OAM_CreateSM Error\r\n")));
    }

    OAM_DestroySM(nSm);
}
```

(2) Example to implement the function in pSOS

```
BOOL32
OAM_DestroySM(SM32 nHandle)
{
    BOOL32 bRet = TRUE32;

    if (sm_delete(nHandle) != 0)
    {
        bRet = FALSE32;
    }

    return bRet;
}
```

SEE ALSO

OAM_CreateSM, OAM_AcquireSM, OAM_ReleaseSM

OAM_AcquireSM

DESCRIPTION

This function acquires the semaphore.

SYNTAX

```
BOOL32
OAM_AcquireSM(SM32 nHandle)
```

PARAMETERS

Parameter	Type	In/Out	Description
nHandle	SM32	In	Handle of the semaphore to be acquired

RETURN VALUE

Return Value	Description
TRUE32	If this function acquires the semaphore successfully, it returns TRUE32.
FALSE3	Else it returns FALSE32.

REMARKS

This function is an optional semaphore function.

This function is called by the function that wants to acquire the semaphore.

EXAMPLE

(1) Example to call the function

```
#include <OAM.h>
#include <XSRTypes.h>

VOID
Example(VOID)
{
   SM32      nSm;

   if (OAM_CreateSM (&nSm) == FALSE32)
   {
      FVM_DBG_PRINT((TEXT("OAM_CreateSM Error\r\n")));
   }
   OAM_ReleaseSM(nSm);

   OAM_AcquireSM(nSm);
   OAM_ReleaseSM(nSm);
}
```

(2) Example to implement the function in pSOS

```
BOOL32
OAM_AcquireSM(SM32 nHandle)
{
   BOOL32 bRet = TRUE32;
```

```
    if (sm_p(nHandle, SM_WAIT, 0) != 0)
    {
        bRet = FALSE32;
    }

    return bRet;
}
```

SEE ALSO

`OAM_CreateSM, OAM_DestroySM, OAM_ReleaseSM`

OAM_ReleaseSM

DESCRIPTION

This function releases the semaphore.

SYNTAX

```
BOOL32
OAM_ReleaseSM(SM32 nHandle)
```

PARAMETERS

Parameter	Type	In/Out	Description
nHandle	SM32	In	Handle of the semaphore to be released

RETURN VALUE

Return Value	Description
TRUE32	If this function releases the semaphore successfully, it returns TRUE32.
FALSE32	Else it returns FALSE32.

REMARKS

This function is an optional semaphore function.

This function is called by the function that wants to release the semaphore.

EXAMPLE

(1) Example to call the function

```
#include <OAM.h>
#include <XSRTypes.h>

VOID
Example(VOID)
{
    SM32        nSm;

    if (OAM_CreateSM (&(nSm)) == FALSE32)
    {
        FVM_DBG_PRINT((TEXT("OAM_CreateSM Error\r\n")));
    }
    OAM_ReleaseSM(nSm);

    OAM_AcquireSM(nSm);
    OAM_ReleaseSM(nSm);
}
```

(2) Example to implement the function in pSOS

```
BOOL32
OAM_ReleaseSM(SM32 nHandle)
{
    BOOL32 bRet = TRUE32;
    if (sm_v(nHandle) != 0)
    {
        bRet = FALSE32;
    }

    return bRet;
}
```

SEE ALSO

`OAM_CreateSM, OAM_DestroySM, OAM_AcquireSM`

OAM_InitInt

DESCRIPTION

This function initializes the specified logical interrupt for NAND device.

SYNTAX

```
VOID
OAM_InitInt(UINT32 nLogIntId)
```

PARAMETERS

Parameter	Type	In/Out	Description
`nLogIntId`	`UINT32`	`In`	Logical interrupt ID number

RETURN VALUE

None

REMARKS

This function is an optional interrupt function.
Currently, this function is used for asynchronous operation.

EXAMPLE

(1) Example to call the function

```
#include <OAM.h>
#include <XSRTypes.h>

#define   INT_ID_NAND_0   (0)    /* Interrupt ID : 1st NAND */

VOID
Example(VOID)
{
    OAM_InitInt(INT_ID_NAND_0);
}
```

(2) Example to implement the function in Symbian

```
VOID
OAM_InitInt(UINT32 nLogIntId)
{
    switch (nLogIntId)
    {
        case XSR_INT_ID_NAND_0:
            iNANDInt = new TNandInterrupt;
            break;

        default:
            break;
    }
}
```

SEE ALSO

```
OAM_BindInt, OAM_EnableInt, OAM_DisableInt, OAM_ClearInt
```

OAM_BindInt

DESCRIPTION

This function binds the specified interrupt for NAND device.

SYNTAX

```
VOID
OAM_BindInt(UINT32 nLogIntId, UINT32 nPhyIntId)
```

PARAMETERS

Parameter	Type	In/Out	Description
`nLogIntId`	`UINT32`	`In`	Logical interrupt ID number
`nPhyIntId`	`UINT32`	`In`	Physical interrupt ID number

RETURN VALUE

None

REMARKS

This function is an optional interrupt function.
Currently, this function is used for asynchronous operation.

EXAMPLE

(1) Example to call the function

```
#include <OAM.h>
#include <XSRTypes.h>

#define   INT_ID_NAND_0   (0)    /* Interrupt ID : 1st NAND */

enum TPlatformInterruptId
{
          EIrqExt0,           // IRQ 0
          EIrqExt1,           // IRQ 1
          EIrqExt2,           // IRQ 2
          EIrqExt3,           // IRQ 3
          EIrqExt4_7,         // IRQ 4
          EIrqExt8_23,        // IRQ 5
          EIrqCAM,            // IRQ 6
          EIrqBatteryFault,   // IRQ 7
          EIrqTick,           // IRQ 8
          EIrqWatchdog,       // IRQ 9
          EIrqTimer0,         // IRQ 10
          EIrqTimer1,         // IRQ 11
          EIrqTimer2,         // IRQ 12
};

VOID
Example(VOID)
{
   OAM_BindInt(INT_ID_NAND_0, EIrqExt4_7);
}
```

(2) Example to implement the function in Symbian

```
VOID
OAM_BindInt(UINT32 nLogIntId, UINT32 nPhyIntId)
{
    switch (nLogIntId)
    {
        case XSR_INT_ID_NAND_0:
            iNANDInt->Bind((TInt)nPhyIntId, NandIsr, iNANDInt);
            break;

        default:
            break;
    }
}
```

SEE ALSO

`OAM_InitInt, OAM_EnableInt, OAM_DisableInt, OAM_ClearInt`

OAM_EnableInt

DESCRIPTION

This function enables the specified interrupt for NAND device.

SYNTAX

```
VOID
OAM_EnableInt(UINT32 nLogIntId, UINT32 nPhyIntId)
```

PARAMETERS

Parameter	Type	In/Out	Description
`nLogIntId`	`UINT32`	`In`	Logical interrupt ID number
`nPhyIntId`	`UINT32`	`In`	Physical interrupt ID number

RETURN VALUE

None

REMARKS

This function is an optional interrupt function.
Currently, this function is used for asynchronous operation.

EXAMPLE

(1) Example to call the function

```
#include <OAM.h>
#include <XSRTypes.h>

#define   INT_ID_NAND_0   (0)    /* Interrupt ID : 1st NAND */

enum TPlatformInterruptId
{
          EIrqExt0,           // IRQ 0
          EIrqExt1,           // IRQ 1
          EIrqExt2,           // IRQ 2
          EIrqExt3,           // IRQ 3
          EIrqExt4_7,         // IRQ 4
          EIrqExt8_23,        // IRQ 5
          EIrqCAM,            // IRQ 6
          EIrqBatteryFault,   // IRQ 7
          EIrqTick,           // IRQ 8
          EIrqWatchdog,       // IRQ 9
          EIrqTimer0,         // IRQ 10
          EIrqTimer1,         // IRQ 11
          EIrqTimer2,         // IRQ 12
};

VOID
Example(VOID)
{
   OAM_EnableInt(INT_ID_NAND_0, EIrqExt4_7);
}
```

(2) Example to implement the function in Symbian

```
VOID
OAM_EnableInt(UINT32 nLogIntId, UINT32 nPhyIntId)
{
    switch (nLogIntId)
    {
        case XSR_INT_ID_NAND_0:
            iNANDInt->Enable((TInt)nPhyIntId);
            break;

        default:
            break;
    }
}
```

SEE ALSO

`OAM_InitInt, OAM_BindInt, OAM_DisableInt, OAM_ClearInt`

OAM_DisableInt

DESCRIPTION

This function disables the specified interrupt for NAND device.

SYNTAX

```
VOID
OAM_DisableInt(UINT32 nLogIntId, UINT32 nPhyIntId)
```

PARAMETERS

Parameter	Type	In/Out	Description
`nLogIntId`	`UINT32`	`In`	Logical interrupt ID number
`nPhyIntId`	`UINT32`	`In`	Physical interrupt ID number

RETURN VALUE

None

REMARKS

This function is an optional interrupt function.
Currently, this function is used for asynchronous operation.

EXAMPLE

(1) Example to call the function

```
#include <OAM.h>
#include <XSRTypes.h>

#define   INT_ID_NAND_0   (0)    /* Interrupt ID : 1st NAND */

enum TPlatformInterruptId
{
          EIrqExt0,             // IRQ 0
          EIrqExt1,             // IRQ 1
          EIrqExt2,             // IRQ 2
          EIrqExt3,             // IRQ 3
          EIrqExt4_7,           // IRQ 4
          EIrqExt8_23,          // IRQ 5
          EIrqCAM,              // IRQ 6
          EIrqBatteryFault,     // IRQ 7
          EIrqTick,             // IRQ 8
          EIrqWatchdog,         // IRQ 9
          EIrqTimer0,           // IRQ 10
          EIrqTimer1,           // IRQ 11
          EIrqTimer2,           // IRQ 12
};

VOID
Example(VOID)
{
   OAM_DisableInt(INT_ID_NAND_0, EIrqExt4_7);
}
```

(2) Example to implement the function in Symbian

```
VOID
OAM_DisableInt(UINT32 nLogIntId, UINT32 nPhyIntId)
{
    switch (nLogIntId)
    {
        case XSR_INT_ID_NAND_0:
            iNANDInt->Disable((TInt)nPhyIntId);
            break;

        default:
            break;
    }
}
```

SEE ALSO

`OAM_InitInt, OAM_BindInt, OAM_EnableInt, OAM_ClearInt`

OAM_ClearInt

DESCRIPTION

This function clears the specified interrupt for NAND device.

SYNTAX

```
VOID
OAM_ClearInt(UINT32 nLogIntId, UINT32 nPhyIntId)
```

PARAMETERS

Parameter	Type	In/Out	Description
`nLogIntId`	`UINT32`	`In`	Logical interrupt ID number
`nPhyIntId`	`UINT32`	`In`	Physical interrupt ID number

RETURN VALUE

None

REMARKS

This function is an optional interrupt function.
Currently, this function is used for asynchronous operation.

EXAMPLE

(1) Example to call the function

```
#include <OAM.h>
#include <XSRTypes.h>

#define   INT_ID_NAND_0   (0)    /* Interrupt ID : 1st NAND */

enum TPlatformInterruptId
{
          EIrqExt0,            // IRQ 0
          EIrqExt1,            // IRQ 1
          EIrqExt2,            // IRQ 2
          EIrqExt3,            // IRQ 3
          EIrqExt4_7,          // IRQ 4
          EIrqExt8_23,         // IRQ 5
          EIrqCAM,             // IRQ 6
          EIrqBatteryFault,    // IRQ 7
          EIrqTick,            // IRQ 8
          EIrqWatchdog,        // IRQ 9
          EIrqTimer0,          // IRQ 10
          EIrqTimer1,          // IRQ 11
          EIrqTimer2,          // IRQ 12

};

VOID
Example(VOID)
{
   OAM_ClearInt(INT_ID_NAND_0, EIrqExt4_7);
}
```

(2) Example to implement the function in Symbian

```
VOID
OAM_ClearInt(UINT32 nLogIntId, UINT32 nPhyIntId)
{
   switch (nLogIntId)
   {
      case XSR_INT_ID_NAND_0:
         iNANDInt->Clear((TInt)nPhyIntId);
         break;

      default:
         break;
   }
}
```

SEE ALSO

`OAM_InitInt, OAM_BindInt, OAM_EnableInt, OAM_DisableInt`

OAM_ResetTimer

DESCRIPTION

This function resets the timer.

SYNTAX

```
VOID
OAM_ResetTimer(VOID)
```

PARAMETERS

None

RETURN VALUE

None

REMARKS

This function is a recommended timer function.
Currently, this function is used for asynchronous operation.

In current implementation, this function does not use a timer of operating system but uses global counter variables. However, if user wants to implement the asynchronous feature based on execution time of operation, this function should be changed to use the real OS timer instead of the counter.

For more information about timer functions for asynchronous feature, refer to **오류! 참조 원본을 찾을 수 없습니다.** Timer.

EXAMPLE

(1) Example to call the function

```
#include <OAM.h>
#include <XSRTypes.h>

VOID
Example(VOID)
{
    OAM_ResetTimer();
}
```

(2) Example to implement the function in Symbian

```
static UINT32 nTimerCounter = 0;
static UINT16 nTimerPrevCnt = 0;

VOID
OAM_ResetTimer(VOID)
{
    nTimerPrevCnt = 0;
    nTimerCounter = 0;
}
```

SEE ALSO

```
       OAM_GetTime, OAM_WaitNMSec
```

OAM_GetTime

DESCRIPTION

This function returns the current time value.

SYNTAX

```
UINT32
OAM_GetTime(VOID)
```

PARAMETERS

None

RETURN TYPE

Return Type	Description
UINT32	Current time value

REMARKS

This function is a recommended timer function.
Currently, this function is used for asynchronous operation.

In current implementation, this function does not use a timer of operating system but uses global counter variables. However, if user wants to implement the asynchronous feature based on execution time of operation, this function should be changed to use the real OS timer instead of the counter.

For more information about timer functions for asynchronous feature, refer to 오류! 참조 원본을 찾을 수 없습니다. Timer.

EXAMPLE

(1) Example to call the function

```
#include <OAM.h>
#include <XSRTypes.h>

VOID
Example(VOID)
{
    UINT32    nStartTime;

    nStartTime = OAM_GetTime();
}
```

(2) Example to implement the function in Symbian

```
UINT32
OAM_GetTime(VOID)
{
    return nTimerCounter++;
}
```

SEE ALSO

```
OAM_ResetTimer, OAM_WaitNMSec
```

OAM_WaitNMSec

DESCRIPTION

This function is called for waiting as a unit of milliseconds.

SYNTAX

```
VOID
OAM_WaitNMSec(UINT32 nNMSec)
```

PARAMETERS

Parameter	Type	In/Out	Description
`nNMSec`	`UINT32`	`In`	μsec time for waiting

RETURN TYPE

None

REMARKS

This function is a recommended timer function.
Currently, this function is used to wait the time in handling Power-off error.

For more information about timer functions for power-off recovery, refer to **오류! 참조 원본을 찾을 수 없습니다.** Power-Off Recovery.

EXAMPLE

(1) Example to implement the function in Win32

```
VOID
OAM_WaitNMSec(UINT32 nNMSec)
{
    Sleep(nNMSec);
}
```

SEE ALSO

`OAM_ResetTimer, OAM_GetTime`

OAM_Pa2Va

DESCRIPTION

This function is called for the address translation to access to the hardware from the system using virtual memory.

SYNTAX

```
UINT32
OAM_Pa2Va(UINT32 nPAddr)
```

PARAMETERS

Parameter	Type	In/Out	Description
`nPAddr`	`UINT32`	`In`	Physical address of NAND device

RETURN TYPE

Return Type	Description
`UINT32`	Virtual address of NAND device that Symbian OS uses

REMARKS

This function is recommended.

EXAMPLE

(1) Example to call the function

```
#include <OAM.h>
#include <XSRTypes.h>

VOID
Example(VOID)
{
    INT32 nBaseAddr = 0x30000000;
    UINT32 nVirtualAddr;

    nVirtualAddr  = OAM_Pa2Va(nBaseAddr));
}
```

(2) Example to implement the function in Symbian

```
UINT32
OAM_Pa2Va(UINT32 nPAddr)
{
    DPlatChunkHw *NandChunk;
    TLinAddr NandVirtAddr;

    XSR_DBG_PRINT((TEXT(">Nand::Open -> OneNandPhyAddr = 0x%x"),
                 nPAddr));

    TInt r=DPlatChunkHw::New(NandChunk,nPAddr,0x80000,
                 EMapAttrSupRw|EMapAttrFullyBlocking);

    if (r != KErrNone)
    {
       XSR_DBG_PRINT((TEXT(">Nand::Open -> NandChunk->
                                    DoCreateL failed = 0x%x"), r));
       return r;
    }

    NandVirtAddr = NandChunk->LinearAddress();
    XSR_DBG_PRINT((TEXT(">Nand::Open -> OneNandVirtAddr
                                    = 0x%x"), NandVirtAddr));

    return (UINT32)NandVirtAddr;

}
```

SEE ALSO

OAM_Idle

DESCRIPTION

This function is called when XSR is at idle time.

SYNTAX

```
VOID
OAM_Idle(VOID)
```

PARAMETERS

None

RETURN TYPE

None

REMARKS

This function is optional.

If XSR is polling on the device status, this function is called.
XSR usually keep polling on device status register to perform next operation. This polling takes little time, so ,usually, this function is not needed.to implement. But, under certain condition, it is better to yield CPU to other task instead of just waiting. XSR performance will be decreased, but other task can be performed with XSR simultaneously.

Caution : Do not perform any flash memory operation (XSR operation) in this function.

EXAMPLE

(1) Example to implement the function in Symbian

```
VOID
OAM_Idle(VOID)
{
    /* Default : Do nothing */
}
```

SEE ALSO

OAM_GetROLockFlag

DESCRIPTION

This function is called when XSR determines Read Only attribute.

SYNTAX

```
BOOL32
OAM_GetROLockFlag(VOID)
```

PARAMETERS

None

RETURN TYPE

Return Type	Description
`BOOL32`	TRUE32 with RO partition.

REMARKS

This function is optional.

The function OAM_GetROLockFlag is called when XSR determines whether certain block is in Read-Only partition or not. If XSR finds it is in range of RO partition, this function is called. If it is necessary to regard blocks in RO partition as RW under certain condition, implement this function to return FALSE. Do not modify this function unless you deeply understand internal implementation of XSR. Default implementation of this function just returns TRUE.

When the RO partition should be regarded as RW, this function should return FALSE.

EXAMPLE

(1) Example to implement the function in Symbian

```
BOOL32
OAM_GetROLockFlag(VOID)
{
    return TRUE32;
}
```

SEE ALSO

5. LLD (Low Level Driver)

This chapter describes the definition, system architecture, features, and APIs of LLD.

5.1. Description & Architecture

LLD is an abbreviation of Low Level Device Driver. LLD is adaptation module of XSR. LLD accesses the real device.

XSR cannot send a command directly to the device. When XSR sends a command to the device, it is needed a kind of translator, converting XSR command to the device-understandable message. The translator is a device driver LLD. LLD directly access to the device.

☞ **Reference**

Generally, a device is a machine or hardware designed for a purpose. For example, it can include keyboards, mouse, display monitors, hard disk drives, CD-ROM players, printers, audio speakers, and etc. In this document, a device means NAND flash memory.

Generally, a device driver is a program that controls a particular type of a device. That is, a device driver converts the general input/output instruction of the Operation system to messages that the device type can understand.

For example, if XSR orders “read” command to the device, the device cannot receive “read” command of XSR itself. LLD translates “read” command for the device. Thus, the device receives “read” command not by XSR but by LLD, and executes it. Therefore, a user must implement LLD suitable for the device when a user ports XSR.

Figure 5-1 shows LLD in XSR system architecture.

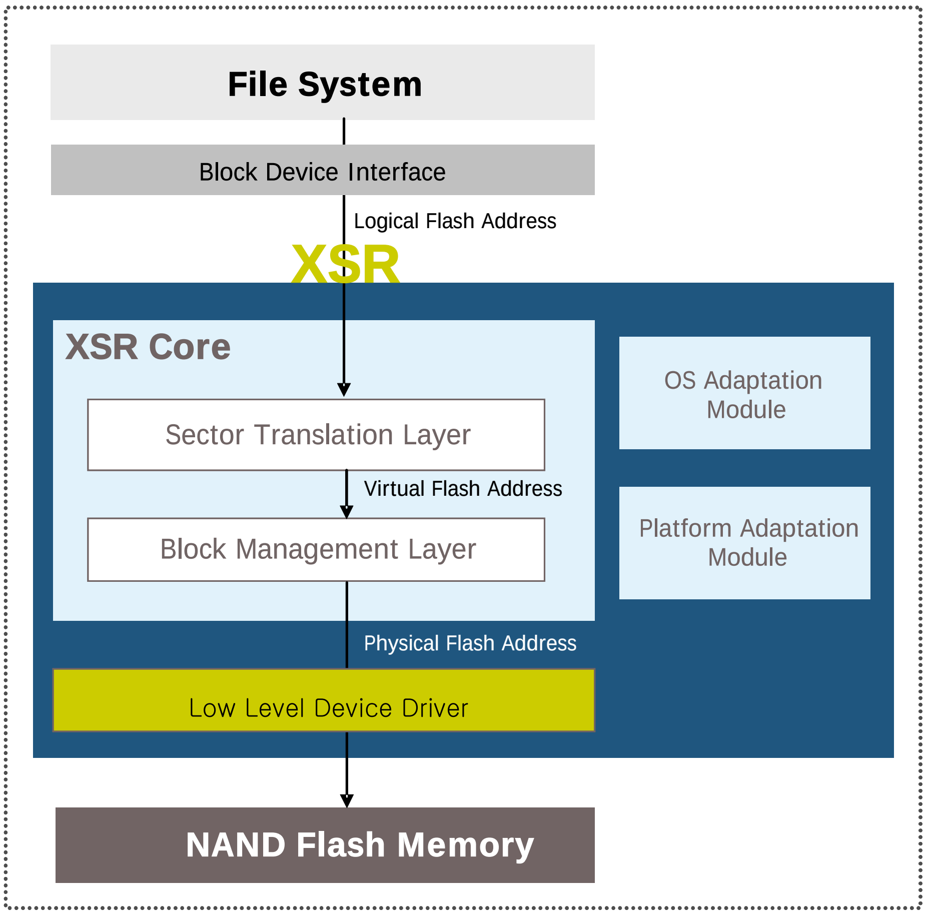


Figure 5-1. LLD in XSR System Architecture

LLD has 17 functions that are classified into 6 categories as follows.

☐ **Initialization functions** : initialization, open, and close

☐ **Device information query function** : device information return

☐ **Flash operation function** : read, write, and erase

☐ **Copyback function** : copyback

☐ **Other functions** : initial bad block check, writable area setting

☐ **Deferred Check Operation functions**

In the next chapter, LLD APIs are covered in detail.

5.2. API

This chapter describes LLD APIs.

☞ **Note**

In Table 5-1, a user can rename XXX in the function name. It is recommended to name XXX with the device name and three or four capital letters.

Table 5-1 shows the lists of LLD APIs.
The right row in table shows that the function is **M**andatory or **O**ptional or **R**ecommended. Optional functions should be existed, but contents of the functions does not need to be implemented.

Table 5-1. LLD API

Function	Description	
`XXX_Init`	This function initializes the device driver.	**M**
`XXX_Open`	This function opens the device and makes it be ready.	**M**
`XXX_Close`	This function closes the device and closes linking.	**M**
`XXX_GetDevInfo`	This function reports the device information to upper layer.	**M**
`XXX_Read`	This function reads data from a page of NAND flash memory within page boundry.	**M**
`XXX_Write`	This function writes data into a page of NAND flash memory page boundry.	**M**
`XXX_Erase`	This function erases a block of NAND flash memory.	**M**
`XXX_MRead`	This function reads data from a page of NAND flash memory within block boundary.	**M**
`XXX_MWrite`	This function writes data into a page of NAND flash memory within block boundary.	**M**
`XXX_MErase`	This function erases multiple blocks of NAND flash memory	**M**
`XXX_EraseVerify`	This function verifies an erase operation whether success or not	**M**
`XXX_CopyBack`	This function copies data by using internal buffer in the device.	**M**
`XXX_ChkInitBadBlk`	This function checks whether a block is an initial bad block or not.	**M**
`XXX_SetRWArea`	This function is called when NAND device provides write/erase protection functionality in hardware.	**O**
`XXX_IOCtl`	This function is called to extend LLD functionality.	**O**
`XXX_GetPrevOpData`	This function copies data of previous write operation to the given buffer.	**O**
`XXX_FlushOp`	This function completes the current working operation.	**O**

XXX_Init

DESCRIPTION

This function initializes XXX device driver.

SYNTAX

```
INT32
XXX_Init(VOID *pParm)
```

PARAMETERS

Parameter	Type	In/Out	Description
pParm	VOID *	In	Pointer to XsrVolParm data structure

RETURN VALUE

Return Value	Description
LLD_SUCCESS	Initialize Success
LLD_INIT_FAILURE	Initialize Failure

REMARKS

This function is a mandatory initialization function.

For more information about XsrVolParm data structure, refer to the API page of PAM_GetPAParm.

EXAMPLE

(1) Example to call the function

```
#include <XSRTypes.h>
#include <PAM.h>
#include <LLD.h>
#include <XXX.h>   /* Header File of Low Level Device Driver */

BOOL32
Example(VOID)
{
    INT32      nErr;
    UINT32     nVol = 0;
    UINT32     nBaseAddr = 0x20000000;
    LowFuncTbl stLFT[MAX_VOL];

    PAM_RegLFT((VOID *)stLFT);
    nErr = stLFT[nVol].Init((VOID *) PAM_GetPAParm());

    if (nErr != LLD_SUCCESS)
    {
        printf("XXX_Init(%d) fail. ErrCode = %x\n", nDev, nErr);
        return(FALSE32);
    }
    return(TRUE32);
}
```

(2) Example to implement the function in OneNAND

```
INT32
ONLD_Init(VOID *pParm)
{
    UINT32       nCnt;
    UINT32       nIdx;
    UINT32       nVol;
    static BOOL32 nInitFlg = FALSE32;
    XsrVolParm  *pstParm = (XsrVolParm*)pParm;

    ONLD_DBG_PRINT((TEXT("[ONLD :  IN] ++ONLD_Init()\r\n")));

    if (nInitFlg == TRUE32)
    {
         return(ONLD_SUCCESS);
    }

    for (nCnt = 0; nCnt < MAX_SUPPORT_DEVS; nCnt++)
    {
        pstPrevOpInfo[nCnt]        = (PrevOpInfo *) NULL;
        astONLDDev[nCnt].bOpen      = FALSE32;
        astONLDDev[nCnt].bPower     = FALSE32;
        astONLDDev[nCnt].pstDevSpec = NULL;
    }

    for (nVol = 0; nVol < XSR_MAX_VOL; nVol++)
    {
        for (nIdx = 0; nIdx < (XSR_MAX_DEV / XSR_MAX_VOL); nIdx++)
        {
            nCnt = nVol * (XSR_MAX_DEV / XSR_MAX_VOL) + nIdx;

            if (pstParm[nVol].nBaseAddr[nIdx] != NOT_MAPPED)
                astONLDDev[nCnt].BaseAddr
                     = OAM_Pa2Va(pstParm[nVol].nBaseAddr[nIdx]);
            else
                astONLDDev[nCnt].BaseAddr   = NOT_MAPPED;
        }
    }

    nInitFlg = TRUE32;

    ONLD_DBG_PRINT((TEXT("[ONLD : OUT] --ONLD_Init()\r\n")));

    return(ONLD_SUCCESS);
}
```

SEE ALSO

XXX_Open, XXX_Close

XXX_Open

DESCRIPTION

This function opens the device and makes it be ready.

SYNTAX

```
INT32
XXX_Open(UINT32 nDev)
```

PARAMETERS

Parameter	Type	In/Out	Description
nDev	UINT32	In	Physical Device Number (0 ~ 7)

RETURN VALUE

Return Value	Description
LLD_SUCCESS	Open Success
LLD_OPEN_FAILURE	Open Failure

REMARKS

This function is a mandatory initialization function.

EXAMPLE

(1) Example to call the function

```
#include <XSRTypes.h>
#include <PAM.h>
#include <LLD.h>
#include <XXX.h>   /* Header File of Low Level Device Driver */

BOOL32
Example(VOID)
{
    INT32     nErr;
    UINT32    nDev = 0;
    UINT32    nVol = 0;
    LowFuncTbl stLFT[MAX_VOL];

    PAM_RegLFT((VOID *)stLFT);

    nErr = stLFT[nVol].Open(nDev);

    if (nErr != LLD_SUCCESS)
    {
        printf("XXX_Open(%d) fail. ErrCode = %x\n", nDev, nErr);
        return (FALSE32);
    }
    return (TRUE32);
}
```

(2) Example to implement the function in OneNAND

```
INT32
ONLD_Open(UINT32 nDev)
{
    INT32   nCnt;
    UINT16  nMID, nDID, nVID;
    UINT32    nBAddr;
    LLDMEArg   *pstMEArg;

    SET_PWR_FLAG(nDev);

    _GetDevID(nDev, &nMID, &nDID, &nVID);

    for (nCnt = 0; astNandSpec[nCnt].nMID != 0; nCnt++)
    {
        if (nDID == astNandSpec[nCnt].nDID)
        {
            if ((nVID >> 8) == astNandSpec[nCnt].nGEN)
            {
                astONLDDev[nDev].bOpen      = TRUE32;
                astONLDDev[nDev].pstDevSpec = &astNandSpec[nCnt];
                break;
            }
            else
            {
                continue;
            }
        }
    }

    _InitDevInfo(nDev, &nDID, &nVID);

    if (astONLDDev[nDev].bOpen != TRUE32)
    {
        CLEAR_PWR_FLAG(nDev);
        return (ONLD_OPEN_FAILURE);
    }

    if (pstPrevOpInfo[nDev] == (PrevOpInfo*)NULL)
    {
        pstPrevOpInfo[nDev]
                  = (PrevOpInfo*)MALLOC(sizeof(PrevOpInfo));

        if (pstPrevOpInfo[nDev] == (PrevOpInfo*)NULL)
        {
            return (ONLD_OPEN_FAILURE);
        }
    }
    pstPrevOpInfo[nDev]->ePreOp     = NONE;
    pstPrevOpInfo[nDev]->nCmd       = 0;
    pstPrevOpInfo[nDev]->nPsn       = 0;
    pstPrevOpInfo[nDev]->nScts      = 0;
    pstPrevOpInfo[nDev]->nFlag      = 0;
    pstPrevOpInfo[nDev]->pstPreMEArg
                      = (LLDMEArg*)MALLOC(sizeof(LLDMEArg));

    pstMEArg = pstPrevOpInfo[nDev]->pstPreMEArg;
    if (pstMEArg == NULL)
    {
        return (ONLD_OPEN_FAILURE);
    }

    MEMSET(pstMEArg, 0x00, sizeof(LLDMEArg));
    pstMEArg->pstMEList
      = (LLDMEList*)MALLOC(sizeof(LLDMEList) * XSR_MAX_MEBLK);
    if (pstMEArg->pstMEList == NULL)
    {
        return (ONLD_OPEN_FAILURE);
    }

    pstMEArg->nNumOfMList = (UINT16)0x00;
    pstMEArg->nBitMapErr  = (UINT16)0x00;
    pstMEArg->bFlag       = FALSE32;

    pstPrevOpInfo[nDev]->nBufSel = DATA_BUF0;

    nBAddr = GET_DEV_BADDR(nDev);

    /* IO Buffer Enable for NAND interrupt enable/disable */
    ONLD_REG_SYS_CONF1(nBAddr) &= MASK_SYNC_BURST_READ;
    ONLD_REG_SYS_CONF1(nBAddr) |=
          (IOBE_ENABLE | BST_RD_LATENCY_4 | BST_LENGTH_8WD);

    ONLD_REG_SYS_CONF1(nBAddr) |= (SYNC_READ_MODE);

    LLD_RTL_PRINT((TEXT("[ONLD:MSG]  nNumOfBlks   = %d\r\n"),
astONLDDev[nDev].pstDevSpec->nNumOfBlks));
    LLD_RTL_PRINT((TEXT("[ONLD:MSG]  nNumOfPlanes = %d\r\n"),
astONLDDev[nDev].pstDevSpec->nNumOfPlanes));
    LLD_RTL_PRINT((TEXT("[ONLD:MSG]  nBlksInRsv   = %d\r\n"),
astONLDDev[nDev].pstDevSpec->nBlksInRsv));
    LLD_RTL_PRINT((TEXT("[ONLD:MSG]  nBadPos      = %d\r\n"),
astONLDDev[nDev].pstDevSpec->nBadPos));
    LLD_RTL_PRINT((TEXT("[ONLD:MSG]  nLsnPos      = %d\r\n"),
astONLDDev[nDev].pstDevSpec->nLsnPos));
    LLD_RTL_PRINT((TEXT("[ONLD:MSG]  nECCPos      = %d\r\n"),
astONLDDev[nDev].pstDevSpec->nEccPos));
    LLD_RTL_PRINT((TEXT("[ONLD:MSG]  nBWidth      = %d\r\n"),
astONLDDev[nDev].pstDevSpec->nBWidth));
    LLD_RTL_PRINT((TEXT("[ONLD:MSG]  nMEFlag      = %d\r\n"),
astONLDDev[nDev].pstDevSpec->nMEFlag));
    LLD_RTL_PRINT((TEXT("[ONLD:MSG]  nLKFlag      = %d\r\n"),
astONLDDev[nDev].pstDevSpec->nLKFlag));

    return (ONLD_SUCCESS);
}
```

SEE ALSO

`XXX_Init, XXX_Close`

XXX_Close

DESCRIPTION

This function closes XXX device and closes linking.

SYNTAX

```
INT32
XXX_Close(UINT32 nDev)
```

PARAMETERS

Parameter	Type	In/Out	Description
nDev	UINT32	In	Physical Device Number (0 ~ 7)

RETURN VALUE

Return Value	Description
LLD_SUCCESS	Close Success
LLD_CLOSE_FAILURE	Close Failure

REMARKS

This function is a mandatory initialization function.

EXAMPLE

(1) Example to call the function

```
#include <XSRTypes.h>
#include <PAM.h>
#include <LLD.h>
#include <XXX.h>   /* Header File of Low Level Device Driver */

BOOL32
Example(VOID)
{
   INT32     nErr;
   UINT32    nDev = 0;
   UINT32    nVol = 0;
   LowFuncTbl stLFT[MAX_VOL];

   PAM_RegLFT((VOID *)stLFT);

   nErr = stLFT[nVol].Close(nDev);

   if (nErr != LLD_SUCCESS)
   {
      printf("XXX_Close(%d) fail. ErrCode = %x\n", nDev, nErr);
      return (FALSE32);
   }
   return (TRUE32);
}
```

(2) Example to implement the function in OneNAND

```
INT32
ONLD_Close(UINT32 nDev)
{
    UINT32  nBAddr;
    INT32   nRes = ONLD_SUCCESS;

    nBAddr = GET_DEV_BADDR(nDev);

    if ((nRes =ONLD_FlushOp(nDev)) != ONLD_SUCCESS)
    {
        return nRes;
    }

    if (pstPrevOpInfo[nDev] != (PrevOpInfo*)NULL)
    {
        FREE(pstPrevOpInfo[nDev]->pstPreMEArg->pstMEList);
        pstPrevOpInfo[nDev]->pstPreMEArg->pstMEList
                                     = (LLDMEList*)NULL;
        FREE(pstPrevOpInfo[nDev]->pstPreMEArg);
        pstPrevOpInfo[nDev]->pstPreMEArg = (LLDMEArg*)NULL;

        FREE(pstPrevOpInfo[nDev]);
        pstPrevOpInfo[nDev] = (PrevOpInfo*)NULL;
    }

    astONLDDev[nDev].bOpen      = FALSE32;
    astONLDDev[nDev].bPower     = FALSE32;
    astONLDDev[nDev].pstDevSpec = NULL;

    return (ONLD_SUCCESS);
}
```

SEE ALSO

`XXX_Init, XXX_Open`

XXX_GetDevInfo

DESCRIPTION

This function reports the device information to upper layer.

SYNTAX

```
INT32
XXX_GetDevInfo(UINT32 nDev, LLDSpec* pstDevInfo)
```

PARAMETERS

Parameter	Type	In/Out	Description
nDev	UINT32	In	Physical Device Number (0 ~ 7)
pstDevInfo	LLDSpec *	Out	Data structure of device information

RETURN VALUE

Return Value	Description
LLD_SUCCESS	Sending the requested information
LLD_ILLEGAL_ACCESS	Illegal Access

REMARKS

This function is a mandatory device information query function.

LLDSpec data structure is declared in LLD.h.

☐ **LLDSpec** data structure

```
typedef struct {                                /* offset size */
    UINT8   nMCode;      /* Manufacturer Code     0x00   1  */
    UINT8   nDCode;      /* Device Code           0x01   1  */
    UINT16  nNumOfBlks;  /* The Number of Blocks 0x02   2  */
    UINT16  nPgsPerBlk;  /* The Number of Pages per Block
                                                  0x04   2  */
    UINT16  nBlksInRsv;  /* The Number of Blocks 0x06   2
                               in Reserved Block Pool      */
    UINT8   nSctsPerPg;  /* The Number of Sectors per Page
                                                  0x08   1  */
    UINT8   nNumOfPlane; /* The Number of Plane   0x09   1  */
    UINT8   nMEFlag;     /* Multi-block Erase Flag 0x0A 1  */

    UINT8   nBWidth;     /* Device Bus Width      0x0C   1  */
    UINT8   nBadPos;     /* BadBlock Information Position
                                                  0x0E   1  */
    UINT8   nLsnPos;     /* LSN Position          0x0E   1  */
    UINT8   nEccPos;     /* ECC Value Position    0x0F   1  */


    UINT8   aUID[XSR_UID_SIZE]; /* UID          0x10   16,
                                0xFF(absence case of UID)  */
    UINT16  nTrTime; /* Physical Read Operation Time  0x20  2 */
    UINT16  nTwTime; /* Physical Write Operation Time  0x22  2 */
    UINT16  nTeTime; /* Physical Erase Operation Time  0x24  2 */
    UINT16  nTfTime; /* Data Transfer Time            0x26  2 */
} LLDSpec;
```

Table 5-2 explains `LLDSpec` data structure.

Table 5-2. LLDSpec in LLD.h

Member Variable	Member Variable
`nMCode`	Manufacturer code of a device
`nDCode`	Device code
`nNumOfBlks`	Total number of blocks of a device
`nPgsPerBlk`	The number of pages per one block of a device
`nBlksInRsv`	The number of blocks in reserved block pool
`nSctsPerPg`	The number of sectors per one page of device
`nNumOfPlane`	The number of planes of a device
`nMEFlag`	Flag for multi-block erase
`nBWidth`	Device bus width
`nBadPos`	Bad block information position
`nLsnPos`	Position to store LSN
`nECCPos`	Position to store ECC value
`aUID [XSR_UID_SIZE]`	Unique ID of device
`nTrTime`	Physical read operation time of a device (nsec)
`nTwTime`	Physical write operation time of a device (nsec)
`nTeTime`	Physical erase operation time of a device (nsec)
`nTfTime`	Data transfer time of a device (nsec)

Here is more detailed explanation about LLDSpec.

☐ nBlksInRsv

In general, NAND flash memory can contain bad block. `nBlksInRsv` is the number of the reserved block in NAND flash memory. The related information about the number of the reserved block is described in “VALID BLOCK” chapter inside data sheet of flash memory. In VALID BLOCK chapter, the maximum valid block number and the minimum valid block number is marked. `nBlksInRsv` is the remainder between the maximum valid block number and the minimum valid block number.

☐ nNumOfPlane

`nNumOfPlane` is the number of planes in NAND flash memory. NAND flash memory can consists of one or more planes internally.

☐ nMEFlag

`nMEFlag` means whether NAND flash memory support multi-block erase functionality or not. If NAND flash memory supports multi-block erase, `nMEFlag` can have LLD_ME_OK or LLD_ME_NO. However, NAND flash memory does not support multi-block erase, `nMEFlag` must have LLD_ME_NO. (For more information about which device supports multi-block erase, refer to the Specification of NAND flash memory.)

☐ nBWidth

`nBWidth` is the data bus width in NAND flash memory. The data bus of NAND flash memory can be 8bit or 16bit. If the data bus is 8bit, nBWidth becomes `LLD_BW_X08`. If

the data bus is 16bit, nBWidth becomes `LLD_BW_X16`.
This value is used at software ECC module in BML. If this value is abnormal, the return value of software ECC can be abnormal.

☐ nBadPos

To show a bad block, the blocks of NAND flash memory records the specific value at the specific position of spare array. `nBadPos` is offset of the bad block position of spare array.
`nBadPos` depends on the kind of NAND flash memory. A user can know `nBadPos` in the data sheet of NAND flash memory or "Samsung NAND flash Spare Area Assignment Standard (21.Feb.2003)".

☐ nLsnPos

`nLsnPos` is offset that the first byte of LSN(Logical Sector Number) of spare array is located.
`nLsnPos` depends on the kind of NAND flash memory. A user can know `nLsnPos` in the data sheet of NAND flash memory or "Samsung NAND flash Spare Area Assignment Standard (21.Feb.2003)".

☐ nEccPos

`nEccPos` is offset that the first byte of ECC of spare array is located.
`nEccPos` depends on the kind of NAND flash memory. A user can know `nEccPos` in the data sheet of NAND flash memory or "Samsung NAND flash Spare Area Assignment Standard (21.Feb.2003)".

EXAMPLE

(1) Example to call the function

```
#include <XSRTypes.h>
#include <PAM.h>
#include <LLD.h>
#include <XXX.h>   /* Header File of Low Level Device Driver */

BOOL32
Example(VOID)
{
   INT32      nErr;
   UINT32     nDev = 0;
   UINT32     nVol = 0;
   LLDSpec    stDevInfo;
   LowFuncTbl stLFT[MAX_VOL];

   PAM_RegLFT((VOID *)stLFT);

   nErr = stLFT[nVol].GetDevInfo(nDev, &stDevInfo);

   if (nErr != LLD_SUCCESS)
   {
      printf("XXX_ GetDevInfo()fail. ErrCode = %x\n", nErr);
      return (FALSE32);
   }
   return (TRUE32);
}
```

(2) Example to implement the function in OneNAND

```
INT32
ONLD_GetDevInfo(UINT32 nDev, LLDSpec *pstFILDev)
{
    UINT32 nBAddr;

    if (astONLDDev[nDev].pstDevSpec == NULL)
    {
        return(ONLD_ILLEGAL_ACCESS);
    }

    nBAddr = GET_DEV_BADDR(nDev);

    pstFILDev->nMCode
            = (UINT8)astONLDDev[nDev].pstDevSpec->nMID;
    pstFILDev->nDCode
            = (UINT8)astONLDDev[nDev].pstDevSpec->nDID;
    pstFILDev->nNumOfBlks
            = (UINT16)astONLDDev[nDev].pstDevSpec->nNumOfBlks;
    pstFILDev->nPgsPerBlk   = (UINT16)GET_PGS_PER_BLK(nDev);
    pstFILDev->nBlksInRsv
            = (UINT16)astONLDDev[nDev].pstDevSpec->nBlksInRsv;

    pstFILDev->nSctsPerPg   = (UINT8)GET_SCTS_PER_PG(nDev);
    pstFILDev->nNumOfPlane
            =(UINT8)astONLDDev[nDev].pstDevSpec->nNumOfPlanes;

    pstFILDev->nBadPos
            = (UINT8)astONLDDev[nDev].pstDevSpec->nBadPos;
    pstFILDev->nLsnPos
            = (UINT8)astONLDDev[nDev].pstDevSpec->nLsnPos;
    pstFILDev->nEccPos
            = (UINT8)astONLDDev[nDev].pstDevSpec->nEccPos;
    pstFILDev->nBWidth
            = (UINT8)astONLDDev[nDev].pstDevSpec->nBWidth;
    pstFILDev->nMEFlag
            = (UINT8)astONLDDev[nDev].pstDevSpec->nMEFlag;

    pstFILDev->aUID[0]      = 0xEC;
    pstFILDev->aUID[1]      = 0x00;
    pstFILDev->aUID[2]      = 0xC5;
    pstFILDev->aUID[3]      = 0x5F;
    pstFILDev->aUID[4]      = 0x3D;
    pstFILDev->aUID[5]      = 0x12;
    pstFILDev->aUID[6]      = 0x34;
    pstFILDev->aUID[7]      = 0x37;
    pstFILDev->aUID[8]      = 0x34;
    pstFILDev->aUID[9]      = 0x33;
    pstFILDev->aUID[10]     = 0x30;
    pstFILDev->aUID[11]     = 0x30;
    pstFILDev->aUID[12]     = 0x03;
    pstFILDev->aUID[13]     = 0x03;
    pstFILDev->aUID[14]     = 0x06;
    pstFILDev->aUID[15]     = 0x02;

    pstFILDev->nTrTime
           = (UINT32)astONLDDev[nDev].pstDevSpec->nTrTime;
    pstFILDev->nTwTime
           = (UINT32)astONLDDev[nDev].pstDevSpec->nTwTime;
    pstFILDev->nTeTime
           = (UINT32)astONLDDev[nDev].pstDevSpec->nTeTime;
    pstFILDev->nTfTime
```

```
            = (UINT32)astONLDDev[nDev].pstDevSpec->nTfTime;

    return (ONLD_SUCCESS);
}
```

SEE ALSO

XXX_Read

DESCRIPTION

This function reads data from NAND flash memory. XXX_Read, unlikely XXX_MRead, only read sectors within a page boundry. The sector number of the large block and small block are different.

SYNTAX

```
INT32
XXX_Read(UINT32 nDev, UINT32 nPsn, UINT32 nNumOfScts, UINT8
*pMBuf, UINT8 *pSBuf, UINT32 nFlag)
```

PARAMETERS

Parameter	Type	In/Out	Description
`nDev`	`UINT32`	`In`	Physical Device Number (0 ~ 7)
`nPsn`	`UINT32`	`In`	Physical Sector Number
`nNumOfScts`	`UINT32`	`In`	Number of sectors
`pMBuf`	`UINT8 *`	`Out`	Memory buffer for main array of NAND flash memory
`pSBuf`	`UINT8 *`	`Out`	Memory buffer for spare array of NAND flash memory
`nFlag`	`UINT32`	`In`	Operation options (ECC on/off)

`nFlag` has the the operation options as follows.

Flag	Value	Description
`LLD_FLAG_ECC_ON`	`(1<<1)`	ECC on (Read Operation with ECC)
`LLD_FLAG_ECC_OFF`	`(0<<1)`	ECC off (Read Operation without ECC)

RETURN VALUE

Return Value	Description
`LLD_SUCCESS`	Read Success
`LLD_READ_ERROR | ECC result code`	Data Integrity Fault (1 or 2bit ECC error) This return value is available only in case of using Hardware ECC.
`LLD_PREV_WRITE_ERROR | LLD_PREV_OP_RESULT`	In DCOP (Deferred Check Operation), previous write error happens.
`LLD_PREV_ERASE_ERROR | LLD_PREV_OP_RESULT`	In DCOP (Deferred Check Operation), previous erase error happens.
`LLD_ILLEGAL_ACCESS`	Illegal Read Operation
`LLD_READ_DISTURBANCE`	1bit ECC error by read disturbance happens.

REMARKS

This function is a mandatory flash operation function.

DCOP (Deferred Check Operation) : a method optimizing the operation performance. The DCOP method is a procedure to terminate the function (write or erase) right after the command issue. Then it checks the result of the operation at next function call.

The parameters `nPsn` and `nNumOfScts` read data as a unit of a sector.
For more information about the byte alignment, refer to 오류! 참조 원본을 찾을 수

EXAMPLE

(1) Example to call the function

```
#include <XSRTypes.h>
#include <PAM.h>
#include <LLD.h>
#include <XXX.h>   /* Header File of Low Level Device Driver */

BOOL32
Example(VOID)
{
    INT32     nErr;
    UINT32    nDev = 0;
    UINT32    nVol = 0;
    UINT32    nPSN = 0;
    UINT32    nNumOfScts = 1;
    UINT8     aMBuf[LLD_MAIN_SIZE];
    UINT8     aSBuf[LLD_SPARE_SIZE];
    UINT32    nFlag = LLD_FLAG_ECC_ON;
    LowFuncTbl stLFT[MAX_VOL];

    PAM_RegLFT((VOID *)stLFT);

    nErr = stLFT[nVol].Read(nDev, nPSN, nNumOfScts, aMBuf,
                            aSBuf, nFlag);

    if (nErr != LLD_SUCCESS)
    {
        printf("XXX_Read() fail. ErrCode = %x\n", nErr);
        return (FALSE32);
    }
    return (TRUE32);
}
```

(2) Example to implement the function in OneNAND

```
INT32
ONLD_Read(UINT32 nDev, UINT32 nPsn, UINT32 nScts,
         UINT8 *pMBuf, UINT8 *pSBuf, UINT32 nFlag)
{
    UINT32  nCnt;
    UINT16  nBSA;
    UINT32 *pONLDMBuf;
    UINT32 *pONLDSBuf;
    UINT32  nBAddr;
    UINT16  nPbn;
    UINT32  nPpn;
    UINT16  nEccRes     = (UINT16)0x0;
    UINT16  nEccMask    = (UINT16)0x0;
    UINT32  nPsnO       = nPsn;
    UINT32  nSctsO      = nScts;
    INT32   nRes;

    nBAddr = GET_DEV_BADDR(nDev);

    if ((pMBuf == NULL) && (pSBuf == NULL))
    {
        return (ONLD_ILLEGAL_ACCESS);
    }

    nPbn = GET_PBN(nDev, nPsn);
    nPpn = GET_PPN(nDev, nPsn);

    /* ECC Value Bit Mask Setting */
    for (nCnt = 0; nCnt < nScts; nCnt++)
    {
        if (pMBuf != NULL)
        {
            nEccMask |= (0x08 << (nCnt * 4));
        }
        if (pSBuf != NULL)
        {
            nEccMask |= (0x02 << (nCnt * 4));
        }
    }

    if ((nRes = _ChkPrevOpResult(nDev)) != ONLD_SUCCESS)
    {
        pstPrevOpInfo[nDev]->ePreOp = NONE;
        return nRes;
    }

    ONLD_REG_START_ADDR2(nBAddr) = (UINT16)MAKE_DBS(nPbn);

    /* Block Number Set */
    ONLD_REG_START_ADDR1(nBAddr) = (UINT16)MAKE_FBA(nPbn);

    /* Sector Number Set */
    ONLD_REG_START_ADDR8(nBAddr)
          = (UINT16)(
         ((nPsn << astONLDInfo[nDev].nFPASelSft) & MASK_FPA)
         | (nPsn & astONLDInfo[nDev].nFSAMask));

    nBSA = (UINT16)MAKE_BSA(nPsn, GET_NXT_BUF_SEL(nDev));

    /* Start Buffer Selection */
    ONLD_REG_START_BUF(nBAddr)
         = (UINT16)((nBSA & MASK_BSA) | (nScts & MASK_BSC));

    if (nFlag & ONLD_FLAG_ECC_ON)
    {
        /* System Configuration Reg set (ECC On)*/
        ONLD_DBG_PRINT((TEXT("[ONLD : MSG]  ECC ON\r\n")));
        ONLD_REG_SYS_CONF1(nBAddr) &= CONF1_ECC_ON;
    }
    else
    {
        /* System Configuration Reg set (ECC Off)*/
        ONLD_DBG_PRINT((TEXT("[ONLD : MSG]  ECC OFF\r\n")));
        ONLD_REG_SYS_CONF1(nBAddr) |= CONF1_ECC_OFF;
    }

    /* INT Stat Reg Clear */
    ONLD_REG_INT(nBAddr)        = (UINT16)INT_CLEAR;
    /*-------------------------------------------*/
    /*ONLD Read CMD is issued                    */
    /*-------------------------------------------*/
    if (pMBuf != NULL)
    {
        /* Page Read Command issue */
        ONLD_DBG_PRINT((TEXT("[ONLD : MSG]  Read Page\r\n")));
        ONLD_REG_CMD(nBAddr)
                = (UINT16)ONLD_CMD_READ_PAGE;
    }
    else
    {
        /* Spare Read Command issue */
        ONLD_DBG_PRINT((TEXT("[ONLD : MSG]  Read Spare\r\n")));
        ONLD_REG_CMD(nBAddr)
                = (UINT16)ONLD_CMD_READ_SPARE;
    }

    while (GET_ONLD_INT_STAT(nBAddr, PEND_READ)
               !=  (UINT16)PEND_READ)
    {
        /* Wait until device ready */
    }

    pONLDMBuf = (UINT32*)GET_ONLD_MBUF_ADDR(
                        nBAddr, nPsn0, GET_NXT_BUF_SEL(nDev));
    pONLDSBuf = (UINT32*)GET_ONLD_SBUF_ADDR(nBAddr,
                        nPsn0, GET_NXT_BUF_SEL(nDev));

    if (pMBuf != NULL)
    {
        /* Memcopy for main data */
        _ReadMain(pMBuf, pONLDMBuf, nScts0);

    }
    if (pSBuf != NULL)
    {
        /* Memcopy for spare data */
        _ReadSpare(pSBuf, pONLDSBuf, nScts0);

    }

    pstPrevOpInfo[nDev]->nBufSel    = GET_NXT_BUF_SEL(nDev);

    if (nFlag & ONLD_FLAG_ECC_ON)
    {
        nEccRes = (ONLD_REG_ECC_STAT(nBAddr) & nEccMask);

        if (nEccRes != 0)
        {
            return (ONLD_READ_ERROR | nEccRes);
        }
    }

    return (ONLD_SUCCESS);
}
```

SEE ALSO

`XXX_Write, XXX_Erase, XXX_Copyback, XXX_MRead, XXX_MWrite, XXX_MErase, XXX_EraseVerify`

XXX_Write

DESCRIPTION

This function writes data into NAND flash memory. XXX_Write, unlikely XXX_MWrite, only write sectors within a page boundry. The sector number of the large block and small block are different.

SYNTAX

```
INT32
XXX_Write(UINT32 nDev, UINT32 nPsn, UINT32 nNumOfScts, UINT8
*pMBuf, UINT8 *pSBuf, UINT32 nFlag)
```

PARAMETERS

Parameter	Type	In/Out	Description
`nDev`	`UINT32`	`In`	Physical Device Number (0 ~ 7)
`nPsn`	`UINT32`	`In`	Physical Sector Number
`nNumOfScts`	`UINT32`	`In`	Number of sectors
`pMBuf`	`UINT8 *`	`In`	Memory buffer for main array of NAND flash memory
`pSBuf`	`UINT8 *`	`In`	Memory buffer for spare array of NAND flash memory
`nFlag`	`UINT32`	`In`	Operation options (ECC on/off, Sync/Async)

`nFlag` has the the operation options as follows.

Flag	Value	Description
`LLD_FLAG_ASYNC_OP`	`(1<<0)`	Asynchronous Operation
`LLD_FLAG_SYNC_OP`	`(0<<0)`	Synchronous Operation
`LLD_FLAG_ECC_ON`	`(1<<1)`	ECC on (Read Operation with ECC)
`LLD_FLAG_ECC_OFF`	`(0<<1)`	ECC off (Read Operation without ECC)

Flag value is devided into Sync/Async Operation flag and ECC on/off flag. These two flags can be merged as follow.

```
nFlag = LLD_FLAG_SYNC_OP | LLD_FLAG_ECC_ON;
```

RETURN VALUE

Return Value	Description
`LLD_SUCCESS`	Write Success
`LLD_WRITE_ERROR`	Write Failure
`LLD_PREV_WRITE_ERROR|LLD_PREV_OP_RESULT`	In DCOP (Deferred Check Operation), previous write error happens
`LLD_PREV_ERASE_ERROR|LLD_PREV_OP_RESULT`	In DCOP (Deferred Check Operation), previous erase error happens
`LLD_WR_PROTECT_ERROR`	Write Operation at Locked Area
`LLD_ILLEGAL_ACCESS`	Illegal Write Operation

REMARKS

This function is a mandatory flash operation function.

DCOP(Deferred Check Operation) : a method optimizing the operation performance. The DCOP method is a procedure to terminate the function (write or erase) right after the command issue. Then it checks the result of the operation at next function call.

The parameters `nPsn` and `nNumOfScts` write data as a unit of a sector.
For more information about the byte alignment, refer to Chapter 오류! 참조 원본을 찾을 수 없습니다. 오류! 참조 원본을 찾을 수 없습니다..

In order to support asynchronous mode, codes which execute next steps must be added. First, check the value of a flag. And then, clear an interrupt. Finally, enable the interrupt.
For more information about the interrupt, refer to Chapter 오류! 참조 원본을 찾을 수 없습니다. 오류! 참조 원본을 찾을 수 없습니다..

EXAMPLE

(1) Example to call the function

```
#include <XSRTypes.h>
#include <PAM.h>
#include <LLD.h>
#include <XXX.h>   /* Header File of Low Level Device Driver */

BOOL32
Example(VOID)
{
   INT32     nErr;
   UINT32    nDev = 0;
   UINT32    nVol = 0;
   UINT32    nPSN = 0;
   UINT32    nNumOfScts = 4;
   UINT8     aMBuf[LLD_MAIN_SIZE * 4];
   UINT8     aSBuf[LLD_SPARE_SIZE * 4];
   UINT32    nFlag = LLD_FLAG_ASYNC_OP | LLD_FLAG_ECC_ON;
   LowFuncTbl stLFT[MAX_VOL];

   PAM_RegLFT((VOID *)stLFT);

   nErr = stLFT[nVol].Write(nDev, nPSN, nNumOfScts, aMBuf,
                             aSBuf, nFlag);

   if (nErr != LLD_SUCCESS)
   {
      printf("XXX_Write() fail. ErrCode = %x\n", nErr);
      return (FALSE32);
   }
   return (TRUE32);
}
```

(2) Example to implement the function in OneNAND

```
INT32
ONLD_Write(UINT32 nDev, UINT32 nPsn, UINT32 nScts, UINT8 *pMBuf,
UINT8 *pSBuf,
         UINT32 nFlag)
{
   UINT16  nBSA;
   UINT32 *pONLDMBuf, *pONLDSBuf;
   UINT32  nBAddr;
   UINT32  nPbn;
```

```
    INT32   nRes;

    nBAddr = GET_DEV_BADDR(nDev);

    if ((pMBuf == NULL) && (pSBuf == NULL))
    {
       return (ONLD_ILLEGAL_ACCESS);
    }

    nPbn = GET_PBN(nDev, nPsn);

    if ((GET_DEV_DID(nDev) & 0x0008) == DDP_CHIP)
    {
       if ((nRes = _ChkPrevOpResult(nDev)) != ONLD_SUCCESS)
       {
           return nRes;
       }
    }
    /* Device BufferRam Select */
    ONLD_REG_START_ADDR2(nBAddr) = (UINT16)MAKE_DBS(nPbn);

    pONLDMBuf = (UINT32*)GET_ONLD_MBUF_ADDR(
                         nBAddr, nPsn, GET_NXT_BUF_SEL(nDev));
    pONLDSBuf = (UINT32*)GET_ONLD_SBUF_ADDR(
                         nBAddr, nPsn, GET_NXT_BUF_SEL(nDev));

    if (pMBuf != NULL)
    {
       /* Memcopy for main data */
       _WriteMain(pMBuf, pONLDMBuf, nScts);
    }

    if (pSBuf != NULL)
    {
       /* Memcopy for spare data */
       _WriteSpare(pSBuf, pONLDSBuf, nScts);
    }
    else
    {
       /* Memset for spare data 0xff*/
       MEMSET(pONLDSBuf, 0xFF, (ONLD_SPARE_SIZE * nScts));
    }

    if ((GET_DEV_DID(nDev) & 0x0008) != DDP_CHIP)
    {
       if ((nRes = _ChkPrevOpResult(nDev)) != ONLD_SUCCESS)
       {
          return nRes;
       }
    }

    /* Block Number Set */
    ONLD_REG_START_ADDR1(nBAddr) = (UINT16)MAKE_FBA(nPbn);
    /* Sector Number Set */
    ONLD_REG_START_ADDR8(nBAddr) = (UINT16)(
         ((nPsn << astONLDInfo[nDev].nFPASelSft) & MASK_FPA)
         | (nPsn & astONLDInfo[nDev].nFSAMask));
    nBSA = (UINT16)MAKE_BSA(nPsn, GET_NXT_BUF_SEL(nDev));

    ONLD_REG_START_BUF(nBAddr)   =
         (UINT16)((nBSA & MASK_BSA) | (nScts & MASK_BSC));

    if (nFlag & ONLD_FLAG_ECC_ON)
    {
        /* System Configuration Reg set (ECC On)*/
        ONLD_DBG_PRINT((TEXT("[ONLD : MSG]  ECC ON\r\n")));
        ONLD_REG_SYS_CONF1(nBAddr) &= CONF1_ECC_ON;
    }
    else
    {
        /* System Configuration Reg set (ECC Off)*/
        ONLD_DBG_PRINT((TEXT("[ONLD : MSG]  ECC OFF\r\n")));
        ONLD_REG_SYS_CONF1(nBAddr) |= CONF1_ECC_OFF;
    }

    /* in case of async mode, interrupt should be enabled */
    if (nFlag & ONLD_FLAG_ASYNC_OP)
    {
        PAM_ClearInt((UINT32)XSR_INT_ID_NAND_0);
        PAM_EnableInt((UINT32)XSR_INT_ID_NAND_0);
    }

    /* INT Stat Reg Clear */
    ONLD_REG_INT(nBAddr)       = (UINT16)INT_CLEAR;

    /*-----------------------------------------------*/
    /* ONLD Write CMD is issued                      */
    /*----------------------------------------------*/
    if (pMBuf != NULL)
    {
        /* Main Write Command issue */
        ONLD_DBG_PRINT((TEXT("[ONLD : MSG]  Write Page\r\n")));
        ONLD_REG_CMD(nBAddr) = (UINT16)ONLD_CMD_WRITE_PAGE;
    }
    else
    {
        /* Spare Write Command issue */
        ONLD_DBG_PRINT((TEXT("[ONLD : MSG]  Write Spare\r\n")));
        ONLD_REG_CMD(nBAddr) = (UINT16)ONLD_CMD_WRITE_SPARE;
    }
    pstPrevOpInfo[nDev]->ePreOp    = WRITE;
    pstPrevOpInfo[nDev]->nPsn      = nPsn;
    pstPrevOpInfo[nDev]->nScts     = nScts;
    pstPrevOpInfo[nDev]->nFlag     = nFlag;
    pstPrevOpInfo[nDev]->nBufSel   = GET_NXT_BUF_SEL(nDev);

    return (ONLD_SUCCESS);
}
```

SEE ALSO

XXX_Read, XXX_Erase, XXX_Copyback, XXX_MRead, XXX_MWrite, XXX_MErase, XXX_EraseVerify

XXX_Erase

DESCRIPTION

This function erases a block of NAND flash memory.

SYNTAX

```
INT32
XXX_Erase(UINT32 nDev, UINT32 nPbn, UINT32 nFlag)
```

PARAMETERS

Parameter	Type	In/Out	Description
nDev	UINT32	In	Physical Device Number (0 ~ 7)
nPbn	UINT32	In	Physical Block Number
nFlag	UINT32	In	Operation options (Sync/Async)

nFlag has the the operation options as follows.

Flag	Value	Description
LLD_FLAG_ASYNC_OP	(1<<0)	Asynchronous Operation
LLD_FLAG_SYNC_OP	(0<<0)	Synchronous Operation

RETURN VALUE

Return Value	Description
LLD_SUCCESS	Erase Success
LLD_ERASE_ERROR	Erase Failure
LLD_WR_PROTECT_ERROR	Erase Operation Error at Locked Area
LLD_PREV_WRITE_ERROR| LLD_PREV_OP_RESULT	In DCOP (Deferred Check Operation), previous write error happens
LLD_PREV_ERASE_ERROR| LLD_PREV_OP_RESULT	In DCOP (Deferred Check Operation), previous erase error happens
LLD_ILLEGAL_ACCESS	Illigal Erase Operation

REMARKS

This function is a mandatory flash operation function.

DCOP(Deferred Check Operation) : a method optimizing the operation performance. The DCOP method is a procedure to terminate the function (write or erase) right after the command issue. Then it checks the result of the operation at next function call.

In order to support asynchronous mode, codes which execute next steps must be added. First, check the value of a flag. And then, clear an interrupt. Finally, enable the interrupt. For more information about the interrupt, refer to Chapter 오류! 참조 원본을 찾을 수 없습니다. 오류! 참조 원본을 찾을 수 없습니다..

EXAMPLE

(1) Example to call the function

```
#include <XSRTypes.h>
#include <PAM.h>
```

```
#include <LLD.h>
#include <XXX.h>   /* Header File of Low Level Device Driver */

BOOL32
Example(VOID)
{
   INT32     nErr;
   UINT32    nDev = 0;
   UINT32    nVol = 0;
   UINT32    nPbn = 0;
   UINT32    nFlag = LLD_FLAG_ASYNC_OP;
   LowFuncTbl stLFT[MAX_VOL];

   PAM_RegLFT((VOID *)stLFT);

   nErr = stLFT[nVol].Erase(nDev, nPbn, nFlag)

   if (nErr != LLD_SUCCESS)
   {
      printf(“XXX_Erase()fail. ErrCode = %x\n”, nErr);
      return (FALSE32);
   }
   return (TRUE32);
}
```

(2) Example to implement the function in OneNAND

```
INT32
ONLD_Erase(UINT32 nDev, UINT32 nPbn, UINT32 nFlag)
{
   UINT32  nBAddr;
   UINT32   nRes;

   nBAddr = GET_DEV_BADDR(nDev);

   if ((nRes = _ChkPrevOpResult(nDev)) != ONLD_SUCCESS)
   {
       return nRes;
   }

   /* Block Number Set */
   ONLD_REG_START_ADDR1(nBAddr) = (UINT16)MAKE_FBA(nPbn);
   ONLD_REG_START_ADDR2(nBAddr) = (UINT16)MAKE_DBS(nPbn);

   /* INT Stat Reg Clear */
   ONLD_REG_INT(nBAddr)       = (UINT16)INT_CLEAR;

   /*-----------------------------------------*/
   /* ONLD Erase CMD is issued                */
   /*---------------------------------------- -*/
   ONLD_REG_CMD(nBAddr)       = (UINT16)ONLD_CMD_ERASE_BLK;

   pstPrevOpInfo[nDev]->ePreOp    = ERASE;
   pstPrevOpInfo[nDev]->nPsn
                             = nPbn * GET_SCTS_PER_BLK(nDev);
   pstPrevOpInfo[nDev]->nFlag     = nFlag;
   /* in case of async mode, interrupt should be enabled */
   if (nFlag & ONLD_FLAG_ASYNC_OP)
   {
        PAM_ClearInt((UINT32)XSR_INT_ID_NAND_0);
        PAM_EnableInt((UINT32)XSR_INT_ID_NAND_0);
    }

    return (ONLD_SUCCESS);
}
```

SEE ALSO

`XXX_Read`, `XXX_Write`, `XXX_Copyback`, `XXX_MRead`, `XXX_MWrite`, `XXX_MErase`, `XXX_EraseVerify`

XXX_MRead

DESCRIPTION

This function reads data from NAND flash memory. `XXX_MRead`, unlikely `XXX_Read`, only read multiple sectors within a block boundry.

When an error occurs, LLD can return ECC error. If 1bit error occurs, this function returns SUCCESS. If 2bit error occurs, this function performs the read operation of the remaining sector and then returns READ ERROR.

SYNTAX

```
INT32
XXX_MRead(UINT32 nDev, UINT32 nPsn, UINT32 nNumOfScts, SGL
*pstSGL, UINT8 *pSBuf, UINT32 nFlag)
```

PARAMETERS

Parameter	Type	In/Out	Description
nDev	UINT32	In	Physical Device Number (0 ~ 7)
nPsn	UINT32	In	Physical Sector Number
nNumOfScts	UINT32	In	Number of sectors
pstSGL	SGL *	Out	Scatter gather list structure for main array of NAND flash memory
pSBuf	UINT8 *	Out	Memory buffer for spare array of NAND flash memory
nFlag	UINT32	In	Operation options (ECC on/off)

`nFlag` has the the operation options as follows.

Flag	Value	Description
LLD_FLAG_ECC_ON	(1<<1)	ECC on (Read Operation with ECC)
LLD_FLAG_ECC_OFF	(0<<1)	ECC off (Read Operation without ECC)

RETURN VALUE

Return Value	Description
LLD_SUCCESS	Read Success
LLD_READ_ERROR | ECC result code	Data Integrity Fault (1 or 2bit ECC error) This return value is available only in case of using Hardware ECC
LLD_WRITE_ERROR | LLD_PREV_OP_RESULT	In DCOP (Deferred Check Operation), previous write error happens.
LLD_ERASE_ERROR | LLD_PREV_OP_RESULT	In DCOP (Deferred Check Operation), previous erase error happens.
LLD_ILLEGAL_ACCESS	Illegal Read Operation
LLD_READ_DISTURBANCE	1bit ECC error by read disturbance happens.

REMARKS

This function is a mandatory flash operation function.

DCOP (Deferred Check Operation) : a method optimizing the operation performance. The DCOP method is a procedure to terminate the function (write or erase) right after the command issue. Then it checks the result of the operation at next function call.

The parameters nPsn and nNumOfScts read data as a unit of a sector.

For more information about the byte alignment, refer to 오류! 참조 원본을 찾을 수 없습니다. 오류! 참조 원본을 찾을 수 없습니다..

SGL data structure is declared in XsrTypes.h.

☐ **SGL** data structure

```
typedef struct
{
    UINT8        nElements;
    SGLEntry     stSGLEntry[XSR_MAX_SGL_ENTRIES];
} SGL;
```

SGLEntry data structure is declared in XsrTypes.h.

☐ **SGLEntry** data structure

```
typedef struct
{
    UINT8*  pBuf;     /* Buffer for data      */
    UINT16  nSectors;
                /* Number of sectors this entry represents   */
    UINT8  nFlag;     /* user data or meta data      */
} SGLEntry;
```

SGL is abbreviation for Scatter Gather List. To read whole requested data and store it into several buffers within one function call, we use SGL.

EXAMPLE

(1) Example to call the function

```
#include <XSRTypes.h>
#include <PAM.h>
#include <LLD.h>
#include <XXX.h>   /* Header File of Low Level Device Driver */

BOOL32
Example(VOID)
{
    INT32     nErr;
    UINT32    nDev = 0;
    UINT32    nVol = 0;
    UINT32    nPSN = 0;
    UINT32    nNumOfScts = 1;
    SGL       stSGL;
    UINT8     aMBuf[LLD_MAIN_SIZE * nNumOfScts];
    UINT8     aSBuf[LLD_SPARE_SIZE * nNumOfScts];
    UINT32    nFlag = LLD_FLAG_ECC_ON;
    LowFuncTbl stLFT[MAX_VOL];

    PAM_RegLFT((VOID *)stLFT);

    stSGL.stSGLEntry[0].pBuf = aMBuf;
    stSGL.stSGLEntry[0].nSectors = nNumOfScts;
    stSGL.stSGLEntry[0].nFlag = SGL_ENTRY_USER_DATA;

    stSGL.nElements = 1;

    nErr = stLFT[nVol].MRead(nDev, nPSN, nNumOfScts, &stSGL,
                             aSBuf, nFlag);

    if (nErr != LLD_SUCCESS)
    {
        printf("XXX_Read() fail. ErrCode = %x\n", nErr);
        return (FALSE32);
    }
    return (TRUE32);
}
```

(2) Example to implement the function in OneNAND

```
INT32
ONLD_MRead(UINT32 nDev, UINT32 nPsn, UINT32 nScts, SGL *pstSGL,
UINT8 *pSBuf,
        UINT32 nFlag)
{
    UINT32  nCnt;
    UINT16  nBSA;
    UINT32 *pONLDMBuf;
    UINT32 *pONLDSBuf;
    UINT32  nBAddr;
    UINT16  nPbn;
    UINT16  nEccRes    = (UINT16)0x0;
    UINT16  nEccMask   = (UINT16)0x0;
    UINT32  nFlagO     = nFlag;
    UINT32  nReadPsn;
    UINT32  nCurReadPsn;
    UINT32  nReadScts = 0;
    UINT32  nCurReadScts;
    UINT32  nRemainScts;
    UINT32  nRet = ONLD_SUCCESS;
    UINT8   nSGLIdx = 0;
    UINT32  nSctCount = 0;
    UINT8   *pMBuf;
    INT32   nRes;

    if (pstSGL == NULL)
        return (ONLD_ILLEGAL_ACCESS);

    nBAddr = GET_DEV_BADDR(nDev);

    if ((nRes = _ChkPrevOpResult(nDev)) != ONLD_SUCCESS)
    {
        pstPrevOpInfo[nDev]->ePreOp = NONE;
        return nRes;
    }

    pMBuf = pstSGL->stSGLEntry[nSGLIdx].pBuf;

    nRemainScts   = nScts;
    nReadPsn      = nPsn;
    switch (nReadPsn & astONLDInfo[nDev].nSctSelSft)
    {
        case 0:
            nReadScts  =
              (astONLDInfo[nDev].nSctsPerPG > nRemainScts) ?
              nRemainScts : astONLDInfo[nDev].nSctsPerPG;
            break;
        case 1:
            nReadScts  =
              (astONLDInfo[nDev].nSctSelSft > nRemainScts) ?
               nRemainScts : astONLDInfo[nDev].nSctSelSft;
            break;
        case 2:
            nReadScts  = (2 > nRemainScts) ?
                nRemainScts : 2;
            break;
        case 3:
            nReadScts  = (1 > nRemainScts) ?
                nRemainScts : 1;
            break;
    }

    {
        nPbn = GET_PBN(nDev, nReadPsn);

        /* Block Number Set */
        ONLD_REG_START_ADDR1(nBAddr) = (UINT16)MAKE_FBA(nPbn);
        ONLD_REG_START_ADDR2(nBAddr) = (UINT16)MAKE_DBS(nPbn);

        /* Sector Number Set */
        ONLD_REG_START_ADDR8(nBAddr) = (UINT16)(
        ((nReadPsn << astONLDInfo[nDev].nFPASelSft) & MASK_FPA)
        | (nReadPsn & astONLDInfo[nDev].nFSAMask));

        nBSA =
           (UINT16)MAKE_BSA(nReadPsn, GET_CUR_BUF_SEL(nDev));

        /* Start Buffer Selection */
        ONLD_REG_START_BUF(nBAddr)   =
           (UINT16)((nBSA & MASK_BSA) | (nReadScts & MASK_BSC));

        if (nFlag & ONLD_FLAG_ECC_ON)
        {
            /* System Configuration Reg set (ECC On)*/
            ONLD_DBG_PRINT((TEXT("[ONLD : MSG]  ECC ON\r\n")));
            ONLD_REG_SYS_CONF1(nBAddr) &= CONF1_ECC_ON;
        }
        else
        {
            /* System Configuration Reg set (ECC Off)*/
            ONLD_DBG_PRINT((TEXT("[ONLD : MSG]  ECC OFF\r\n")));
            ONLD_REG_SYS_CONF1(nBAddr) |= CONF1_ECC_OFF;
        }

        /* INT Stat Reg Clear */
        ONLD_REG_INT(nBAddr)       = (UINT16)INT_CLEAR;
        /* ----------------------------------------*/
        /* ONLD Read CMD is issued                 */
        /*----------------------------------------*/
        if (pMBuf != NULL)
        {
            /* Page Read Command issue */
            ONLD_REG_CMD(nBAddr) = (UINT16)ONLD_CMD_READ_PAGE;
        }
        else
        {
            /* Spare Read Command issue */
            ONLD_REG_CMD(nBAddr) = (UINT16)ONLD_CMD_READ_SPARE;
        }

        if (nFlagO & ONLD_FLAG_ECC_ON)
        {
            /* ECC Value Bit Mask Setting */
            for (nCnt = 0; nCnt < nReadScts; nCnt++)
            {
                if (pMBuf != NULL)
                {
                    nEccMask |= (0x08 << (nCnt * 4));
                }
                if (pSBuf != NULL)
                {
                    nEccMask |= (0x02 << (nCnt * 4));
                }
            }

        }

        nCurReadPsn   = nReadPsn;
        nCurReadScts  = nReadScts;

        nRemainScts  -= nReadScts;
        nReadPsn     += nReadScts;
        nReadScts     =
            (astONLDInfo[nDev].nSctsPerPG > nRemainScts) ?
             nRemainScts : astONLDInfo[nDev].nSctsPerPG;

        while (GET_ONLD_INT_STAT(nBAddr, PEND_READ)
                != (UINT16)PEND_READ)
        {
            /* Wait until device ready */
        }

        if (nFlagO & ONLD_FLAG_ECC_ON)
        {
            /* No Cache Read */
            nEccRes = (ONLD_REG_ECC_STAT(nBAddr) & nEccMask);

            if (nEccRes != 0)
            {
                nRet = ONLD_READ_ERROR | nEccRes;
            }
        }
    }

    while (nRemainScts > 0)
    {
        nPbn = GET_PBN(nDev, nReadPsn);
        nSctCount += nCurReadScts;

        if (nSctCount == pstSGL->stSGLEntry[nSGLIdx].nSectors)
        {
            nSctCount = 0;
            nSGLIdx++;
        }
        if (pstSGL->stSGLEntry[nSGLIdx].nFlag
             == SGL_ENTRY_META_DATA)
        {
            nReadPsn += pstSGL->stSGLEntry[nSGLIdx].nSectors;
            nReadScts -= pstSGL->stSGLEntry[nSGLIdx].nSectors;
            nRemainScts -= pstSGL->stSGLEntry[nSGLIdx].nSectors;
            nSctCount = 0;
            nSGLIdx++;

            if (GET_SCTS_PER_PG(nDev) == 2)
            {
                nCurReadPsn   = nReadPsn;
                nCurReadScts  = nReadScts;
                nReadScts     =
                   (astONLDInfo[nDev].nSctsPerPG > nRemainScts) ?
                    nRemainScts : astONLDInfo[nDev].nSctsPerPG;
                continue;
            }
        }

        /* Block Number Set */
        ONLD_REG_START_ADDR1(nBAddr) = (UINT16)MAKE_FBA(nPbn);
        ONLD_REG_START_ADDR2(nBAddr) = (UINT16)MAKE_DBS(nPbn);

        /* Sector Number Set */
        ONLD_REG_START_ADDR8(nBAddr) = (UINT16)(
          ((nReadPsn << astONLDInfo[nDev].nFPASelSft) & MASK_FPA)
          | (nReadPsn & astONLDInfo[nDev].nFSAMask));

        nBSA =
            (UINT16)MAKE_BSA(nReadPsn, GET_NXT_BUF_SEL(nDev));

        /* Start Buffer Selection */
        ONLD_REG_START_BUF(nBAddr)   =
            (UINT16)((nBSA & MASK_BSA) | (nReadScts & MASK_BSC));

        /* INT Stat Reg Clear */
        ONLD_REG_INT(nBAddr) = (UINT16)INT_CLEAR;

        /*-----------------------------------------*/
        /* ONLD Read CMD is issued                 */
        /*-----------------------------------------*/
        if (pMBuf != NULL)
        {
            ONLD_REG_CMD(nBAddr)  = (UINT16)ONLD_CMD_READ_PAGE;
        }
        else
        {
            ONLD_REG_CMD(nBAddr) = (UINT16)ONLD_CMD_READ_SPARE;
        }
```

```
              pONLDMBuf = (UINT32*)GET_ONLD_MBUF_ADDR(
                  nBAddr, nCurReadPsn, GET_CUR_BUF_SEL(nDev));
              pONLDSBuf = (UINT32*)GET_ONLD_SBUF_ADDR(
                  nBAddr, nCurReadPsn, GET_CUR_BUF_SEL(nDev));

        if (pMBuf != NULL)
        {
            /* Memcopy for main data */
            _ReadMain(pMBuf, pONLDMBuf, nCurReadScts);
            pMBuf += (ONLD_MAIN_SIZE * nCurReadScts);
        }

        if (pSBuf != NULL)
        {
            /* Memcopy for main data */
            _ReadSpare(pSBuf, pONLDSBuf, nCurReadScts);
            pSBuf += (ONLD_SPARE_SIZE * nCurReadScts);
        }

        if (nFlagO & ONLD_FLAG_ECC_ON)
        {
            /* ECC Value Bit Mask Setting */
            for (nCnt = 0; nCnt < nReadScts; nCnt++)
            {
                if (pMBuf != NULL)
                {
                    nEccMask |= (0x08 << (nCnt * 4));
                }
                if (pSBuf != NULL)
                {
                    nEccMask |= (0x02 << (nCnt * 4));
                }
            }
        }

        pstPrevOpInfo[nDev]->nBufSel = GET_NXT_BUF_SEL(nDev);

        nCurReadPsn   = nReadPsn;
        nCurReadScts  = nReadScts;

        nRemainScts  -= nReadScts;
        nReadPsn     += nReadScts;
        nReadScts     =
           (astONLDInfo[nDev].nSctsPerPG > nRemainScts) ?
            nRemainScts : astONLDInfo[nDev].nSctsPerPG;

        while (GET_ONLD_INT_STAT(nBAddr, PEND_READ)
               !=  (UINT16)PEND_READ)
        {
            /* Wait until device ready */
        }

        if (nFlagO & ONLD_FLAG_ECC_ON)
        {
            /* No Cache Read */
            nEccRes = (ONLD_REG_ECC_STAT(nBAddr) & nEccMask);

            if (nEccRes != 0)
```

```
                {
                    nRet = ONLD_READ_ERROR | nEccRes;
                }
            }
        }

        {
            pONLDMBuf = (UINT32*)GET_ONLD_MBUF_ADDR(
                nBAddr, nCurReadPsn, GET_CUR_BUF_SEL(nDev));
            pONLDSBuf = (UINT32*)GET_ONLD_SBUF_ADDR(
                nBAddr, nCurReadPsn, GET_CUR_BUF_SEL(nDev));

            if (pMBuf != NULL)
            {
                /* Memcopy for main data */
                _ReadMain(pMBuf, pONLDMBuf, nCurReadScts);
                pMBuf += (ONLD_MAIN_SIZE * nCurReadScts);
            }

            if (pSBuf != NULL)
            {
                /* Memcopy for spare data */
                _ReadSpare(pSBuf, pONLDSBuf, nCurReadScts);
                pSBuf += (ONLD_SPARE_SIZE * nCurReadScts);
            }

            pstPrevOpInfo[nDev]->nBufSel    =
                GET_NXT_BUF_SEL(nDev);
        }

        return (nRet);
}
```

SEE ALSO

`XXX_Read, XXX_Write, XXX_Erase, XXX_Copyback, XXX_MWrite, XXX_MErase, XXX_EraseVerify`

XXX_MWrite

DESCRIPTION

This function writes data into NAND flash memory. `XXX_MWrite`, unlikely `XXX_Write`, only write sectors within a block boundry.

SYNTAX

```
INT32
XXX_MWrite(UINT32 nDev,  UINT32 nPsn,  UINT32 nNumOfScts,
       SGL *pstSGL, UINT8 *pSBuf, UINT32 nFlag, UINT32 *pErrPsn)
```

PARAMETERS

Parameter	Type	In/Out	Description
`nDev`	`UINT32`	`In`	Physical Device Number (0 ~ 7)
`nPsn`	`UINT32`	`In`	Physical Sector Number
`nNumOfScts`	`UINT32`	`In`	Number of sectors
`pstSGL`	`SGL *`	`In`	Scatter gather list structure for main array of NAND flash memory
`pSBuf`	`UINT8 *`	`In`	Memory buffer for spare array of NAND flash memory
`nFlag`	`UINT32`	`In`	Operation options (ECC on/off, Sync/Async)
`pErrPsn`	`UINT32 *`	`Out`	Pointer of the sector number where the error occurs. When an error occurs, this function stops the write operation. The errored physical sector number is put on this parameter.

`nFlag` has the the operation options as follows.

Flag	Value	Description
`LLD_FLAG_ASYNC_OP`	`(1<<0)`	Asynchronous Operation
`LLD_FLAG_SYNC_OP`	`(0<<0)`	Synchronous Operation
`LLD_FLAG_ECC_ON`	`(1<<1)`	ECC on (Read Operation with ECC)
`LLD_FLAG_ECC_OFF`	`(0<<1)`	ECC off (Read Operation without ECC)

Flag value is devided into Sync/Async Operation flag and ECC on/off flag. These two flags can be merged as follow.

```
nFlag = LLD_FLAG_SYNC_OP | LLD_FLAG_ECC_ON;
```

RETURN VALUE

Return Value	Description
`LLD_SUCCESS`	Write Success
`LLD_WRITE_ERROR`	Write Failure
`LLD_WRITE_ERROR | LLD_PREV_OP_RESULT`	In DCOP (Deferred Check Operation), previous write error happens
`LLD_ERASE_ERROR | LLD_PREV_OP_RESULT`	In DCOP (Deferred Check Operation), previous erase error happens
`LLD_WR_PROTECT_ERROR`	Write Operation at Locked Area
`LLD_ILLEGAL_ACCESS`	Illegal Write Operation

REMARKS

This function is a mandatory flash operation function.

DCOP(Deferred Check Operation) : a method optimizing the operation performance. The DCOP method is a procedure to terminate the function (write or erase) right after the command issue. Then it checks the result of the operation at next function call.

The parameters nPsn and nNumOfScts write data as a unit of a sector.
For more information about the byte alignment, refer to 오류! 참조 원본을 찾을 수 없습니다. 오류! 참조 원본을 찾을 수 없습니다..

`SGL` data structure is declared in `XsrTypes.h`.

☐ **`SGL`** data structure

```
typedef struct
{
   UINT8         nElements;
   SGLEntry      stSGLEntry[XSR_MAX_SGL_ENTRIES];
} SGL;
```

`SGLEntry` data structure is also declared in `XsrTypes.h`.

☐ **`SGLEntry`** data structure

```
typedef struct
{
   UINT8*  pBuf;     /* Buffer for data      */
   UINT16  nSectors;
             /* Number of sectors this entry represents   */
   UINT8  nFlag;     /* user data or meta data      */
} SGLEntry;
```

SGL is abbreviation for Scatter Gather List. To write whole requested data which exists in several different buffers within one function call, we use SGL.

This function does not support asynchronous mode, whereas XXX_Write supports asynchronous mode.

EXAMPLE

(1) Example to call the function

```
#include <XSRTypes.h>
#include <PAM.h>
#include <LLD.h>
#include <XXX.h>   /* Header File of Low Level Device Driver */

BOOL32
Example(VOID)
{
   INT32     nErr;
   UINT32    nDev = 0;
   UINT32    nVol = 0;
   UINT32    nPSN = 0;
```

```
    SGL        stSGL;
    UINT8      aMBuf[LLD_MAIN_SIZE * nNumOfScts];
    UINT8      aSBuf[LLD_SPARE_SIZE * nNumOfScts];
    UINT32     nFlag = LLD_FLAG_ECC_ON | LLD_FLAG_SYNC_OP;
    LowFuncTbl stLFT[MAX_VOL];

    PAM_RegLFT((VOID *)stLFT);

    stSGL.stSGLEntry[0].pBuf = aMBuf;
    stSGL.stSGLEntry[0].nSectors = nNumOfScts;
    stSGL.stSGLEntry[0].nFlag = SGL_ENTRY_USER_DATA;

    stSGL.nElements = 1;

    nErr = stLFT[nVol].MWrite(nDev, nPSN, nNumOfScts, &stSGL,
                              aSBuf, nFlag);

    if (nErr != LLD_SUCCESS)
    {
       printf("XXX_Write() fail. ErrCode = %x\n", nErr);
       return (FALSE32);
    }
    return (TRUE32);
}
```

(2) Example to implement the function in OneNAND

```
INT32
ONLD_MWrite(UINT32 nDev, UINT32 nPsn, UINT32 nScts, SGL *pstSGL,
            UINT8 *pSBuf, UINT32 nFlag, UINT32 *pErrPsn)
{
    UINT16  nBSA;
    UINT32 *pONLDMBuf;
    UINT32 *pONLDSBuf;
    UINT32  nBAddr;
    UINT32  nPbn;
    UINT32  nWritePsn;
    UINT32  nWriteScts = 0;
    UINT32  nTmpWriteScts;
    UINT8   nBiWriteScts;
    UINT8   nSnapWriteScts;
    UINT32  nRemainScts;
    INT32   nRes;
    UINT8   nSGLIdx;
    UINT8   nSGLCount;
    UINT32  nSctCount = 0;

    UINT8  *pMBuf;
    UINT8  *pSGLBuf = NULL;
    UINT8   nIdx;
    UINT8   nPreSGLIdx = 0;
    UINT8   nTmpRemainScts = 0;
    SGLEntry *pSGLEnt;

    if (pstSGL == NULL)
       return (ONLD_ILLEGAL_ACCESS);

    nBAddr = GET_DEV_BADDR(nDev);
    if ((GET_DEV_DID(nDev) & 0x0008) == DDP_CHIP)
    {
        if ((nRes = _ChkPrevOpResult(nDev)) != ONLD_SUCCESS)
        {
            return nRes;
        }
    }
    /* Previous Operation should be flushed at a upper layer */

    if (nFlag & ONLD_FLAG_ECC_ON)
    {
        /* System Configuration Reg set (ECC On)*/
        ONLD_REG_SYS_CONF1(nBAddr) &= CONF1_ECC_ON;
    }
    else
    {
        /* System Configuration Reg set (ECC Off)*/
        ONLD_REG_SYS_CONF1(nBAddr) |= CONF1_ECC_OFF;
    }

    /* Set user Data Buffer point */
    for (nSGLIdx = 0; nSGLIdx < pstSGL->nElements; nSGLIdx++)
    {
        if (pstSGL->stSGLEntry[nSGLIdx].nFlag ==
             SGL_ENTRY_USER_DATA)
        {
            pMBuf = pstSGL->stSGLEntry[nSGLIdx].pBuf;
            break;
        }
    }

    nSGLIdx     = 0;
    nRemainScts = nScts;
    nWritePsn   = nPsn;

    switch (nWritePsn & astONLDInfo[nDev].nSctSelSft)
    {
        case 0:
          nWriteScts  =
              (astONLDInfo[nDev].nSctsPerPG > nRemainScts) ?
               nRemainScts : astONLDInfo[nDev].nSctsPerPG;
          break;
        case 1:
          nWriteScts  =
              (astONLDInfo[nDev].nSctSelSft > nRemainScts) ?
               nRemainScts : astONLDInfo[nDev].nSctSelSft;
          break;
        case 2:
          nWriteScts  = (2 > nRemainScts) ? nRemainScts : 2;
          break;
        case 3:
         nWriteScts  = (1 > nRemainScts) ? nRemainScts : 1;
         break;
    }

    while (nRemainScts > 0)
    {
        nPbn = GET_PBN(nDev, nWritePsn);
        nTmpWriteScts = nWriteScts;
        nSGLCount = 0;

        if (nSctCount != 0 &&
            pstSGL->stSGLEntry[nSGLIdx].nSectors - nSctCount <
            nTmpWriteScts)
        {
            nTmpRemainScts =
                pstSGL->stSGLEntry[nSGLIdx].nSectors - nSctCount;
        }

        do
        {
            nSctCount += 1;
            if (nSctCount >=
                pstSGL->stSGLEntry[nSGLIdx].nSectors)
            {
                nSctCount = 0;
                nSGLIdx++;
                nSGLCount++;
            }
            else if (nWriteScts == 1)
            {
                nSGLCount++;
            }
        } while(--nWriteScts);

        nBiWriteScts = 0;
        nSnapWriteScts = 0;

        ONLD_REG_START_ADDR2(nBAddr) = (UINT16)MAKE_DBS(nPbn);

        pONLDMBuf = (UINT32*)GET_ONLD_MBUF_ADDR(
                        nBAddr, nWritePsn, GET_NXT_BUF_SEL(nDev));
        pONLDSBuf = (UINT32*)GET_ONLD_SBUF_ADDR(
                        nBAddr, nWritePsn, GET_NXT_BUF_SEL(nDev));

        for (nIdx = 0; nIdx < nSGLCount; nIdx++)
        {
            pSGLEnt = pstSGL->stSGLEntry[nPreSGLIdx + nIdx];

            switch(pSGLEnt->nFlag)
            {
            case SGL_ENTRY_BISCT_VALID_DATA:
                pSGLBuf       = pSGLEnt->pBuf;
                nBiWriteScts  += pSGLEnt->nSectors;
                nWriteScts    = pSGLEnt->nSectors;
                break;
            case SGL_ENTRY_BISCT_INVALID_DATA:
                pSGLBuf        = pSGLEnt->pBuf;
                nBiWriteScts  += pSGLEnt->nSectors;
                nWriteScts     =  pSGLEnt->nSectors;
                break;
            case SGL_ENTRY_META_DATA:
                pSGLBuf        = pSGLEnt->pBuf;
                nSnapWriteScts += pSGLEnt->nSectors;
                nWriteScts     = pSGLEnt->nSectors;
                break;
            case SGL_ENTRY_USER_DATA:
                if (nTmpRemainScts != 0)
                {
                    nWriteScts     = nTmpRemainScts;
                    nTmpRemainScts = 0;
                }
                else
                {
                    nWriteScts     =
                     nTmpWriteScts - nBiWriteScts - nSnapWriteScts;
                    if (nWriteScts > pSGLEnt->nSectors)
                    {
                        nWriteScts = pSGLEnt->nSectors;
                    }
                }
                break;
            default:
                return (ONLD_ILLEGAL_ACCESS);
            }
            if (pSGLEnt->nFlag != SGL_ENTRY_USER_DATA
                 && pSGLBuf != NULL)
            {
                _WriteMain(pSGLBuf, pONLDMBuf, nWriteScts);
                pONLDMBuf += (BUFF_MAIN_SIZE * nWriteScts);
            }
            else if (pMBuf != NULL)
            {
                /* Memcopy for main data */
                _WriteMain(pMBuf, pONLDMBuf, nWriteScts);
                pMBuf     += (ONLD_MAIN_SIZE * nWriteScts);
                pONLDMBuf += (BUFF_MAIN_SIZE * nWriteScts);

            }
        }

        nPreSGLIdx = nSGLIdx;
        nWriteScts = nTmpWriteScts;

        if (pSBuf != NULL)
        {
            /* Memcopy for spare data */
            _WriteSpare(pSBuf, pONLDSBuf, nWriteScts);
            pSBuf += (ONLD_SPARE_SIZE * nWriteScts);
        }
        else
        {
            /* Memset for spare data 0xff*/
            MEMSET(pONLDSBuf, 0xFF,
                     (ONLD_SPARE_SIZE * nWriteScts));
        }

        if ((nRes = _ChkPrevOpResult(nDev)) != ONLD_SUCCESS)
        {
            *pErrPsn = pstPrevOpInfo[nDev]->nPsn;
            return nRes;
        }
        /* Block Number Set */
        ONLD_REG_START_ADDR1(nBAddr) = (UINT16)MAKE_FBA(nPbn);

        /* Sector Number Set */
        ONLD_REG_START_ADDR8(nBAddr) =
        (UINT16)(((nWritePsn << astONLDInfo[nDev].nFPASelSft)
         & MASK_FPA)
         | (nWritePsn & astONLDInfo[nDev].nFSAMask));

        nBSA =
           (UINT16)MAKE_BSA(nWritePsn, GET_NXT_BUF_SEL(nDev));

        ONLD_REG_START_BUF(nBAddr)   =
           (UINT16)((nBSA & MASK_BSA) | (nWriteScts & MASK_BSC));

        /* INT Stat Reg Clear */
        ONLD_REG_INT(nBAddr)       = (UINT16)INT_CLEAR;

        /*-----------------------------------------*/
        /* ONLD Write CMD is issued                 */
        /*-----------------------------------------*/
        if (pMBuf != NULL || pSGLBuf != NULL)
        {
           ONLD_REG_CMD(nBAddr) = (UINT16)ONLD_CMD_WRITE_PAGE;
        }
        else
        {
           ONLD_REG_CMD(nBAddr) = (UINT16)ONLD_CMD_WRITE_SPARE;
        }

        pstPrevOpInfo[nDev]->ePreOp    = WRITE;
        pstPrevOpInfo[nDev]->nPsn      = nWritePsn;
        pstPrevOpInfo[nDev]->nScts     = nWriteScts;
        pstPrevOpInfo[nDev]->nFlag     = nFlag;

        nRemainScts -= nWriteScts;
        nWritePsn   += nWriteScts;
        nWriteScts   =
           (astONLDInfo[nDev].nSctsPerPG > nRemainScts) ?
            nRemainScts : astONLDInfo[nDev].nSctsPerPG;

        pstPrevOpInfo[nDev]->nBufSel   =
            GET_NXT_BUF_SEL(nDev);
    }

    return (ONLD_SUCCESS);
}
```

SEE ALSO

XXX_Read, XXX_Write, XXX_Erase, XXX_Copyback, XXX_MRead, XXX_MErase, XXX_EraseVerify

XXX_MErase

DESCRIPTION

This function erases blocks of NAND flash memory. `XXX_MErase`, unlikely `XXX_Erase`, erases multiple blocks simultaneously. When a device supports multi-block erase operation, XXX_MErase can be used.

SYNTAX

```
INT32
XXX_MErase(UINT32 nDev, LLDMEArg *pstMEArg, UINT32 nFlag)
```

PARAMETERS

Parameter	Type	In/Out	Description
`nDev`	`UINT32`	`In`	Physical Device Number (0 ~ 7)
`pstMEArg`	`LLDMEArg`	`In`	Pointer to LLDMEArg data structure
`nFlag`	`UINT32`	`In`	Operation options (Sync/Async)

`nFlag` has the the operation options as follows.

Flag	Value	Description
`LLD_FLAG_ASYNC_OP`	`(1<<0)`	Asynchronous Operation
`LLD_FLAG_SYNC_OP`	`(0<<0)`	Synchronous Operation

RETURN VALUE

Return Value	Description
`LLD_SUCCESS`	Erase Success
`LLD_WR_PROTECT_ERROR|LLD_PREV_OP_RESULT`	In DCOP (Deferred Check Operation), previous write Protection error happens
`LLD_PREV_WRITE_ERROR|LLD_PREV_OP_RESULT`	In DCOP (Deferred Check Operation), previous write error happens
`LLD_PREV_ERASE_ERROR|LLD_PREV_OP_RESULT`	In DCOP (Deferred Check Operation), previous erase error happens
`LLD_ILLEGAL_ACCESS`	Illigal Erase Operation

REMARKS

This function is a mandatory flash operation function.

DCOP(Deferred Check Operation) : a method optimizing the operation performance. The DCOP method is a procedure to terminate the function (write or erase) right after the command issue. Then it checks the result of the operation at next function call.

In order to support asynchronous mode, codes which execute next steps must be added. First, check the value of a flag. And then, clear an interrupt. Finally, enable the interrupt. For more information about the interrupt, refer to Chapter 오류! 참조 원본을 찾을 수 없습니다. 오류! 참조 원본을 찾을 수 없습니다..

`XXX_MErase` can be used by only devices which support multi-block erase feature (for example OneNAND256). Multi-block erase operation erases multiple blocks simultaneously. The unit of erase operation is 16 blocks at maximum. After `XXX_MErase`, the blocks must be verified by `XXX_EraseVerify`.

`XXX_MErase` must have information about blocks to be erased. **`LLDMEArg`** data structure and **`LLDMEList`** data structure that are required for additional information are as follows

`LLDMEArg` data structure is declared in `LLD.h`.

☐ **`LLDMEArg`** data structure

```
typedef struct {
   LLDMEList  *pstMEList;  /* Pointer to LLDMEList          */
   UINT16     nNumOfMList; /* Number of Entries of LLDMEList */
   UINT16     nBitMapErr; /* Error Bitmap Position of MEList */
   BOOL32     bFlag;       /* Valid Flag                     */
} LLDMEArg;
```

Table 5-3 describes `LLDMEArg` data structure.

Table 5-3. LLDMEArg data structure in LLD.h

Member Varilable	Description
`pstMEList`	Pointer to LLDMEList data structure
`nNumOfMList`	Number of blocks to be erased simultaneously. The maximum number of blocks is 16.
`nBitMapErr`	Each bit indicates whether error occurs or not for each block
`bFlag`	Valid flag for a block list in LLDMEList

`LLDMEList` data structure is also declared in `LLD.h`.

☐ **`LLDMEList`** data structure

```
typedef struct {
   UINT16 nMEListSbn; /* MEList Semi-physical Block Number */
   UINT16 nMEListPbn; /* MEList Physical Block Number      */
} LLDMEList;
```

Table 5-4 describes `LLDMEList` data structure.

Table 5-4. LLDMEList data structure in LLD.h

Member Varilable	Description
`nMEListSbn`	Semi-physical block number of a block in block list
`nMEListPbn`	Physical block number of a block in block list

EXAMPLE

(1) Example to call the function

```
#include <XSRTypes.h>
#include <PAM.h>
#include <LLD.h>
#include <XXX.h>   /* Header File of Low Level Device Driver */

BOOL32
```

```
Example(VOID)
{
   INT32     nErr;
   UINT32    nDev = 0;
   UINT32    nVol = 0;
   UINT16    nPbn = 13;
   UINT16    nSbn = 13;
   UINT16    nNum = 0;
   UINT16    nNumOfPbn = 1;
   UINT32    nFlag = LLD_FLAG_ASYNC_OP;
   LowFuncTbl stLFT[MAX_VOL];
   LLDMEArg   *pstLLDMEArg[XSR_MAX_DEV];
   LLDMEList  *pstLLDMEList;

   pstLLDMEArg[nDev]->nBitMapErr  = (UINT16)0x0;
   pstLLDMEArg[nDev]->nNumOfMList = nNumOfPbn;
   pstLLDMEArg[nDev]->bFlag       = TRUE32;

   pstLLDMEList = pstLLDMEArg[nDev]->pstMEList;

   pstLLDMEList[nNum].nMEListSbn   = nSbn;
   pstLLDMEList[nNum].nMEListPbn   = nPbn;

   PAM_RegLFT((VOID *)stLFT);

   nErr = stLFT[nVol].MErase(nDev, pstLLDMEArg[nDev], nFlag)

   if (nErr != LLD_SUCCESS)
   {
      printf("XXX_MErase()fail. ErrCode = %x\n", nErr);
      return (FALSE32);
   }
   return (TRUE32);
}
```

(2) Example to implement the function in OneNAND

```
INT32
ONLD_MErase(UINT32 nDev, LLDMEArg *pstMEArg, UINT32 nFlag)
{
   UINT32      nBAddr, nPbn;
   UINT32      nCurPbn;
   UINT32      nFirstchipPbn = 0xffff;
   UINT32      nSecondchipPbn = 0xffff;
   UINT16      nCnt;
   INT32       nRes;
   INT32       nRet = ONLD_SUCCESS;
   LLDMEList   *pstMEPList;

   nBAddr = GET_DEV_BADDR(nDev);

   if ((nRes = _ChkPrevOpResult(nDev)) != ONLD_SUCCESS)
      return nRes;

   pstMEPList = pstMEArg->pstMEList;

   for(nCnt = 0; nCnt < pstMEArg->nNumOfMList; nCnt++)
   {
     nCurPbn = pstMEPList[nCnt].nMEListPbn;
```

```
        if ((((nCurPbn << 5) & MASK_DBS) == 0x0000)
            && (nFirstchipPbn == 0xffff))
        {
            nFirstchipPbn = nCurPbn;
            continue;
        }
        else if ((((nCurPbn << 5) & MASK_DBS) == 0x8000)
                 && (nSecondchipPbn == 0xffff))
        {
            nSecondchipPbn = nCurPbn;
            continue;
        }

        /* Block Number Set */
        ONLD_REG_START_ADDR1(nBAddr) = (UINT16)MAKE_FBA(nCurPbn);
        ONLD_REG_START_ADDR2(nBAddr) =(UINT16)MAKE_DBS(nCurPbn);
        if(ONLD_REG_WR_PROTECT_STAT(nBAddr) !=
               (UINT16)(UNLOCKED_STAT))
        {
           return (ONLD_WR_PROTECT_ERROR);
        }
        /* INT Stat Reg Clear */
        ONLD_REG_INT(nBAddr)       = (UINT16)INT_CLEAR;
        /*-------------------------------------------*/
        /* ONLD Erase CMD is issued                  */
        /*-------------------------------------------*/
        ONLD_REG_CMD(nBAddr) = (UINT16)ONLD_CMD_ERASE_MBLK;

        while (GET_ONLD_INT_STAT(nBAddr, PEND_INT) !=
               (UINT16)PEND_INT)
        {
           /* Wait until device ready */
        }

      }

      if ((nFirstchipPbn != 0xffff) && (nSecondchipPbn != 0xffff))
      {
         /* Block Number Set */
         ONLD_REG_START_ADDR1(nBAddr) =
                (UINT16)MAKE_FBA(nFirstchipPbn);
         ONLD_REG_START_ADDR2(nBAddr) =
                (UINT16)MAKE_DBS(nFirstchipPbn);

         if (ONLD_REG_WR_PROTECT_STAT(nBAddr) !=
               (UINT16)(UNLOCKED_STAT))
         {
            return (ONLD_WR_PROTECT_ERROR);
         }
         /* INT Stat Reg Clear */
         ONLD_REG_INT(nBAddr)       = (UINT16)INT_CLEAR;

         ONLD_REG_CMD(nBAddr) = (UINT16)ONLD_CMD_ERASE_BLK;

         while (GET_ONLD_INT_STAT(nBAddr, PEND_ERASE) !=
                (UINT16)PEND_ERASE)
         {
            /* Wait until device ready */
        }

        /* Block Number Set */
        ONLD_REG_START_ADDR1(nBAddr) =
             (UINT16)MAKE_FBA(nSecondchipPbn);
        ONLD_REG_START_ADDR2(nBAddr) =
             (UINT16)MAKE_DBS(nSecondchipPbn);

        if (ONLD_REG_WR_PROTECT_STAT(nBAddr) !=
             (UINT16)(UNLOCKED_STAT))
        {
             return (ONLD_WR_PROTECT_ERROR);
        }

        /* INT Stat Reg Clear */
        ONLD_REG_INT(nBAddr) = (UINT16)INT_CLEAR;
        ONLD_REG_CMD(nBAddr) = (UINT16)ONLD_CMD_ERASE_BLK;

        nPbn = nSecondchipPbn;

    }
    else if (nFirstchipPbn != 0xffff)
    {
        /* Block Number Set */
        ONLD_REG_START_ADDR1(nBAddr) =
            (UINT16)MAKE_FBA(nFirstchipPbn);
        ONLD_REG_START_ADDR2(nBAddr) =
            (UINT16)MAKE_DBS(nFirstchipPbn);

        if (ONLD_REG_WR_PROTECT_STAT(nBAddr) !=
             (UINT16)(UNLOCKED_STAT))
        {
             return (ONLD_WR_PROTECT_ERROR);
        }
        /* INT Stat Reg Clear */
        ONLD_REG_INT(nBAddr)    = (UINT16)INT_CLEAR;
        ONLD_REG_CMD(nBAddr)    = (UINT16)ONLD_CMD_ERASE_BLK;

        nPbn = nFirstchipPbn;
    }
    else
    {
        /* Block Number Set */
        ONLD_REG_START_ADDR1(nBAddr) =
           (UINT16)MAKE_FBA(nSecondchipPbn);
        ONLD_REG_START_ADDR2(nBAddr) =
           (UINT16)MAKE_DBS(nSecondchipPbn);
        if (ONLD_REG_WR_PROTECT_STAT(nBAddr) !=
            (UINT16)(UNLOCKED_STAT))
        {
            return (ONLD_WR_PROTECT_ERROR);
        }
        /* INT Stat Reg Clear */
        ONLD_REG_INT(nBAddr)    = (UINT16)INT_CLEAR;
        ONLD_REG_CMD(nBAddr)    = (UINT16)ONLD_CMD_ERASE_BLK;

        nPbn = nSecondchipPbn;
        while (GET_ONLD_INT_STAT(nBAddr, PEND_ERASE)
                != (UINT16)PEND_ERASE)
        {
            /* Wait until device ready */
        }
    }

    pstPrevOpInfo[nDev]->ePreOp = MERASE;
    pstPrevOpInfo[nDev]->nFlag  = nFlag;
    pstPrevOpInfo[nDev]->nPsn = nPbn * GET_SCTS_PER_BLK(nDev);
    MEMCPY(pstPrevOpInfo[nDev]->pstPreMEArg,
           pstMEArg, sizeof(LLDMEArg));

    /* in case of async mode, interrupt should be enabled */
    if (nFlag & ONLD_FLAG_ASYNC_OP)
    {
        PAM_ClearInt((UINT32)XSR_INT_ID_NAND_0);
        PAM_EnableInt((UINT32)XSR_INT_ID_NAND_0);
    }

    return nRet;
}
```

SEE ALSO

`XXX_Read, XXX_Write, XXX_Erase, XXX_Copyback, XXX_MRead, XXX_MWrite, XXX_EraseVerify`

XXX_EraseVerify

DESCRIPTION

This function verifies an erase operation whether it checks blocks are properly erased. Mainly this function is used with `XXX_MErase` function.

SYNTAX

```
INT32
MyLLD_EraseVerify(UINT32 nDev, LLDMEArg *pstMEArg, UINT32 nFlag)
```

PARAMETERS

Parameter	Type	In/Out	Description
`nDev`	`UINT32`	`In`	Physical Device Number (0 ~ 7)
`pstMEArg`	`LLDMEArg`	`In`	Pointer to LLDMEArg data structure
`nFlag`	`UINT32`	`In`	Operation options (Sync/Async)

`nFlag` has the the operation options as follows.

Flag	Value	Description
`LLD_FLAG_ASYNC_OP`	`(1<<0)`	Asynchronous Operation
`LLD_FLAG_SYNC_OP`	`(0<<0)`	Synchronous Operation

RETURN VALUE

Return Value	Description
`LLD_SUCCESS`	Erase Success
`LLD_WR_PROTECT_ERROR|` `LLD_PREV_OP_RESULT`	In DCOP (Deferred Check Operation), previous write Protection error happens
`LLD_PREV_WRITE_ERROR|` `LLD_PREV_OP_RESULT`	In DCOP (Deferred Check Operation), previous write error happens
`LLD_PREV_ERASE_ERROR|` `LLD_PREV_OP_RESULT`	In DCOP (Deferred Check Operation), previous erase error happens
`LLD_ERASE_ERROR`	Erase Failure

REMARKS

This function is a mandatory flash operation function.

DCOP(Deferred Check Operation) : a method optimizing the operation performance. The DCOP method is a procedure to terminate the function (write or erase) right after the command issue. Then it checks the result of the operation at next function call.

After erase operation, `XXX_EraseVerify` checks all blocks in `LLDMEList` of `LLDMEArg`. If blocks that is not erased properly are detected, `XXX_EraseVerify` returns erase error. `XXX_MErase` requires `XXX_EraseVerify` becasuse `XXX_MErase` does not support the functionality to verify erase errors. `XXX_EraseVerify` only can be used when a device supports erase verify functionality. For more information about `LLDMEList` and `LLDMEArg` data structure, refer to the API page of `XXX_MErase`.

EXAMPLE

(1) Example to call the function

```
#include <XSRTypes.h>
#include <PAM.h>
#include <LLD.h>
#include <XXX.h>   /* Header File of Low Level Device Driver */

BOOL32
Example(VOID)
{
   INT32     nErr;
   UINT32    nDev = 0;
   UINT32    nVol = 0;
   UINT16    nPbn = 13;
   UINT16    nSbn = 13;
   UINT16    nNum = 0;
   UINT16    nNumOfPbn = 1;
   UINT32    nFlag = LLD_FLAG_ASYNC_OP;

   LowFuncTbl stLFT[MAX_VOL];
   LLDMEArg   *pstLLDMEArg[XSR_MAX_DEV];
   LLDMEList  *pstLLDMEList;

   pstLLDMEArg[nDev]->nBitMapErr  = (UINT16)0x0;
   pstLLDMEArg[nDev]->nNumOfMList = nNumOfPbn;
   pstLLDMEArg[nDev]->bFlag       = TRUE32;

   pstLLDMEList = pstLLDMEArg[nDev]->pstMEList;

   pstLLDMEList[nNum].nMEListSbn   = nSbn;
   pstLLDMEList[nNum].nMEListPbn   = nPbn;

   PAM_RegLFT((VOID *)stLFT);

   nErr = stLFT[nDev].EraseVerify(nDev, pstLLDMEArg[nDev],
                                                       nFlag)

   if (nErr != LLD_SUCCESS)
   {
      printf(“XXX_EraseVerify()fail. ErrCode = %x\n”, nErr);
      return (FALSE32);
   }
   return (TRUE32);
}
```

(2) Example to implement the function in OneNAND

```
INT32
ONLD_EraseVerify(UINT32 nDev, LLDMEArg *pstMEArg, UINT32 nFlag)
{
   UINT32     nBAddr;
   UINT32     nCnt;
   INT32      nRet = ONLD_SUCCESS;
   LLDMEList   *pstMEPList;

   nBAddr = GET_DEV_BADDR(nDev);

   /* for verify */
   pstMEPList = pstMEArg->pstMEList;
```

```
    if((nFlag & ONLD_FLAG_SYNC_MASK) == ONLD_FLAG_SYNC_OP)
    {
       while (GET_ONLD_INT_STAT(nBAddr, PEND_ERASE)
             != (UINT16)PEND_ERASE)
       {
          /* Wait until device ready */
       }
       pstPrevOpInfo[nDev]->ePreOp    = NONE;
    }

    for(nCnt = 0; nCnt < pstMEArg->nNumOfMList; nCnt++)
    {
       /* Block Number Set */
       ONLD_REG_START_ADDR1(nBAddr)
            = (UINT16)MAKE_FBA(pstMEPList[nCnt].nMEListPbn);
       ONLD_REG_START_ADDR2(nBAddr)
            = (UINT16)MAKE_DBS(pstMEPList[nCnt].nMEListPbn);

       /* Erase Verify Command issue */
       ONLD_DBG_PRINT((TEXT("[ONLD:MSG]  Erase Verify\r\n")));

        /* INT Stat Reg Clear */
       ONLD_REG_INT(nBAddr)   = (UINT16)INT_CLEAR;

       ONLD_REG_CMD(nBAddr)   = (UINT16)ONLD_CMD_ERASE_VERIFY;

       while (GET_ONLD_INT_STAT(nBAddr, PEND_INT)
              != (UINT16)PEND_INT)
       {
          /* Wait until device ready */
       }

       /* Erase Operation Verifying Error Check */
       if (GET_ONLD_CTRL_STAT(nBAddr, ERROR_STATE)
           == ERROR_STATE)
       {
          pstMEArg->nBitMapErr |= (1 << nCnt);
          nRet = LLD_MERASE_ERROR;
       }
    }

    return (nRet);
}
```

SEE ALSO

XXX_Read, XXX_Write, XXX_Erase, XXX_Copyback, XXX_MRead, XXX_MWrite, XXX_MErase

XXX_CopyBack

DESCRIPTION

This function copies data by using internal buffer in the device.

SYNTAX

```
INT32
XXX_CopyBack(UINT32 nDev, CpBkArg *pstCpArg, UINT32 nFlag)
```

PARAMETERS

Parameter	Type	In/Out	Description
nDev	UINT32	In	Physical Device Number (0 ~ 7)
pstCpArg	CpBkArg	In	Pointer to CpBkArg data structure
nFlag	UINT32	In	Operation options (ECC on/off, Sync/Async)

`nFlag` has the operaion options as follows.

Flag	Value	Description
LLD_FLAG_ASYNC_OP	(1<<0)	Asynchronous Operation
LLD_FLAG_SYNC_OP	(0<<0)	Synchronous Operation
LLD_FLAG_ECC_ON	(1<<1)	ECC on (Read Operation with ECC)
LLD_FLAG_ECC_OFF	(0<<1)	ECC off (Read Operation without ECC)

Flag value is divided into Sync/Async Operation flag and ECC on/off flag. These two flags can be merged as follows.

```
nFlag = LLD_FLAG_SYNC_OP | LLD_FLAG_ECC_ON;
```

RETURN VALUE

Return Value	Description
LLD_SUCCESS	Copyback Success
LLD_READ_ ERROR | ECC result code	Data Integrity Fault (1 or 2bit ECC error)
LLD_WRITE_ERROR	Write Operation Error
LLD_PREV_WRITE_ERROR | LLD_PREV_OP_RESULT	In DCOP (Deferred Check Operation), previous write error happens
LLD_PREV_ERASE_ERROR | LLD_PREV_OP_RESULT	In DCOP (Deferred Check Operation), previous erase error happens
LLD_ILLEGAL_ACCESS	Illegal Copyback Operaion

REMARKS

This function is mandatory.

DCOP(Deferred Check Operation) : a method optimizing the operation performance. The DCOP method is a procedure to terminate the function (write or erase) right after the command issue. Then it checks the result of the operation at next function call.

Examples in this document do not implement the interrupt, because this Copyback example is implemented by calling Read and Write functions directly. If implementation of

Copyback does not call Read and Write functions directly, codes which execute next steps must be added to support asynchoronous mode. First, check the value of a flag. And then, clear an interrupt. Finally, enable the interrupt.

Copyback means the operation method to copy pages using the internal buffer in a NAND device. This copyback method improves the performance by cutting the transfer time and operation procedure, because this method does not use the external memory. When copying a page using the copyback method, a part of data can be brought the outside device; this is called **Random-in**.

`RndInArg` and **`CpBkArg`** data structures are declared in `XsrTypes.h`.

☐ **`RndInArg`** data structure

```
typedef struct
{
   UINT16   nOffset;     /* nOffset : sector offset(0 - 3) * 1024
                          + Main(0 - 511) + Spare(512 - 527) */
   UINT16   nNumOfBytes; /* Random In Bytes                   */
   UINT8   *pBuf;        /* Data Buffer Pointer               */
} RndInArg;
```

Table 5-5 describes `RndInArg` data structure.

Table 5-5. RndInArg data structure in XsrTypes.h

Member Varilable	**Description**
`nNumOfBytes`	The size of data to be changed
`nOffset`	The location of data to Random-in Offset : sector offset(0 - 3) * 1024+ Main(0 - 511) + Spare(512 - 527)
`pBuf`	The pointer of data to be changed

☐ **`CpBkArg`** data structure

```
typedef struct
{
   UINT32   nSrcSn;       /* Copy Back Source Vsn, should be page
                          aligned */
   UINT32   nDstSn;       /* Copy Back Dest.  Vsn, should be page
                          aligned */
   UINT32   nRndInCnt;    /* Random In Count                   */
   RndInArg *pstRndInArg; /* RndInArg Array pointer            */
} CpBkArg;
```

Table 5-6 describes `CpBkArg` data structure.

Table 5-6. CpBkArg data structure in XsrTypes.h

Member Varilable	**Description**
`nSrcSn`	The location of a source page in NAND flash memory Physical sector number aligned at Physical page address

nDstSn	The location of data to be copied Physical sector number aligned at Physical page address
nRndInCnt	The count of Random-in
pstRndInArg	Pointer to RndInArg data structure

EXAMPLE

(1) Example to call the function

```
#include <XSRTypes.h>
#include <PAM.h>
#include <LLD.h>
#include <XXX.h>   /* Header File of Low Level Device Driver */

BOOL32
Example(VOID)
{
   INT32     nErr;
   UINT32    nDev = 0;
   UINT32    nVol = 0;
   UINT8     aMBuf[XSR_MAIN_SIZE];
   UINT8     aSBuf[XSR_SPARE_SIZE];
   CpBkArg   stCpArg;
   RndInArg  stRIArg[2];
   UINT32    nFlag = LLD_FLAG_ASYNC_OP;
   LowFuncTbl stLFT[MAX_VOL];

   PAM_RegLFT((VOID *)stLFT);

   stCpArg.nSrcSn         = 32;
   stCpArg.nDstSn      = 64;
   stCpArg.nRndInCnt      = 2;
   stCpArg.pstRndInArg    = &stRIArg[0];
   stRIArg[0].nOffset     = 0;
   stRIArg[0].nNumOfBytes = LLD_MAIN_SIZE;
   stRIArg[0].pBuf        = &aMBuf[0];
   stRIArg[1].nOffset     = 512;
   stRIArg[1].nNumOfBytes = LLD_SPARE_SIZE;
   stRIArg[1].pBuf        = &aSBuf[0];

   nErr = stLFT[nVol].CopyBack(nDev, &stCpArg, nFlag);

   if (nErr != LLD_SUCCESS)
   {
      printf("XXX_CopyBack()fail. ErrCode = %x\n", nErr);
      return (FALSE32);
   }
   return (TRUE32);
}
```

(2) Example to implement the function in OneNAND

```
INT32
ONLD_CopyBack(UINT32 nDev, CpBkArg *pstCpArg, UINT32 nFlag)
{
   UINT8              aBABuf[2];
   UINT8             *pRIBuf;
   INT32              nSctNum, nOffset;
```

```
    UINT16           nBSA;
    UINT16           nEccRes;
    UINT16           nPbn;
    volatile UINT16   *pDevBuf;
    UINT32           nCnt;
    UINT32          *pONLDMBuf, *pONLDSBuf;
    UINT32           nBAddr;
    UINT32           nRISize;
    INT32      nRes;
    RndInArg   *pstRIArg;

    nBAddr = GET_DEV_BADDR(nDev);

    if ((nRes = _ChkPrevOpResult(nDev)) != ONLD_SUCCESS)
    {
        return nRes;
    }
    /*-----------------------------------------------*/
    /* Step 1. READ                                 */
    /*---------------------------------------------*/

    nPbn = GET_PBN(nDev, pstCpArg->nSrcSn);

    /* Block Number Set */
    ONLD_REG_START_ADDR1(nBAddr) = (UINT16)MAKE_FBA(nPbn);
    /* Device BufferRam Select */
    ONLD_REG_START_ADDR2(nBAddr) = (UINT16)MAKE_DBS(nPbn);

    /* Sector Number Set */
    ONLD_REG_START_ADDR8(nBAddr) = (UINT16)(
         ((pstCpArg->nSrcSn << astONLDInfo[nDev].nFPASelSft)
          & MASK_FPA)
          |(pstCpArg->nSrcSn & astONLDInfo[nDev].nFSAMask));

    nBSA = (UINT16)MAKE_BSA(0, DATA_BUF0);

    ONLD_REG_START_BUF(nBAddr)   = (UINT16)(
         (nBSA & MASK_BSA) | (GET_SCTS_PER_PG(nDev) & MASK_BSC));

    pONLDMBuf = (UINT32*)GET_ONLD_MBUF_ADDR(
                  nBAddr, 0, DATA_BUF0);
    pONLDSBuf = (UINT32*)GET_ONLD_SBUF_ADDR(
                  nBAddr, 0, DATA_BUF0);

    if (nFlag & ONLD_FLAG_ECC_ON)
    {
        /* System Configuration Reg set (ECC On)*/
        ONLD_REG_SYS_CONF1(nBAddr) &= CONF1_ECC_ON;
    }
    else
    {
        /* System Configuration Reg set (ECC Off)*/
        ONLD_REG_SYS_CONF1(nBAddr) |= CONF1_ECC_OFF;
    }

    /* INT Stat Reg Clear */
    ONLD_REG_INT(nBAddr)        = (UINT16)INT_CLEAR;
    /*---------------------------------------------*/
    /* ONLD Read CMD is issued                     */
    /*---------------------------------------------*/
    /* Page Read Command issue */
    ONLD_REG_CMD(nBAddr) = (UINT16)ONLD_CMD_READ_PAGE;

    while (GET_ONLD_INT_STAT(nBAddr, PEND_READ)
           != (UINT16)PEND_READ)
    {
        /* Wait until device ready */
    }

    if (nFlag & ONLD_FLAG_ECC_ON)
    {
        nEccRes = ONLD_REG_ECC_STAT(nBAddr);
        if (nEccRes & ONLD_READ_UERROR_A)
        {
            return (ONLD_READ_ERROR | nEccRes);
        }
    }

    /*---------------------------------------------*/
    /* Step 2. DATA RANDOM IN                      */
    /*---------------------------------------------*/

     pstRIArg = pstCpArg->pstRndInArg;

    for (nCnt = 0 ; nCnt < pstCpArg->nRndInCnt ; nCnt++)
    {
        nSctNum = (pstRIArg[nCnt].nOffset / 1024);
        nOffset = (pstRIArg[nCnt].nOffset % 1024);
        pRIBuf  = pstRIArg[nCnt].pBuf;
        nRISize = pstRIArg[nCnt].nNumOfBytes;

        if (nOffset < ONLD_MAIN_SIZE)
        {
            /* byte align for 16 */
            if ((nOffset % sizeof(UINT16)) != 0)
            {
                pDevBuf =(volatile UINT16*)((UINT32)
                          pONLDMBuf + (nSctNum * ONLD_MAIN_SIZE)
                          + nOffset - 1);

                *(volatile UINT16*)aBABuf = *pDevBuf;
                aBABuf[1] = *pRIBuf++;
                *pDevBuf = *(volatile UINT16*)aBABuf;

                if (--nRISize <= 0)
                {
                    continue;
                }
                nOffset++;
            }

            if ((nRISize % sizeof(UINT16)) != 0)
            {
                pDevBuf = (volatile UINT16*)((UINT32)
                           pONLDMBuf + (nSctNum * ONLD_MAIN_SIZE)
```

```
                                + nOffset + nRISize - 1);

                    *(volatile UINT16*)aBABuf = *pDevBuf;
                    aBABuf[0] = *(pRIBuf + nRISize - 1);
                    *pDevBuf = *(volatile UINT16*)aBABuf;

                    if (--nRISize <= 0)
                    {
                        continue;
                    }
                }

                MEMCPY((UINT8*)((UINT32)
                      pONLDMBuf+(nSctNum * ONLD_MAIN_SIZE)+nOffset),
                      pRIBuf,
                      nRISize);
            }
            else
            {
                if ((nOffset % sizeof(UINT16)) != 0)
                {
                    pDevBuf = (volatile UINT16*)((UINT32)
                                pONLDSBuf + (nSctNum * ONLD_SPARE_SIZE)
                                + (nOffset - ONLD_MAIN_SIZE) - 1);

                    *(volatile UINT16*)aBABuf = *pDevBuf;
                    aBABuf[1] = *pRIBuf++;
                    *pDevBuf = *(volatile UINT16*)aBABuf;
                    if (--nRISize <= 0)
                    {
                        continue;
                    }
                    nOffset++;
                }

                if ((nRISize % sizeof(UINT16)) != 0)
                {
                    pDevBuf = (volatile UINT16*)((UINT32)
                                pONLDSBuf + (nSctNum * ONLD_SPARE_SIZE)
                                + (nOffset - ONLD_MAIN_SIZE)
                                + nRISize - 1);

                    *(volatile UINT16*)aBABuf = *pDevBuf;
                    aBABuf[0] = *(pRIBuf + nRISize - 1);
                    *pDevBuf = *(volatile UINT16*)aBABuf;

                    if (--nRISize <= 0)
                    {
                        continue;
                    }
                }

                MEMCPY((UINT8*)((UINT32)
                       pONLDSBuf + (nSctNum * ONLD_SPARE_SIZE)
                       + (nOffset - ONLD_MAIN_SIZE)),
                       pRIBuf,
                       nRISize);
             }
```

```
    }

    /*---------------------------------------------*/
    /* Step 3. WRITE                              */
    /*--------------------------------------------*/
    nPbn = GET_PBN(nDev, pstCpArg->nDstSn);

    /* Block Number Set */
    ONLD_REG_START_ADDR1(nBAddr) = (UINT16)MAKE_FBA(nPbn);
    ONLD_REG_START_ADDR2(nBAddr) = (UINT16)MAKE_DBS(nPbn);
    /* Sector Number Set */
    ONLD_REG_START_ADDR8(nBAddr) = (UINT16)(
            ((pstCpArg->nDstSn << astONLDInfo[nDev].nFPASelSft)
            & MASK_FPA)
            | (pstCpArg->nDstSn & astONLDInfo[nDev].nFSAMask));

    nBSA = (UINT16)MAKE_BSA(pstCpArg->nDstSn, DATA_BUF0);

    ONLD_REG_START_BUF(nBAddr)   = (UINT16)(
             (nBSA & MASK_BSA) |
             (GET_SCTS_PER_PG(nDev) & MASK_BSC));

    if (nFlag & ONLD_FLAG_ECC_ON)
    {
        /* System Configuration Reg set (ECC On)*/
        ONLD_REG_SYS_CONF1(nBAddr) &= CONF1_ECC_ON;
    }
    else
    {
        /* System Configuration Reg set (ECC Off)*/
        ONLD_REG_SYS_CONF1(nBAddr) |= CONF1_ECC_OFF;
    }

    ONLD_REG_INT(nBAddr)        = (UINT16)INT_CLEAR;

    /*---------------------------------------------*/
    /* ONLD Write CMD is issued                    */
    /*---------------------------------------------*/

    /* Main Write Command issue */
    ONLD_REG_CMD(nBAddr) = (UINT16)ONLD_CMD_WRITE_PAGE;

    pstPrevOpInfo[nDev]->ePreOp    = CPBACK;
    pstPrevOpInfo[nDev]->nPsn      = pstCpArg->nDstSn;
    pstPrevOpInfo[nDev]->nScts     = GET_SCTS_PER_PG(nDev);
    pstPrevOpInfo[nDev]->nFlag     = nFlag;
    pstPrevOpInfo[nDev]->nBufSel    = DATA_BUF0;

    /* in case async mode, interrupt should be enabled */
    if (nFlag & ONLD_FLAG_ASYNC_OP)
    {
        PAM_ClearInt((UINT32)XSR_INT_ID_NAND_0);
        PAM_EnableInt((UINT32)XSR_INT_ID_NAND_0);
    }

    return (ONLD_SUCCESS);
}
```

SEE ALSO

`XXX_Read, XXX_Write, XXX_Erase, XXX_MRead, XXX_MWrite, XXX_MErase, XXX_EraseVerify`

XXX_ChkInitBadBlk

DESCRIPTION

This function checks whether a block is an initial bad block or not.

SYNTAX

```
INT32
XXX_ChkInitBadBlk(UINT32 nDev, UINT32 nPbn)
```

PARAMETERS

Parameter	Type	In/Out	Description
nDev	UINT32	In	Physical Device Number (0 ~ 7)
nPbn	UINT32	In	Physical Block Number

RETURN VALUE

Return Value	Description
LLD_SUCCESS	Bad Block Check Success
LLD_INIT_GOODBLOCK	In a Good Block (Not a Bad Block)
LLD_INIT_BADBLOCK	In an Initial Bad Block
LLD_PREV_WRITE_ERROR | LLD_PREV_OP_RESULT	In DCOP (Deferred Check Operation), previous write error happens
LLD_PREV_ERASE_ERROR | LLD_PREV_OP_RESULT	In DCOP (Deferred Check Operation), previous erase error happens
LLD_ILLEGAL_ACCESS	Illegal Operation

REMARKS

This function is mandatory.

DCOP(Deferred Check Operation) : a method optimizing the operation performance. The DCOP method is a procedure to terminate the function (write or erase) right after the command issue. Then it checks the result of the operation at next function call.

If the value of the bad mark position in the first or second page of a block is not `0xff`(a normal statement), the block is the initial bad block.

EXAMPLE

(1) Example to call the function

```
#include <XSRTypes.h>
#include <PAM.h>
#include <LLD.h>
#include <XXX.h>   /* Header File of Low Level Device Driver */

BOOL32
Example(VOID)
{
    INT32     nErr;
    UINT32    nDev = 0;
    UINT32    nVol = 0;
    UINT32    nPbn = 0;
    LowFuncTbl stLFT[MAX_VOL];

    PAM_RegLFT((VOID *)stLFT);

    nErr = stLFT[nVol].ChkInitBadBlk(nDev, nPbn);

    if (nErr != LLD_SUCCESS)
    {
        printf("XXX_ChkInitBadBlk()fail. ErrCode = %x\n", nErr);
        return (FALSE32);
    }
    return (TRUE32);
}
```

(2) Example to implement the fuinction in OneNAND

```
INT32
ONLD_ChkInitBadBlk(UINT32 nDev, UINT32 nPbn)
{
    INT32   nRet;
    UINT16  aSpare[ONLD_SPARE_SIZE / 2];
    UINT32  nPsn;
    UINT32  nBAddr;

    nBAddr = GET_DEV_BADDR(nDev);

    nPsn = nPbn * GET_SCTS_PER_BLK(nDev);

    nRet = ONLD_Read(nDev,      /* Device Number              */
                  nPsn,        /* Physical Sector Number     */
                  (UINT32)1,   /* Number of Sectors to be read */
                  (UINT8*)NULL,
                           /* Buffer pointer for Main area  */
                  (UINT8*)aSpare,
                          /* Buffer pointer for Spare area */
                  (UINT32)ONLD_FLAG_ECC_OFF);/*flag       */

    if ((nRet != ONLD_SUCCESS) && ((nRet & (0xFFFF0000))
         != (UINT32)ONLD_READ_ERROR))
    {
        return (nRet);
    }

    if (aSpare[0] != (UINT16)VALID_BLK_MARK)
    {
        return (ONLD_INIT_BADBLOCK);
    }

    return (ONLD_INIT_GOODBLOCK);
}
```

SEE ALSO

XXX_SetRWArea

DESCRIPTION

This function is called when NAND device provides write/erase protection functionality in hardware.

SYNTAX

```
INT32
XXX_SetRWArea(UINT32 nDev, UINT32 n1stUB, UINT32 nNumOfUBs)
```

PARAMETERS

Parameter	Type	In/Out	Description
nDev	UINT32	In	Physical Device Number (0 ~ 7)
n1stUB	UINT32	In	Start block index of unlocked area
nNumOfUBs	UINT32	In	Total number of blocks of unlocked area nNumOfUBs = 0, the device is locked.

RETURN VALUE

Return Value	Description
LLD_SUCCESS	Unlock Aea Setting Success
LLD_ILLEGAL_ACCESS	Illegal Setting

REMARKS

This function is optional.

If the hardware does not provide write/erase protection functionality in hardware, a user does not need to implement this function.

EXAMPLE

(1) Example to call the function

```
#include <XSRTypes.h>
#include <PAM.h>
#include <LLD.h>
#include <XXX.h>   /* Header File of Low Level Device Driver */

BOOL32
Example(VOID)
{
   INT32     nErr;
   UINT32    nDev      = 0;
   UINT32    nVol      = 0;
   UINT32    n1stUB    = 0;
   UINT32    nNumOfUBs = 1024;
   LowFuncTbl stLFT[MAX_VOL];

   PAM_RegLFT((VOID *)stLFT);

   nErr = stLFT[nVol].SetRWArea(nDev, n1stUB, nNumOfUBs);
```

```
    if (nErr != LLD_SUCCESS)
    {
        printf(“XXX_ SetRWArea()fail. ErrCode = %x\n”, nErr);
        return (FALSE32);
    }
    return (TRUE32);
}
```

(2) Example to implement the function in OneNAND

```
INT32
ONLD_SetRWArea(UINT32 nDev, UINT32 nSUbn, UINT32 nUBlks)
{
    INT32   nRes;

    if ((nRes = _ChkPrevOpResult(nDev)) != ONLD_SUCCESS)
    {
        pstPrevOpInfo[nDev]->ePreOp = NONE;
        return nRes;
    }

    if (astONLDInfo[nDev].SetRWArea != NULL)
    {
        astONLDInfo[nDev].SetRWArea(nDev, nSUbn, nUBlks);
    }
    else
    {
        return (ONLD_ILLEGAL_ACCESS);
    }

    return (ONLD_SUCCESS);
}
```

SEE ALSO

XXX_IOCtl

DESCRIPTION

This function is called to extend LLD functionality.

SYNTAX

```
INT32
XXX_IOCtl(UINT32  nDev,  UINT32 nCode, UINT8  *pBufI,
          UINT32 nLenI, UINT8 *pBufO, UINT32 nLenO,
          UINT32 *pByteRet)
```

PARAMETERS

Parameter	Type	In/Out	Description
nDev	UINT32	In	Physical Device Number (0 ~ 7)
nCode	UINT32	In	IO Control Command
pBufI	UINT8 *	In	Input Buffer pointer
nLenI	UINT32	In	Length of Input Buffer
pBufO	UINT8 *	Out	Output Buffer pointer
nLenO	UINT32	In	Length of Output Buffer
pByteRet	UINT32 *	Out	The number of bytes (length) of Output Buffer as the result of function call

RETURN VALUE

Return Value	Description
LLD_SUCCESS	Success
LLD_IOC_NOT_SUPPORT	In not-supported command

REMARKS

This function is optional.

DCOP(Deferred Check Operation) : a method optimizing the operation performance. The DCOP method is a procedure to terminate the function (write or erase) right after the command issue. Then it checks the result of the operation at next function call.

The following list is IO control code command.

- LLD_IOC_SET_SECURE_LT
- LLD_IOC_SET_BLOCK_LOCK
- LLD_IOC_GET_SECURE_STAT
- LLD_IOC_RESET_NAND_DEV

The following explains the description, parameters, and return value of each IO control code.

LLD_IOC_SET_SECURE_LT

1. Description

If NAND flash memory supports the lock scheme, this command code lock-tighten the current lock statement.
If NAND flash memory does not support the lock scheme, this command returns `LLD_ILLEGAL_ACCESS`

2. Parameter

Parameter	Description
`nDev`	Physical Device Number (0 ~ 7)
`nCode`	`LLD_IOC_SET_SECURE_LT`
`pBufI`	Pointer to Start Block Number and Number of Blks if Lock Block device is used. Not used if Lock Range device is used
`nLenI`	Length of Input Buffer if Lock Block device is used Not used if Lock Range device is used
`pBufO`	Not used
`nLenO`	Not used
`pByteRet`	This value is set as 0 in `XXX_IOCtl.`

3. Return Value

Return Value	Description
`LLD_SUCCESS`	Lock-tighten the current lock statement

`LLD_IOC_SET_BLOCK_LOCK`

1. Description

If NAND flash memory supports the lock scheme, this command code locks the blocks given in pBufI.

2. Parameter

Parameter	Description
`nDev`	Physical Device Number (0 ~ 7)
`nCode`	`LLD_IOC_SET_SECURE_LT`
`pBufI`	Pointer to Start Block Number and Number of Blks
`nLenI`	Length of Input Buffer
`pBufO`	Not used
`nLenO`	Not used
`pByteRet`	This value is set as 0 in `XXX_IOCtl.`

3. Return Value

Return Value	Description
`LLD_SUCCESS`	Lock the blocks given in pBufI

LLD_IOC_GET_SECURE_STAT

1. Description

If NAND flash memory supports the lock scheme, this command code gets the current lock statement. The current lock statement is saved at `pBufO`.
If NAND flash memory does not support the lock scheme, the current lock statement is `LLD_IOC_SECURE_US`.

2. Parameter

Parameter	Description
`nDev`	Physical Device Number (0 ~ 7)
`nCode`	`LLD_IOC_GET_SECURE_STAT`
`pBufI`	Not used
`nLenI`	Not used
`pBufO`	Buffer to store return value
`nLenO`	Length of pBufO
`pByteRet`	This value is set as output buffer length in `XXX_IOCtl.`

3. Return Value

Return Value	Description
`LLD_SUCCESS`	Get the current lock statement
`LLD_ILLEGAL_ACCESS`	The value of pBufO or nLenO parameter is abnormal

4. Remark

There are three values of the lock statement. The lock statement is declared in LLD.h.
The following describes each lock statement.

LLD_IOC_SECURE_LT is that the locked block of NAND flash memory is lock-tightened.
The block cannot be changed to unlocked or locked by software.

LLD_IOC_SECURE_LS is that all block of NAND flash memory is locked.
All block can be read and cannot be written or erased.

LLD_IOC_SECURE_US is that the sequential block of NAND flash memory is unlocked.
The unlocked sequential block can be read/written/erased.
The locked block keeps the locked statement, so it cannot be read/written/erased.

LLD_IOC_RESET_NAND_DEV

1. Description

This control command resets NAND flash memory.

2. Parameter

Parameter	Description
nDev	Physical Device Number (0 ~ 7)
nCode	LLD_IOC_RESET_NAND_DEV
pBufI	Not used
nLenI	Not used
pBufO	Not used
nLenO	Not used
pByteRet	This value is set as 0 in XXX_IOCtl.

3. Return Value

Return Value	Description
LLD_SUCCESS	Reset NAND flash memory

EXAMPLE

(1) Example to implement the function in OneNAND

```
INT32
ONLD_IOCtl(UINT32  nDev,  UINT32 nCode,
           UINT8  *pBufI, UINT32 nLenI,
           UINT8  *pBufO, UINT32 nLenO,
           UINT32 *pByteRet)
{
    INT32   nRet;
    UINT32  nBAddr;
    UINT16  nRegVal;
    INT32   nRes;

    if (pByteRet == NULL)
    {
        return (ONLD_ILLEGAL_ACCESS);
    }

    nBAddr = GET_DEV_BADDR(nDev);

    if ((nRes = _ChkPrevOpResult(nDev)) != ONLD_SUCCESS)
    {
        return nRes;
    }

    switch (nCode)
    {
        case LLD_IOC_SET_SECURE_LT:
            if (astONLDInfo[nDev].LockTight != NULL)
                astONLDInfo[nDev].LockTight(nDev, pBufI, nLenI);
            else
                return (ONLD_ILLEGAL_ACCESS);
            *pByteRet = (UINT32)0;
            nRet = ONLD_SUCCESS;
            break;

        case LLD_IOC_SET_BLOCK_LOCK:

            if (_LockBlock(nDev, pBufI, nLenI) != ONLD_SUCCESS)
```

```
          {
             return (ONLD_ILLEGAL_ACCESS);
          }

          *pByteRet = (UINT32)0;
          nRet = ONLD_SUCCESS;
          break;

       case LLD_IOC_GET_SECURE_STAT:
          if ((pBufO == NULL) || (nLenO < 2))
          {
             return (ONLD_ILLEGAL_ACCESS);
          }
          nRegVal = ONLD_REG_WR_PROTECT_STAT(nBAddr);
          MEMCPY(pBufO, &nRegVal, sizeof(UINT16));
          *pByteRet = (UINT32)2;
          nRet = ONLD_SUCCESS;
          break;

       case LLD_IOC_RESET_NAND_DEV:

          if ((GET_DEV_DID(nDev) & 0x0008) == DDP_CHIP)
          {
             ONLD_REG_START_ADDR1(nBAddr) = (UINT16)(0x0000);
             ONLD_REG_START_ADDR2(nBAddr) = (UINT16)(0x0000);

             ONLD_REG_INT(nBAddr) = (UINT16)INT_CLEAR;
             /*---------------------------------------*/
             /* ONLD Unlock CMD is issued            */
             /*--------------------------------------*/
             ONLD_REG_CMD(nBAddr)   = (UINT16)ONLD_CMD_RESET;

             while (GET_ONLD_INT_STAT(nBAddr, PEND_RESET)
                    != (UINT16)PEND_RESET)
             {
                /* Wait until device ready */
             }

             ONLD_REG_START_ADDR1(nBAddr) = (UINT16)(0x8000);
             ONLD_REG_START_ADDR2(nBAddr) = (UINT16)(0x8000);
          } /*if DDP_CHIP */

          ONLD_REG_INT(nBAddr)          = (UINT16)INT_CLEAR;


           /*--------------------------------*/
           /* ONLD Unlock CMD is issued      */
           /*---------------------------------*/
          ONLD_REG_CMD(nBAddr) = (UINT16)ONLD_CMD_RESET;

          while (GET_ONLD_INT_STAT(nBAddr, PEND_RESET)
                 != (UINT16)PEND_RESET)
          {
             /* Wait until device ready */
          }

          *pByteRet = (UINT32)0;
          nRet = ONLD_SUCCESS;
```

```
            break;

        default:
            nRet = ONLD_IOC_NOT_SUPPORT;
            break;
    }
    return nRet;
}
```

SEE ALSO

XXX_GetPrevOpData

DESCRIPTION

This function copies data of previous write operation to the given buffer. This function is called to rewrite the block in the error case of the previous write operation.

SYNTAX

```
INT32
XXX_GetPrevOpData(UINT32 nDev, UINT8 *pMBuf, UINT8 *pSBuf)
```

PARAMETERS

Parameter	Type	In/Out	Description
nDev	UINT32	In	Physical Device Number (0 ~ 7)
pMBuf	UINT8 *	Out	Memory buffer for main array of NAND flash memory
pSBuf	UINT8 *	Out	Memory buffer for spare array of NAND flash memory

RETURN VALUE

Return Value	Description
LLD_SUCCESS	Copy Success
LLD_ILLEGAL_ACCESS	Illegal access

REMARKS

This function is an optional Deferred Check Operation function.

DCOP(Deferred Check Operation) : a method optimizing the operation performance. The DCOP method is a procedure to terminate the function (write or erase) right after the command issue. Then it checks the result of the operation at next function call.

EXAMPLE

(1) Example to call the function

```
#include <XSRTypes.h>
#include <PAM.h>
#include <LLD.h>
#include <XXX.h>   /* Header File of Low Level Device Driver */

BOOL32
Example(VOID)
{
   INT32     nErr;
   UINT32    nDev = 0;
   UINT32    nVol = 0;
   UINT8     aMBuf[LLD_MAIN_SIZE];
   UINT8     aSBuf[LLD_SPARE_SIZE];
   LowFuncTbl stLFT[MAX_VOL];

   PAM_RegLFT((VOID *)stLFT);
```

```
    nErr = stLFT[nVol].GetPrevOpData(nDev, aMBuf, aSBuf);

    if (nErr != LLD_SUCCESS)
    {
       printf("XXX_ GetPrevOpData()fail. ErrCode = %x\n", nErr);
       return (FLASE32);
    }
    return (TRUE32);
}
```

(2) Example to implement the function in OneNAND

```
INT32
ONLD_GetPrevOpData(UINT32 nDev, UINT8 *pMBuf, UINT8 *pSBuf)
{
    UINT32  nBAddr;
    UINT32  nPbn;
    UINT32 *pONLDMBuf, *pONLDSBuf;

    nBAddr = GET_DEV_BADDR(nDev);

    if ((pMBuf == NULL) && (pSBuf == NULL))
    {
       return (ONLD_ILLEGAL_ACCESS);
    }

    nPbn = GET_PBN(nDev, pstPrevOpInfo[nDev]->nPsn);
    ONLD_REG_START_ADDR2(nBAddr) = (UINT16)MAKE_DBS(nPbn);

    pONLDMBuf = (UINT32*)GET_ONLD_MBUF_ADDR(
                                 nBAddr,
                                 pstPrevOpInfo[nDev]->nPsn,
                                 GET_CUR_BUF_SEL(nDev));
    pONLDSBuf = (UINT32*)GET_ONLD_SBUF_ADDR(
                                 nBAddr,
                                 pstPrevOpInfo[nDev]->nPsn,
                                 GET_CUR_BUF_SEL(nDev));

    /*-------------------------------------------------*/
    /* Data is loaded into Memory                      */
    /*-------------------------------------------------*/
    if (pMBuf != NULL)
    {
       /* Memcopy for main data */
       MEMCPY(pMBuf, pONLDMBuf,
              (ONLD_MAIN_SIZE * pstPrevOpInfo[nDev]->nScts));
    }
    if (pSBuf != NULL)
    {
       /* Memcopy for spare data */
       MEMCPY(pSBuf, pONLDSBuf,
              (ONLD_SPARE_SIZE * pstPrevOpInfo[nDev]->nScts));
    }

    return (ONLD_SUCCESS);
}
```

SEE ALSO

```
XXX_FlushOp
```

XXX_FlushOp

DESCRIPTION

This function completes the current working operation.

SYNTAX

```
INT32
XXX_FlushOp(UINT32 nDev)
```

PARAMETERS

Parameter	Type	In/Out	Description
nDev	UINT32	In	Physical Device Number (0 ~ 7)

RETURN VALUE

Return Value	Description
LLD_SUCCESS	Success
LLD_ILLEGAL_ACCESS	Illegal Access
LLD_PREV_WRITE_ERROR | LLD_PREV_OP_RESULT	In DCOP (Deferred Check Operation), previous write error happens
LLD_PREV_ERASE_ERROR | LLD_PREV_OP_RESULT	In DCOP (Deferred Check Operation), previous erase error happens

REMARKS

This function is an optional Deferred Check Operation function.

EXAMPLE

(1) Example to call the function

```
#include <XSRTypes.h>
#include <PAM.h>
#include <LLD.h>
#include <XXX.h>   /* Header File of Low Level Device Driver */

BOOL32
Example(VOID)
{
   INT32     nErr;
   UINT32    nDev = 0;
   UINT32    nVol = 0;
   LowFuncTbl stLFT[MAX_VOL];

   PAM_RegLFT((VOID *)stLFT);

   nErr = stLFT[nVol].FlushOp(nDev);

   if (nErr != LLD_SUCCESS)
   {
      printf("XXX_ FlushOp()fail. ErrCode = %x\n", nErr);
      return (FALSE32);
   }
```

```
    return (TRUE32);
}
```

(2) Example to implement the function in OneNAND

```
INT32
ONLD_FlushOp(UINT32 nDev)
{
    UINT32 nBAddr;
    INT32  nRes;

    nBAddr = GET_DEV_BADDR(nDev);

    if ((nRes = _ChkPrevOpResult(nDev)) != ONLD_SUCCESS)
    {
        return nRes;
    }

    return (ONLD_SUCCESS);
}
```

SEE ALSO

`XXX_GetPrevOpData`

6. PAM (Platform Adaptation Module)

This chapter describes the definition, system architecture, features, and APIs of PAM.

6.1. Description & Architecture

PAM is an abbreviation of Platform Adaptation Module. PAM links XSR with the platform. PAM is responsible for the platform-dependent part of XSR layer (STL, and BML). If the platform is changed, a user only changes PAM.

☞ **Reference**

Generally, the platform is underlying the computer system on which application program can run. This document calls the platform is the board that consists of CPU, DRAM, NAND flash memory, etc.

For example, a layer of XSR wants to requests the volume and device information of NAND flash memory. The requested information is dependent on the platform. Each layer calls an adaptation module PAM to use the platform functionalities. Therefore, a user must implement PAM suitable for the platform when a user ports XSR.

Figure 6-1 shows PAM in XSR system architecture.

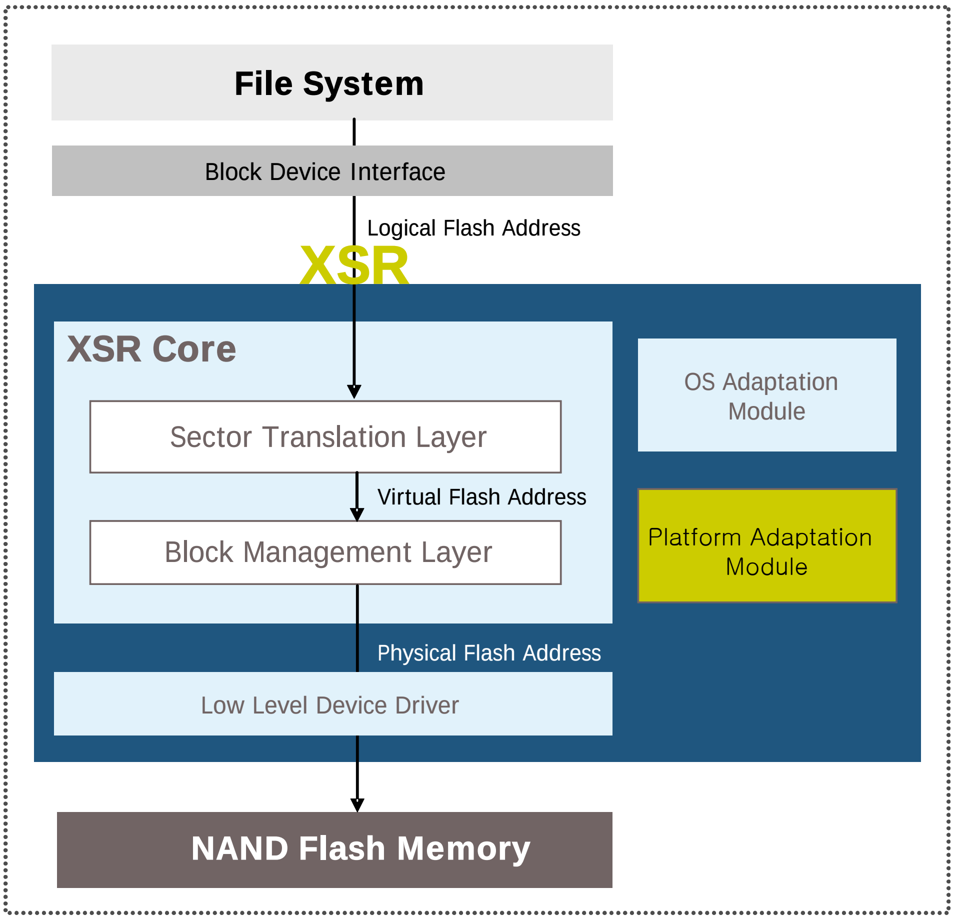


Figure 6-1. PAM in XSR System Architecture

PAM has 9 functions that are classified into 4 categories as follows.

☐ **Initialization function :** hardware initialization

☐ **Device Configuration functions :** LFT registration, and XSR and LLD information return

☐ **Interrupt functions :** interrupt initialization, interrupt bind, interrupt enable, interrupt disable, and interrupt clear

☐ **Memory Operation function :** memory copy

In the next chapter, PAM APIs are covered in detail.

6.2. API

This chapter describes PAM APIs.

☞ **Reference**

All the PAM function has a prefix "`PAM_`" on each function name.

Table 6-1 shows the lists of PAM APIs.
The right row in table shows that the function is **M**andatory or **O**ptional or **R**ecommended. Optional functions should be existed, but contents of the functions does not need to be implemented.

Table 6-1. PAM API

Function	Description	
`PAM_Init`	This function initializes NAND specific hardware	**O**
`PAM_GetPAParm`	This function maps the platform and device.	**M**
`PAM_RegLFT`	This function registers LLD to XSR.	**M**
`PAM_InitInt`	This function initializes the interrupt for NAND device.	**O**
`PAM_BindInt`	This function binds the interrupt for NAND device.	**O**
`PAM_EnableInt`	This function enables the interrupt for NAND device.	**O**
`PAM_DisableInt`	This function disables the interrupt for NAND device.	**O**
`PAM_ClearInt`	This function clears the interrupt for NAND device.	**O**
`PAM_Memcpy`	This function copies data from source to destination	**M**

PAM_Init

DESCRIPTION

This function initializes NAND specific Hardware.

SYNTAX

```
VOID
PAM_Init(VOID)
```

PARAMETERS

None

RETURN VALUE

None

REMARKS

This function performs platform specific initialization for allowing access to NAND flash device. If necessary, this function should initialize memory bus width, and memory configuration registers for NAND flash device.

EXAMPLE

(1) Example to call the function

```
#include <PAM.h>
#include <XSRTypes.h>

VOID
Example(VOID)
{
    /* PAM_Init() should be called at open time */
    PAM_Init();

    /* LLD Function Table initialization */
    PAM_RegLFT(gstLFT);
}
```

(2) Example to implement the function in S3C2410

```
VOID
PAM_Init(VOID)
{
}
```

SEE ALSO

PAM_GetPAParm

DESCRIPTION

This function maps the platform and device.

SYNTAX

```
VOID*
PAM_GetPAParm(VOID)
```

PARAMETERS

None

RETURN VALUE

Return Value	Description
`VOID *`	Returns the address of the array having information about the volume and device

REMARKS

This function is mandatory.

Currently, XSR supports two volumes and eight devices at maximum, because the number of maximum volume (`XSR_MAX_VOL`) is defined as 2 and the number of maximum device (`XSR_MAX_DEV`) is defined as 8 in XSRTypes. When calling `PAM_GetPAParm`, a user can get the volume and device information together. So, a user gets the platform information by calling `PAM_GetPAParm.`

`XsrVolParm` data structure is declared in PAM.h.

☐ **`XsrVolParm`** data structure

```
typedef struct {
    UINT32  nBaseAddr[XSR_MAX_DEV/XSR_MAX_VOL];
    /* the base address for accessing NAND device*/

    UINT16  nEccPol;
    /* Ecc Execution Section
        NO_ECC : No ECC or ECC execution by
                 another type of ECC algorithm
        SW_ECC : ECC execution by XSR Software
                 (based on Hamming code)
        HW_ECC : ECC execution by HW
                 (if HW has ECC functionality
                  based on Hamming code) */

    UINT16  nLSchemePol;
    /* Lock Scheme Policy Section
        NO_LOCK_SCHEME : No Lock Scheme
        SW_LOCK_SCHEME : Lock Scheme Execution by SW
        HW_LOCK_SCHEME : Lock Scheme Execution by HW
```

```
                        (if HW has Lock/Unlock functionality)*/

    BOOL32  bByteAlign;
    /* Memory Byte Alignment Problem
       TRUE32 : Byte Align Problem Free in XSR and LLD
                 (Memory usage increased)
       FALSE32 : No Action for Byte Align Problem */

    UINT32  nDevsInVol;
    /* number of devices in the volume */

    VOID   *pExInfo;
    /* For Device Extension. For Extra Information of Device,
       data structure can be mapped.      */

} XsrVolParm;
```

More detailed explanation about `XsrVolParm` is as follow.

☐ **`nBaseAddr`** is a base address of NAND device for LLD.

☐ **`nEccPol`** is a policy whether using ECC code or not: `nEccPol` can be `HW_ECC`, `SW_ECC` and `NO_ECC`. A user sets as `HW_ECC` when NAND device provides ECC generation/correction based on Hamming code. In that case, spare assignment for generated ECC code should be compatible with Samsung spare assignment standard. A user sets as `NO_ECC` when NAND device uses no ECC algorithm or hardware ECC algorithm which is not compatible with Samsung standards[6]. When a user wants to use software ECC supported by XSR and sets as `SW_ECC`, BML handles ECC generation/correction. For more information about the ECC policy, refer to Chapter 7.6 ECC Policy.

☐ **`nLSchemePol`** is a policy related to write/erase protection: `nLSchemePol` can be `HW_LOCK_SCHEME`, `SW_LOCK_SCHEME`, and `NO_LOCK_SCHEME`. A user sets as `NO_LOCK_SCHEME` when NAND device does not provide the lock scheme, and sets as `HW_LOCK_SCHEME` when NAND device use the lock scheme. When a user wants to use the lock scheme in software and sets as `SW_LOCK_SCHEME` , BML handles the write/erase protection.

☐ **`bByteAlign`** is used to decide whether LLD fits the alignment or not, when LLD gets not-aligned buffer from the upper layer in read/write operation. A users set as `TRUE32` that means to fit the alignment, while a user sets as `FALSE32` that means to hand it over LLD, although it is not-aligned.

☐ **`nDevsInVol`** is the number of the allocated device in the volume.

☐ **`pExInfo`** is entry for extension usage. It is available for developers who want to add their own platform dependent information.

EXAMPLE

(1) Example to call the function

[6] Memory Division, Samsung Electronics Co., Ltd, "ECC(Error Checking & Correction) Algorithm", http://www.samsung.com/Products/Semiconductor/Flash/TechnicalInfo/eccalgo_040624.pdf

Memory Division, Samsung Electronics Co., Ltd, "NAND Flash Spare Assignment recommendation", http://www.samsung.com/Products/Semiconductor/Flash/TechnicalInfo/Spare_assignment_recommendation.pdf

```
#include <PAM.h>
#include <XSRTypes.h>

VOID
Example(VOID)
{
    XsrVolParm *pstPAM;

    pstPAM = (XsrVolParm *) PAM_GetPAParm();
}
```

(2) Example to implement the function in S3C2410

```
#include <XSRTypes.h>
#include <PAM.h>
#include <XXX.h>  /* Header File of Low Level Device Driver */

#define   VOL0   0
#define   VOL1   1

#define   DEV0   0
#define   DEV1   1
#define   DEV2   2
#define   DEV3   3

VOID*
PAM_GetPAParm(VOID)
{
    gstParm[VOL0].nBaseAddr[DEV0] = 0x20000000;
    gstParm[VOL0].nBaseAddr[DEV1] = NOT_MAPPED;
    gstParm[VOL0].nBaseAddr[DEV2] = NOT_MAPPED;
    gstParm[VOL0].nBaseAddr[DEV3] = NOT_MAPPED;

    gstParm[VOL0].nEccPol         = SW_ECC;
    gstParm[VOL0].nLSchemePol     = SW_LOCK_SCHEME;
    gstParm[VOL0].bByteAlign      = TRUE32;
    gstParm[VOL0].nDevsInVol      = 1;
    gstParm[VOL0].pExInfo         = NULL;

    gstParm[VOL1].nBaseAddr[DEV0] = NOT_MAPPED;
    gstParm[VOL1].nBaseAddr[DEV1] = NOT_MAPPED;
    gstParm[VOL1].nBaseAddr[DEV2] = NOT_MAPPED;
    gstParm[VOL1].nBaseAddr[DEV3] = NOT_MAPPED;

    gstParm[VOL1].nEccPol         = HW_ECC;
    gstParm[VOL1].nLSchemePol     = HW_LOCK_SCHEME;
    gstParm[VOL1].bByteAlign      = TRUE32;
    gstParm[VOL1].nDevsInVol      = 0;
    gstParm[VOL1].pExInfo         = NULL;

    return (VOID *) gstParm;
}
```

SEE ALSO

PAM_RegLFT

DESCRIPTION

This function registers functions to XSR.

SYNTAX

```
VOID
PAM_RegLFT(VOID *pstFunc)
```

PARAMETERS

Parameter	Type	In/Out	Description
`pstFunc`	`VOID *`	`Out`	Pointer to LowFuncTbl data structure

RETURN VALUE

None

REMARKS

This function is mandatory.

1. Registering LLD address to BML

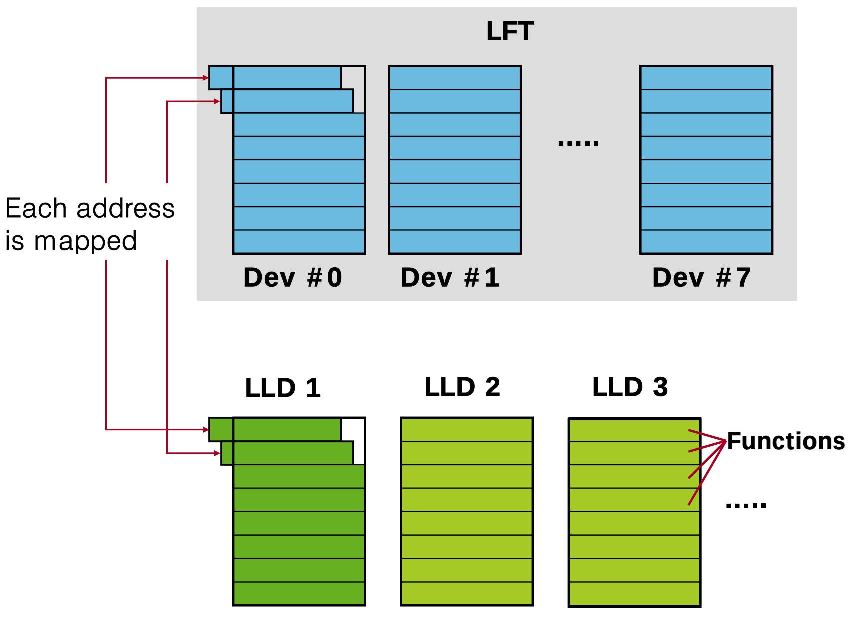


Figure 6-2. Register LLD Address to BML

BML encapsulates the various device driver(LLD)s. LFT(LLD Function Table) is a list of 17 functions that is encapsulated by BML. LFT is defined at LLD.h as LowFuncTbl.

☐ **`LowFuncTbl`** data structure

```
typedef struct {
   INT32 (*Init)    (VOID  *pParm);
   INT32 (*Open)    (UINT32 nDev);
   INT32 (*Close)   (UINT32 nDev);
   INT32 (*Read)    (UINT32 nDev,  UINT32 nPsn, UINT32 nScts,
                     UINT8 *pMBuf, UINT8 *pSBuf, UINT32 nFlag);
   INT32 (*Write)   (UINT32 nDev,  UINT32 nPsn, UINT32 nScts,
                     UINT8 *pMBuf, UINT8 *pSBuf, UINT32 nFlag);
   INT32 (*MRead)   (UINT32 nDev,  UINT32 nPsn, UINT32 nScts,
                     SGL *pstSGL, UINT8 *pSBuf, UINT32 nFlag);
   INT32 (*MWrite)  (UINT32 nDev,  UINT32 nPsn, UINT32 nScts,
                     SGL *pstSGL, UINT8 *pSBuf, UINT32 nFlag,
                     UINT32 *pErrPsn);
   INT32 (*CopyBack)(UINT32 nDev,  CpBkArg *pstCpArg,
                     UINT32 nFlag);
   INT32 (*Erase)   (UINT32 nDev,  UINT32 Pbn, UINT32 nFlag);
   INT32 (*GetDevInfo)(UINT32 nDev,  LLDSpec *pstDevInfo);
   INT32 (*ChkInitBadBlk)(UINT32 nDev,  UINT32 Pbn);
   INT32 (*FlushOp) (UINT32 nDev);
   INT32 (*SetRWArea)(UINT32 nDev, UINT32 nSUbn, UINT32 nUBlks);
   INT32 (*GetPrevOpData)(UINT32 nDev, UINT8 *pMBuf,
                           UINT8 *pSBuf);
   INT32 (*IOCtl)   (UINT32 nDev,  UINT32 nCmd,
                     UINT8 *pBufI, UINT32 nLenI,
                     UINT8 *pBufO, UINT32 nLenO,
                     UINT32 *pByteRet);
   INT32 (*MErase)  (UINT32 nDev, LLDMEArg *pstMEArg,
                     UINT32 nFlag);
   INT32 (*EraseVerify)(UINT32 nDev, LLDMEArg *pstMEArg,
                     UINT32 nFlag);
} LowFuncTbl;
```

`LowFuncTbl` is allocated corresponding to each device and is able to support up to 8. Thus, it is necessary to register the function of real LLD to the corresponding `LowFuncTbl`.

XSR can work together by calling `PAM_RegLFT` and registering the implemented LLD function. BML can call the real LLD function using the function pointer defined at LFT.

`pstFunc` is a pointer of LowFuncTbl, a LLD address table.
When BML calls `PAM_RegLFT`, it finds the real function address to access NAND device using LFT.

2. Defining the volume and device of BML

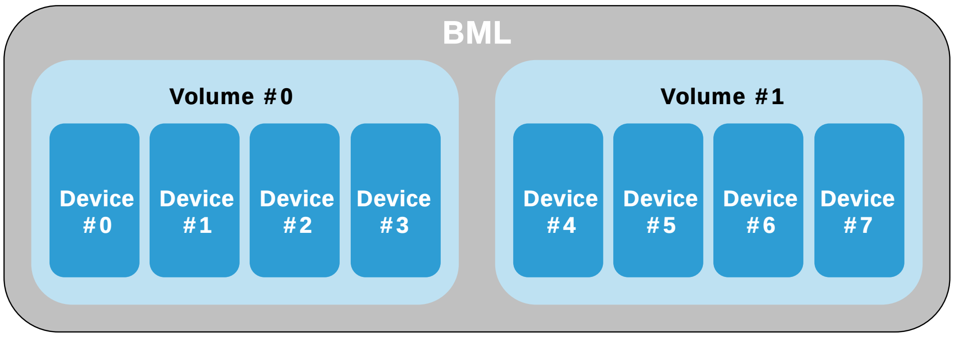


Figure 6-3. Define Volume and Device of BML

A user must recognize the definition of a volume and device to use BML. XSR can support the device up to eight, and BML can manage several devices once bind them with a volume.

BML can support the plural volumes, but it currently supports 2 volumes. BML binds the maximum four devices with a volume, and the devices must be the same type in a volume. For example, the device number `#0 ~ #3` and `#4 ~ #7` must be the same type of LLD.

A user should know this volume and device features at BML, so a user can understand the mapping from BML to LLD using LFT.

EXAMPLE

(1) Example to call the function

```
#include <PAM.h>
#include <XSRTypes.h>

VOID
Example(VOID)
{
    PAM_Init();

    /* LLD Function Table initialization */
    PAM_RegLFT(gstLFT);
}
```

(2) Example to implement the function in S3C2410

```
#include <XSRTypes.h>
#include <PAM.h>
#include <XXX.h>  /* Header File of Low Level Device Driver */

#define   VOL0   0

VOID
PAM_RegLFT(VOID *pstFunc)
{
    LowFuncTbl *pstLFT;

    pstLFT = (LowFuncTbl*)pstFunc;

    pstLFT[VOL0].Init              = ONLD_Init;
    pstLFT[VOL0].Open              = ONLD_Open;
    pstLFT[VOL0].Close             = ONLD_Close;
    pstLFT[VOL0].Read              = ONLD_Read;
    pstLFT[VOL0].Write             = ONLD_Write;
    pstLFT[VOL0].CopyBack          = ONLD_CopyBack;
    pstLFT[VOL0].Erase             = ONLD_Erase;
    pstLFT[VOL0].GetDevInfo        = ONLD_GetDevInfo;
    pstLFT[VOL0].ChkInitBadBlk     = ONLD_ChkInitBadBlk;
    pstLFT[VOL0].FlushOp           = ONLD_FlushOp;
    pstLFT[VOL0].SetRWArea         = ONLD_SetRWArea;
    pstLFT[VOL0].GetPrevOpData     = ONLD_GetPrevOpData;
    pstLFT[VOL0].IOCtl             = ONLD_IOCtl;
    pstLFT[VOL0].MRead             = ONLD_MRead;
    pstLFT[VOL0].MWrite            = ONLD_MWrite;
    pstLFT[VOL0].MErase            = ONLD_MErase;
    pstLFT[VOL0].EraseVerify       = ONLD_EraseVerify;
}
```

SEE ALSO

PAM_InitInt

DESCRIPTION

This function initializes the specified logical interrupt.

SYNTAX

```
VOID
PAM_InitInt(UINT32 nLogIntId)
```

PARAMETERS

Parameter	Type	In/Out	Description
nLogIntId	UINT32	In	Logical interrupt ID number

RETURN VALUE

None

REMARKS

This function is an optional interrupt function.
Currently, this function is used for asynchronous operation.

This function set registers to use interrupts of platform. This function initializes the specified logical interrupt through OS dependent interrupt initialization function.

EXAMPLE

(1) Example to call the function

```
#include <PAM.h>
#include <XSRTypes.h>

#define     INT_ID_NAND_0   (0)     /* Interrupt ID : 1st NAND */

VOID
Example(VOID)
{
    /* initializes interrupt for 1st NAND device */
    PAM_InitInt((UINT32)INT_ID_NAND_0);

    /* initializes interrupt for 1st NAND device */
    PAM_BindInt((UINT32)INT_ID_NAND_0);
}
```

(2) Example to implement the function in S3C2410

```
VOID
PAM_InitInt(UINT32 nLogIntId)
{
    switch (nLogIntId)
    {
        case XSR_INT_ID_NAND_0:
            TS3C2440::GPIO::SelectSignalMethod(EExtInt4,
                ERisingEdgeSignal);
            break;

        default:
            break;
    }

    OAM_InitInt(nLogIntId);
}
```

SEE ALSO

`PAM_BindInt, PAM_EnableInt, PAM_DisableInt, PAM_ClearInt`

PAM_BindInt

DESCRIPTION

This function binds the specified logical interrupt for NAND device.

SYNTAX

```
VOID
PAM_BindInt(UINT32 nLogIntId)
```

PARAMETERS

Parameter	Type	In/Out	Description
`nLogIntId`	`UINT32`	`In`	Logical interrupt ID number

RETURN VALUE

None

REMARKS

This function is an optional interrupt function.
Currently, this function is used for asynchronous operation.

This function translates the specified logical interrupt ID into the physical interrupt ID and binds the interrupt through OS dependent function which binds interrupt.

EXAMPLE

(1) Example to call the function

```
#include <PAM.h>
#include <XSRTypes.h>

#define    INT_ID_NAND_0   (0)    /* Interrupt ID : 1st NAND */

VOID
Example(VOID)
{
   /* initializes interrupt for 1st NAND device */
   PAM_InitInt((UINT32)INT_ID_NAND_0);

   /* initializes interrupt for 1st NAND device */
   PAM_BindInt((UINT32)INT_ID_NAND_0);
}
```

(2) Example to implement the function in S3C2410

```
VOID
PAM_BindInt(UINT32 nLogIntId)
{
   UINT32 nPhyIntId = 0;

   switch (nLogIntId)
   {
      case XSR_INT_ID_NAND_0:
            nPhyIntId = EIrqExt4_7;
            break;

        default:
            break;
    }

    OAM_BindInt(nLogIntId, nPhyIntId);
}
```

SEE ALSO

`PAM_InitInt, PAM_EnableInt, PAM_DisableInt, PAM_ClearInt`

PAM_EnableInt

DESCRIPTION

This function enables the specified logical interrupt for NAND device.

SYNTAX

```
VOID
PAM_EnableInt(UINT32 nLogIntId)
```

PARAMETERS

Parameter	Type	In/Out	Description
`nLogIntId`	`UINT32`	`In`	Logical interrupt ID number

RETURN VALUE

None

REMARKS

This function is an optional interrupt function.
Currently, this function is used for asynchronous operation.

This function translates the specified logical interrupt ID into the physical interrupt ID and enables the interrupt through OS dependent function which enables interrupt.

EXAMPLE

(1) Example to call the function

```
#include <PAM.h>
#include <XSRTypes.h>

#define    INT_ID_NAND_0   (0)    /* Interrupt ID : 1st NAND */

VOID
Example(VOID)
{
   PAM_ClearInt((UINT32)INT_ID_NAND_0);
   PAM_EnableInt((UINT32)INT_ID_NAND_0);
}
```

(2) Example to implement the function in S3C2410

```
VOID
PAM_EnableInt(UINT32 nLogIntId)
{
   UINT32 nPhyIntId = 0;

   switch (nLogIntId)
   {
      case XSR_INT_ID_NAND_0:
         nPhyIntId = EIrqExt4_7;
         break;

```

```
        default:
            break;
    }

    OAM_EnableInt(nLogIntId, nPhyIntId);
}
```

SEE ALSO

`PAM_InitInt, PAM_BindInt, PAM_DisableInt, PAM_ClearInt`

PAM_DisableInt

DESCRIPTION

This function disables the specified logical interrupt for NAND device.

SYNTAX

```
VOID
PAM_DisableInt(UINT32 nLogIntId)
```

PARAMETERS

Parameter	Type	In/Out	Description
`nLogIntId`	`UINT32`	`In`	Logical interrupt ID number

RETURN VALUE

None

REMARKS

This function is an optional interrupt function.
Currently, this function is used for asynchronous operation.

This function translates the specified logical interrupt ID into the physical interrupt ID and disables the interrupt through OS dependent function which disables interrupt.

EXAMPLE

(1) Example to call the function

```
#include <PAM.h>
#include <XSRTypes.h>

#define    INT_ID_NAND_0   (0)    /* Interrupt ID : 1st NAND */

VOID
Example(VOID)
{
    PAM_ClearInt((UINT32)INT_ID_NAND_0);
    PAM_DisableInt((UINT32)INT_ID_NAND_0);
}
```

(2) Example to implement the function in S3C2410

```
VOID
PAM_DisableInt(UINT32 nLogIntId)
{
    UINT32 nPhyIntId = 0;

    switch (nLogIntId)
    {
        case XSR_INT_ID_NAND_0:
            nPhyIntId = EIrqExt4_7;
            break;
        default:
            break;
    }

    OAM_DisableInt(nLogIntId, nPhyIntId);
}
```

SEE ALSO

`PAM_InitInt, PAM_BindInt, PAM_EnableInt, PAM_ClearInt`

PAM_ClearInt

DESCRIPTION

This function clears the specified logical interrupt for NAND device.

SYNTAX

```
VOID
PAM_ClearInt(UINT32 nLogIntId)
```

PARAMETERS

Parameter	Type	In/Out	Description
`nLogIntId`	`UINT32`	`In`	Logical interrupt ID number

RETURN VALUE

None

REMARKS

This function is an optional interrupt function.
Currently, this function is used for asynchronous operation.

This function translates the specified logical interrupt ID into the physical interrupt ID and clears the interrupt through OS dependent function which clears interrupt.

EXAMPLE

(1) Example to call the function

```
#include <PAM.h>
#include <XSRTypes.h>

#define    INT_ID_NAND_0   (0)    /* Interrupt ID : 1st NAND */

VOID
Example(VOID)
{
   PAM_ClearInt((UINT32)INT_ID_NAND_0);
   PAM_EnableInt((UINT32)INT_ID_NAND_0);
}
```

(2) Example to implement the function in S3C2410

```
VOID
PAM_ClearInt(UINT32 nLogIntId)
{
   UINT32 nPhyIntId = 0;

   switch (nLogIntId)
   {
      case XSR_INT_ID_NAND_0:
         nPhyIntId = EIrqExt4_7;
         break;

```

```
        default:
            break;
    }

    OAM_ClearInt(nLogIntId, nPhyIntId);
}
```

SEE ALSO

`PAM_InitInt, PAM_BindInt, PAM_EnableInt, PAM_DisableInt`

PAM_Memcpy

DESCRIPTION

This function copies data from the source to the destination.

SYNTAX

```
VOID
PAM_Memcpy(VOID *pDst, VOID *pSrc, UINT32 nLen)
```

PARAMETERS

Parameter	Type	In/Out	Description
pDst	VOID *	Out	Array Pointer of destination data to be copied
pSrc	VOID *	In	Array Pointer of source data to be copied
nLen	UINT32	In	Length to be copied

RETURN VALUE

None

REMARKS

This function is a mandatory memory operation function.

This function is called by the function that wants to copy data in the source buffer to data in the destination buffer. If system can support a functionality for memory copy by hardware, PAM_Memcpy uses it to adjust the memory copy operation to specific environment of platform. If not, PAM_Memcpy just calls OS dependent Memcpy function.

EXAMPLE

(1) Example to call the function

```
#include <PAM.h>
#include <XSRTypes.h>

UINT8 SrcBuf[512];
UINT8 DstBuf[512];

VOID
Example(VOID)
{
   PAM_Memcpy(&DstBuf[0], &SrcBuf[0], (512));
}
```

(2) Example to implement the function in S3C2410

```
VOID
PAM_Memcpy(VOID *pDst, VOID *pSrc, UINT32 nLen)
{
   OAM_Memcpy(pDst, pSrc, nLen);
}
```

(3) Example to implement the function in O5912

```
VOID
```

```
PAM_Memcpy(VOID *pDst, VOID *pSrc, UINT32 nLen)
{
   if (nLen > 0xffff) return;

   DMA_CSSA_L = (unsigned short)((unsigned int)
                                (src)&0x0000FFFF);
   DMA_CSSA_U = (unsigned short)(((unsigned int)
                                 (src)&0xFFFF0000)>>16);
   DMA_CDSA_L = (unsigned short)((unsigned int)
                                (dst)&0x0000FFFF);
   DMA_CDSA_U = (unsigned short)(((unsigned int)
                                 (dst)&0xFFFF0000)>>16);

   DMA_CEN = byte_len >> 1;   /* channel element number */

   DMA_CCR = 0x54c0;

   /* poll if dma finished */
   while (!(DMA_CSR&0x8))
   {
      //polling if DMA finished
   }
   return;
}
```

SEE ALSO

Index