NITRO-SDK

A Description of the Wireless Communications Library

Version 1.1.5

The contents in this document are highly confidential and should be handled accordingly.

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Contents

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Revision History

Version	Revision Date	Description
1.1.5	1/13/2006	Deleted old descriptions and cleaned up vague descriptions in anticipation of NITRO-SDK 3.0.
1.1.4	12/20/2005	・ Clearly stated that the operations relating to when communication are not possible in "3.3.2 Select a Channel to Use." ・ Added "3.3.5 Precautions to Note When Ending Communications." ・ Added "3.4.5 Send & Receive Buffers for MP Communications." ・ Added "3.10 Taking Greater Control Over Communications" and moved some items around. ・ In the FAQ, added examples of how to determine communications parameters.
1.1.3	12/06/2005	・ Added to text relating to V-Blank synchronization and changed it to a separate section. ・ Change in terminology: "Maximum number of bytes that can be sent" changed to "transmission capacity." ・ Moved the section "3.4.4 Transmission Capacity." ・ Added "3.4.5 Dynamically Changing the Transmission Capacity." ・ Added "3.4.9 Timing control parameter of MP Communications."
1.1.2	11/04/2005	・ Updated table of contents.
1.1.1	11/01/2005	・ Indicated the addition of `WM_STATECODE_DISCONNECT_FROM_MYSELF` notification to each of the `WMStartParent`, `WMStartConnect`, and `WMSetPortCallback` functions. ・ Indicated the addition of the `WM_STATECODE_PORT_INIT` notification to the `WMSetPortCallback` function and the addition of the `connectedAidBitmap` field to the `WMPortRecvCallback` structure.
1.1.0	07/29/2005	- Indicated the addition of `WM_STATECODE_INFORMATION` notification to `WMIndCallback` function callback. - Revised descriptions in each section due to change in the condition for a Null response.
1.0.5	07/12/2005	- Revised the return values of the `WM_Initialize` function in the list “Error Codes Returned from the Wireless Communications Library” - 3.4.3.”Operations When Communications Fail”. Added description of the MP notification that happens when there is a failure. - Added descriptions of changes in “3.11.12 Changes in MP Frame Sending Conditions”
1.0.4	06/07/2005	- Added to each Key Sharing related description that we plan to phase it out. - Changed the `WM_StartKeySharing` and `WM_EndKeySharing` functions in the list, “Error Codes Returned from the Wireless Communications Library”. - Added “3.4.5. Limitations to the number MP Communications related to picture frames”
1.0.3	03/29/2005	- Added warning about repeated calling to 3.1.5 Asynchronous Function Callback and Asynchronous Notifications.
1.0.2	03/22/2005	- Added note about CLASS1 state to 3.1.3 The Library Internal State. - Added note about CLASS1 state to 3.10.2 Connection process.

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Version	Revision Date	Description
1.0.1	03/04/2005	- Made changes to the “List of Error Codes Returned from the Wireless Communications Library” - Changed the number of levels in the send queue from 64 to 32 - Made changes to the items related to the `WM_SetMPData` function in the “Event Notifications Returned from the Wireless Communications Library”: changed the description related to the `restBitmap` field in the `WMPortSendCallback` structure, and added a description related to the `sentBitmap` field - Added items to “Important Notes for Recent Releases”
1.0.0	02/18/2005	Initial version.

1 Wireless Communication Library Overview

1.1 Introduction

The Nitro SDK includes a set of functions for wireless communications. This document describes the basic features of the Wireless Communications Library.

1.2 Basic Specifications of the Wireless Communication Hardware

The basic specifications of the wireless hardware in the Nintendo DS are shown below.

Item	Description
Communications Band Used	2.4-GHz band (May receive interference from microwave ovens or other wireless devices that use the 2.4-GHz band)
Communication Standards	IEEE 802.11 equivalent (Infrastructure mode) Nintendo proprietary protocol (DS Wireless Play mode) Nintendo proprietary protocol (DS download play mode)
Communications Speed	1 Mbps or 2 Mbps
Communications Range	10-30 m (This is highly variable based on the surrounding environment and the positions of the systems)
Remarks	Not compatible with the Game Boy Advance Wireless Adapter

1.3 Configuration of the Wireless Communications Library

The NitroSDK Wireless Communications Library processing is performed by both the ARM9 and ARM7. The ARM7 component controls the wireless communication hardware and the ARM9 library transmits requests from the application to ARM7. When creating an application, the ARM7 component does not have to be considered. However, since caution is required for some cache-related processes, be sure to follow the instructions in the reference manual when exchanging data with the Wireless Communications Library.

The Wireless Communications Library provides three main communication modes.

Mode	Description
DS Wireless Play mode	This mode allows for wireless communication in which a single DS acts as the parent device, and up to 15 other DS devices act as child devices.
DS Single-Card Play mode	Also known as wireless multiboot. This mode allows for the download of the program and data from a parent device to child devices that do not have Game Cards. The child device can then start up that program.
Infrastructure mode	Allows connection to the Internet via wireless access points supporting the IEEE 802.11b/g standard.

This document is focused on DS Wireless Play. For further details about DS Single-Card Play, refer to "A Description of DS Single-Card Play (`AboutMultiBoot.pdf`)".

2 Glossary

This glossary defines the terms used in this guide.

Term	Definition
AID	Association ID (the connection identifier). The parent's AID is always 0. Child devices are assigned AIDs from 1 to 15 when they connect. If the maximum number of children permitted to connect is set to n, assigned AIDs must be from 1 to n.
Beacon	A wireless signal, separate from an MP sequence, sent periodically by the parent. A child can receive the beacon even when it has not established a connection. A child making a new connection selects the parent based on the `GameInfo` contained in the beacon. Normally sent at intervals of several hundred ms.
Block transmission	Feature designed to transmit a chunk of data from the parent to multiple children at the same time. For details, see `WBT*` in the "NITRO-SDK Function Reference Manual."
BSS	Basic Service Set. Specifies a set that performs transactions for a single service. In DS Wireless Play, refers to the group that includes a parent and the children connected to it.
BSSID	Basic Service Set ID. This is an ID used to identify the BSS. For DS Wireless Play, the MAC address of the parent device is used as is for the BSSID. This is used to designate a connection destination when a child device connects to the parent device.
Channel	A portion of the communication band. On the DS wireless communications hardware, 1 to 14 channels can be used, but the actual number of available channels is limited by regulations in each country. Also, adjacent channels can interfere with each other, so we recommend setting up channels with roughly five intervals between them.
Child device	The devices (1–15) that connect to a parent device in DS Wireless Play.
Continuous communication mode	The communication mode sustained using continuous MP sequences. (This contrasts with frame-synchronous communication mode.) It is effective for sending large amounts of data, but consumes lots of power and should not be used for long periods. It differs from frame-synchronous communications mode in that it starts MP sequences continuously, but from a control standpoint, the two modes are virtually identical. Thus, a single program can switch between the two modes.
Data sharing	Enables the sharing of data with a user-defined size in addition to key input.

Term	Definition
DS Single-Card play	A child device without a Game Pak or Game Card can boot by downloading a game's ROM image from the parent over a wireless connection. For details, see `MB_*` in the reference manual.
Frame-synchronous communication mode	The communication mode that synchronizes MP communications and the picture frame. (This contrasts with continuous communications mode.) The number of times to communicate during each picture frame is specified. However, if signal conditions are poor and a resend is necessary, the transmission is resent without synchronizing with the frame (if possible).
Game frame	The period defining a unit of game processing. If a game is running at 30 frames/second, the game frame is 1/30 of second.
GameInfo	A data structure that indicates the type of game offered by a parent and contains the data needed to connect. Contains the GGID, the TGID, the maximum transmission capacity of the parent, etc. It can also contain user-defined information. For example, with Single-Card play, the GameInfo contains the game name, icon data, etc.
GGID	Game Group ID. A unique four-byte ID assigned by Nintendo to each game title and series title. Used when connecting.
IEEE 802.11 Specification	A wireless communication standard defined by the IEEE. It defines a wireless communication method that permits speeds of up to 2 Mbps. (802.11b, which is in the same family of standards, allows a maximum speed of 11 Mbps, and is a popular standard for wireless PC communications. 802.11b is backward compatible with 802.11.) The DS uses the 1–2 Mbps backward compatibility mode defined in the 802.11b standard.
Indication	A notification sent automatically from the wireless hardware to the application in response to receiving data or another event. Differentiated from a response to a request from the application.
Key response frame	The type of frame a child uses to respond to an MP frame from the parent.
Key sharing	Functionality common to key input data. Enables you to use wireless communications without worrying about the details. **We plan to discontinue key sharing and recommend that you use Data Sharing instead.**
MAC address	An ID number for the wireless communication hardware. Each DS device has a different 6-byte MAC address.
MP communications	A generic term for communications using *multi-poll (MP) sequences*. In some cases, it refers to the communication for a single MP sequence.
MP frame	The frame at the beginning of an MP sequence, in which the parent broadcasts to the child.

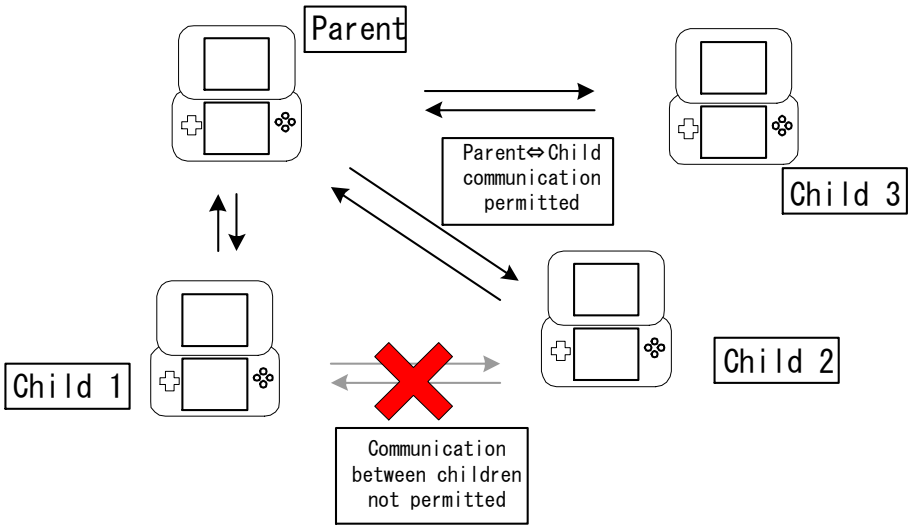
Term	Definition
MP sequence	Multi-Poll sequence. Nintendo's proprietary extension of 802.11 enables wireless communications with a low latency time. For details, see the chapter on DS Wireless Play.
MP_ACK frame	The frame broadcast by a parent to its children at the end of an MP sequence.
Null response frame	The frame a child uses to respond to an MP frame sent by the parent. Sent when the response data cannot be sent within the given time constraints.
Packet	A unit of communication that contains a header and footer. It contains a port number, a packet size and, when necessary, destination information, a sequential number, and so on. In actual communications, within a single MP sequence, a payload contains multiple packets.
Parent device	The device that controls all communication in DS Wireless Play.
Payload	The area in the MP and key response frames that carries data.
Picture frame	The time that elapses from one V-Blank interrupt signal to the next (1/60 of a second).
PollBitmap	A 16-bit bitmap in which each bit corresponds to the AID of a child device. In an MP frame, the bits of the children from which a response is desired are enabled. In an `MP_ACK` frame, the bits of the children from which the parent received no response are enabled.
Port	A concept used in the Wireless Communications Library to realize multiple communication channels. If a transmission specifies a port that is an integer from 0 through 15, the destination calls a callback that corresponds to the number. Note that this port has a lower level of abstraction than ports used in TCP/IP.
Raw communication	A communication method that does not perform additional controls like those in sequential communications. Data may not reach its destination and the same data may be transmitted several times. If ports 0 through 7 are selected, raw communication is used.
Sequential communication	The upper layer of MP communications, which guarantees the integrity of communication. The Wireless Communications Library uses sequential numbers to eliminate long packets and insure that packets reach their destination. If ports 8 through 15 are selected, sequential communication is used.
Session	The period of time from a single `WM_StartParent` to `WM_EndParent`.

Term	Definition
SSID	Info used to screen children connecting to a parent. The child uses the GGID and TGID from `GameInfo` to generate an SSID. The parent connects only to children having a matching GGID and TGID based on the SSID. The latter half of the user area that is not used for matching can be used for communications from the child to the parent.
TGID	Temporary Group ID. A two-byte ID assigned when a new game or session is started. When the same DS continues to be used as the parent device, the TGID splits communications into new and old, since the BSSID and GGID are identical.

3 DS Wireless Play

3.1 Overview

3.1.1 Connection Configuration



In DS Wireless Play, the network is configured in a hub-and-spoke arrangement. Communication is limited to that between parent and children; children cannot communicate with each other. However, a parent can transmit data to multiple children at the same time.

3.1.2 DS Wireless Play Characteristics

- Low latency

  When communications are being performed normally, the send data that is set in the beginning of the picture frame will be received by the communications partner application at the end of the picture frame.

- Data is transmitted at a specified time within one picture frame

  Rather than visualizing that the data is sent at a timing desirable to the parent and child, consider that if the send data is set in advance with the `WM_SetMPDataToPortfunction`, the parent and child send data will be exchanged in fixed sizes when communication occurs.

- The more child devices there are, the smaller the data size that can be sent from each child device

  Since the maximum communication time that a single MP sequence can use is defined in the programming guidelines, the maximum size that can be sent decreases as more child devices are added.

  If there is only one child device, the maximum send size in the Wireless Communications Library

of 512 bytes can be sent on both the parent and child. So, if 15 child devices are connected, the parent device can send 256 bytes and the child devices can only send 8 bytes each. For further details, refer to “3.4.4 Transmission Capacity”.

- The efficiency is better if broadcasting from the parent device

  A particular child device can be selected to send data with the `WM_SetMPDataToPort` function. But, as a characteristic of MP, even if there is a broadcast to multiple child devices, the appropriation time for a wireless channel will not change (except when data is resent or when using a special communication mode).

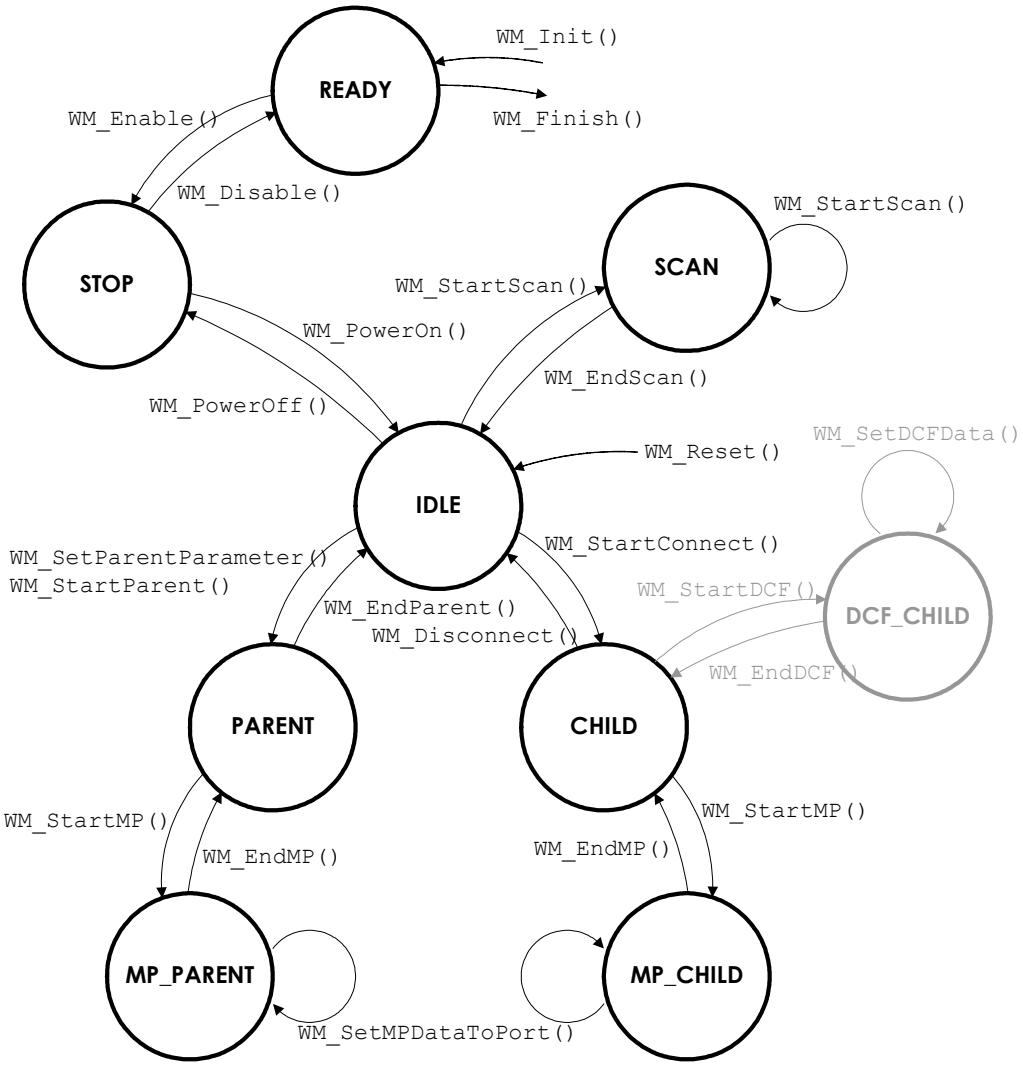
- The efficiency is better for communications of a fixed volume

  Communications from a child device always appropriate a wireless channel for the amount of time required for the child send size (the maximum size that a child can send on a single MP sequence). Therefore, thinking of this as a fixed-length communication allows for more efficient signal use. The initial value of the send size for a child device is set by the parent when the connection is established. .

  Currently, no logic is implemented to increase the number of communications according to how full the send queue is. It is possible for the application to dynamically change the communications frequency, but it is recommended to use communication specifications that do not cause fluctuations in the volume of communication.

3.1.3 The Library Internal State

The Wireless Communications Library shows the internal states in the following diagram. The functions it can call are limited based upon its state. Calling the `WM_Init` function after starting the DS will cause it to transition to a READY state. Refer to the descriptions of each of the functions in the Function Reference to determine in what state each function can be called.



The DCF_CHILD state in the figure above cannot be used in DS Wireless Play.

There is also a CLASS1 state between the IDLE state and the CHILD state. When a connection attempt with WM_StartConnect fails in a specific stage, or when a child disconnects from a parent during connection, it will remain in this state. The only function that can be executed from the CLASS1 state is WM_Reset. Therefore, when WM_StartConnect fails or when a child receives a disconnect notification, use WM_Reset to transition to the IDLE state before moving to the next operation.

3.1.4 Error Codes

With a few exceptions, the Wireless Communications Library functions return the WMErrCode enumerated structure as its error code.

Basically, when operations are normal, synchronous functions return WM_ERRCODE_SUCCESS, while asynchronous functions return WM_ERRCODE_OPERATING.

For further details, refer to "WMErrCode" in the reference, or "3.8 A List of Error Codes Returned from the Wireless Communications Library" in this document.

3.1.5 Asynchronous Function Callback and Asynchronous Notifications

Because the Wireless Communications Library sends instructions to the ARM7 driver, many of those instructions are asynchronous functions. These asynchronous functions take `callback`, a `WMCallbackFunc` type argument, and once the asynchronous process has ended, they call `callback`.

When an asynchronous function is called and its return value is `WM_ERRCODE_OPERATING`, the completion callback is always called.

Also, due to the nature of the communications, there are many asynchronously generated notifications. These notifications are sent as callback function calls. The correspondence between the main notification type and its callback configuration function is shown in the following table:

Communications Type	Function that Configures the Communications Callback Destination
Notification of a connection or a disconnection	`WM_StartParent`, `WM_StartConnect*`
MP sequence-related notification	`WM_StartMP*`
Reception to a port	`WM_SetPortCallback`
All other notifications	`WM_SetIndCallback`

The callback function types in the Wireless Communications Library are defined as `WMCallbackFunc` types. The `WMCallbackFunc` type function takes the sole argument `WMCallback* arg`, but since some functions pass a structure unique to that function (example: `WMPortRecvCallback`), they should be used as needed after casting them to that type. The type of callback argument that each function returns is described in `$NITROSDK_ROOT\man\en_US\wm\wm\WMCallbackFunc.html`.

There may be instances where a field called state has been defined in the structures of the callback arguments for some functions. This state field is used to express notification types that cannot be expressed with the `errcode` field alone. For further details, refer to “3.7 - Event Notifications Returned from the Wireless Communications Library.”

With a few exceptions, each asynchronous function in the wireless communication library registers its callback individually. Use caution because if different callbacks are assigned to the same function at the same time, only the later assigned callback will be valid. This is not true for the `WM_SetMPData*` functions, which store callbacks separately each time they are called. They can be called repeatedly, setting a different callback each time without a problem.

Avoid making multiple calls to asynchronous functions that change the internal state of the wireless communication library. This can cause bugs that are difficult to reproduce.

3.2 Initializing the Wireless Communications Library

3.2.1 Differences between Each of the Initialization and Shutdown Functions

There are two procedures for initializing the Wireless Communications Library: calling the three functions WM_Init, WM_Enable, and WM_PowerOn in order or calling the WM_Initialize function. Similarly, there are two procedures for the shutdown process: calling the three functions WM_PowerOff, WM_Disable, and WM_Finish in order or calling the WM_End function.

The WM_Initialize function performs the same process as calling the three WM_Init, WM_Enable, and WM_PowerOn functions, while the WM_End function performs the same process as calling the three WM_PowerOff, WM_Disable, and WM_Finish functions.

Initialization Process	WM_Initialize	WM_Init	Allocates the buffer the Wireless Communications Library uses.
		WM_Enable	Transitions the wireless communications hardware to a usable state. (The POWER LED will begin to blink irregularly)
		WM_PowerOn	Starts providing power to the wireless communications hardware. (Power consumption will go up)
Shutdown Process	WM_End	WM_PowerOff	Stops providing power to the wireless communications hardware. (Power consumption will go down)
		WM_Disable	Transitions the wireless communications hardware to an unusable state. (Stops the irregular blinking of the POWER LED)
		WM_Finish	Frees the buffer that the Wireless Communications Library uses.

3.2.2 The DS Wireless Communications ON State

The DS wireless communications ON state is defined as the period from when the WM_Enable function is called to when the WM_Disable function is called. There are limitations, such as the need for confirmation to the user, when transitioning to the DS wireless communications ON state. For further details, refer to the DS Programming Guidelines.

3.2.3 The Buffer for the Wireless Communications Library

From the interval after the WM_Init function is called until the WM_Finish function is called, the Wireless Communications Library holds the buffer that will be used inside the library. Pass the WM_SYSTEM_BUF_SIZE-byte region aligned with the 32-byte boundary to the argument of the WM_Init function from main memory.

3.3 Connecting a Parent and a Child

3.3.1 The Connection Process

The process leading up to a connection is as follows:

Parent		Child	
1	Initialize the wireless communication hardware.	**1**	Initialize the wireless communication hardware.
2	Set the parent's GGID, TGID, and other data for communications.		
3	Measure the degree of congestion on each of the wireless channels, and select a channel to use.		
4	Send the beacon on the specified channel. The beacon's `GameInfo` contains the GGID, the TGID, and a flag indicating that it is available for connection.	**2**	Scan the beacons on all channels that the application can possibly use, and obtain the parent device `GameInfo`.
		3	Based on the data in `GameInfo`, list the parent devices for the user and prompt for a selection.
		4	Generate an SSID using the GGID and TGID contained in `GameInfo`, and connect to the parent based on the BSSID (the parent's MAC address) and the SSID.
5	Compare the SSID of the incoming child with its own GGID and TGID, and OK the connection if there is a match.		
6	Assign an AID to the child and complete the connection.	**5**	Receive the assigned AID from the parent and complete the connection.

3.3.2 Select a Channel to Use

The 802.11 specifications define fourteen channels, but the usable channels may be limited depending on the regulations of the country in which they are being used. Also, even if a channel can be used, neighboring channels may cause mutual interference, so try to use channels that are as far apart as possible.

The DS keeps its usable channels internally, and the `WM_GetAllowedChannel` function was prepared therein to present channels that are sufficiently spaced apart. In the application, a channel must be selected from the channels obtained with this function. The application has the responsibility to select a

channel from the presented channels that has as low of a signal usage rate as possible. The signal usage rate of a specific channel can be obtained with the `WM_MeasureChannel` function.

As of January 1, 2006, the international unified specification states that the DS can use channels 1-13. However, this specification is subject to change and there are situations where WM is forbidden from using any special channels internally, so avoid any programming that makes assumptions based on the currently permissible channels. Instead, rely on the results of the WM_GetAllowedChannel function.

Note: If the WM_GetAllowedChannel function returns 0, wireless communications are unavailable. Do not commence communications if this value is returned.

3.3.3 Beacon Information

While the parent device is in the PARENT or MP_PARENT state, it will transmit a signal known as a beacon at regular intervals (the `WMParentParam.beaconPeriod [ms]` interval). The child device that is trying to connect to a parent device will obtain this beacon with the `WM_StartScan` function, and will connect to that parent device by passing the included `WMBssDesc` structure as-is to the argument of the `WM_StartConnect*` function.

`WMBssDesc` contains a variety of fields, but the three most important bits of information are the `WMBssDesc.bssid`, the `WMBssDesc.gameInfo.ggid`, and the TGID.

The BSSID is an identifier for the BSS. During DS Wireless Play, the MAC address of the parent device is used as the BSSID. The GGID and TGID are used to identify the details of the services that the parent device provides. The GGID is an ID assigned by Nintendo to each game or to each series (if communications are possible among the same series). The child device looks for the `WMBssDesc.gameInfo.ggid` of the scan results to confirm that it can connect to the parent device (a code for authorization must be described in the application). The TGID, on the other hand, is assigned by the parent device in each new session so that connections for old sessions are not mistakenly made to new sessions.

3.3.4 Connection Operations

Inside the library, the BSSID and SSID are used when a child device connects to a parent device. The BSSID is the MAC address of the parent device, as described in the previous paragraph. The SSID is a total of 32 bytes, but in DS Wireless Play, the first 4 of those bytes are used to store the GGID and the next 2 bytes are used to store the TGID. A 2 byte reserved region is added to these and used as an 8-byte service identifier. The parent device compares its own GGID and TGID with the first 8 bytes of the SSID that the child device declares to determine whether or not that child device is an appropriate connection partner. If the child device is not an appropriate partner, it will be automatically rejected during the initial steps of the connection process.

Since the first 8 bytes of the SSID are automatically set in the `WM_StartConnect` function by the library based on the `WMBssDesc.gameInfo.ggid` and TGID, there is no need for the application to be aware of them. However, the latter 24 bytes in the SSIDs that are not used in the service identifier are released to the application and can set user data as arguments of the `WM_StartConnect*` function to be sent to the parent device. When the `WM_StartParent` function callback function

receives the `WM_STATECODE_CONNECTED` notification, the parent device receives the data set in the latter 24 bytes of the SSID by the child device as `WMStartParentCallback.ssid`.

3.3.5 Precautions for Ending Communications

Disconnection can be performed by either the parent or the child. Try to avoid the both parent and child performing this operation at the same time, since one of the two processes will fail and in some cases it may take some time for this result to be returned.

Note: There is a possibility that some of the WM functions may return errors, depending on their states, once the process for ending communications has been entered. The end process may go into an infinite loop if it starts on this error: `abnormal end process due to communication error`. If an error occurs, try calling the WM_Reset function once and make sure the error process does not cascade indefinitely.

3.4 MP Protocol Specifications

3.4.1 Communications Overview

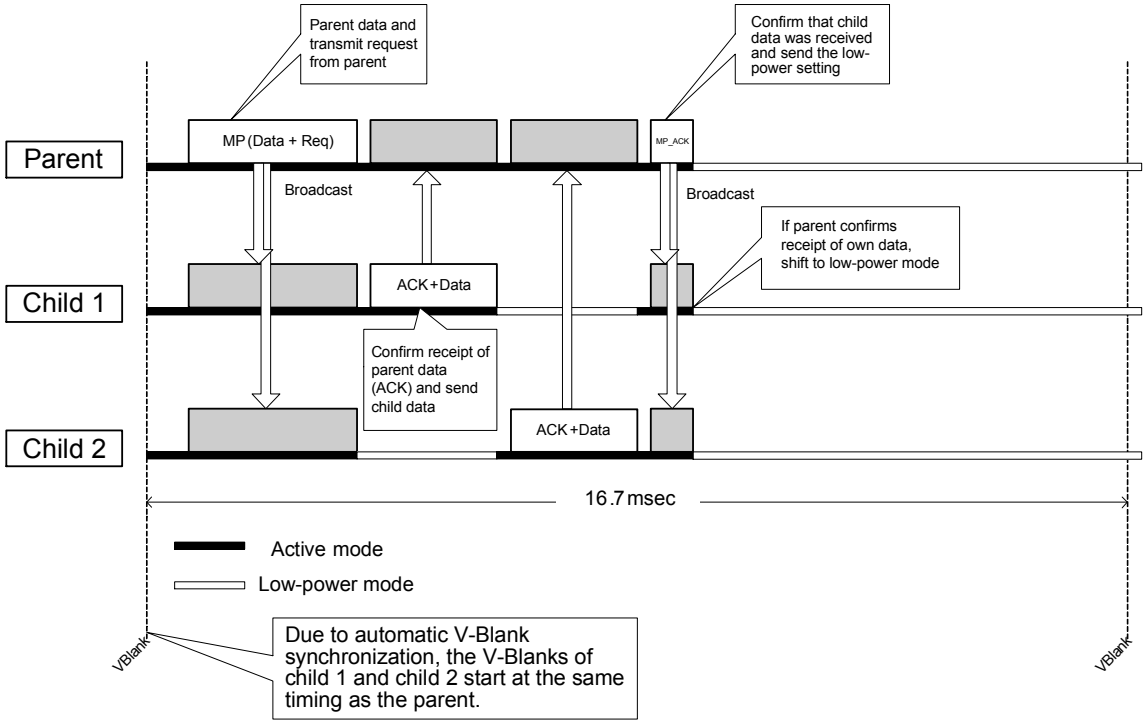
Data can be sent once a connection has been established between a parent and child. Communications are performed in each picture frame in the order shown below:

Parent Device	Child Device

1. Set the send data with the `WM_SetMPDataToPort` function.	1. Set the send data with the `WM_SetMPDataToPort` function.
2. MP communications are automatically performed on the designated timing in each picture frame.	
3. The data reception notification from the child device arrives at the callback function designated to the `WM_SetPortCallback` function. 4. A notification that the send was a success is sent to the callback function designated with `WM_SetMPDataToPort` in step 1, above.	3. The data reception notification from the parent device arrives at the callback function designated to the `WM_SetPortCallback` function. 4. A notification that the send was a success is sent to the callback function designated with `WM_SetMPDataToPort` in step 1, above.

3.4.2 MP Communications Operations

Read this section as necessary. You can use the Wireless Communications Library even if you do not understand all the details of the MP protocol. The MP communications operations, which allow for DS Wireless Play mode, are shown in the figure below:



MP communications is a protocol where the parent completely controls the transmission timing.

1. First, the parent broadcasts an MP frame to all child devices.

   The MP frame includes not only the data to send from the parent to the child but also control data, such as `PollBitmap`, which indicates which children should respond, and `TXOP`, which determines how many bytes of transmission time are assigned to the children.

   Data in the MP frame determine the overall time distribution for that MP sequence.

2. Each child receives the MP frame, looks at `PollBitmap` and TXOP, and then sends the Key response frame to the parent after waiting for its turn to respond.

   The child's Key response contains confirmation that it has received data from the parent in addition to data it is sending to the parent. Since the Key response frame is sent automatically by the hardware as the response to the MP frame, the child needs to set the data in the Key response frame ahead of time. It is not possible to look at the data inside a received MP frame and then alter the contents of the data that will be sent in the response during the same sequence.

   If the TXOP (the allowable transmission time) given by the parent is shorter than the set length of data, then the child cannot send the data. If this is the case, the child transmits a NULL response frame instead of the Key response frame. This occurs when the child's transmission capacity as specified by the parent is smaller than the transmission capacity as recognized by the child.

   The child will not return anything if the send data is not set in the child when the MP frame is received from the parent.

3. Finally, the parent broadcasts an `MP_ACK` frame to all children to acknowledge receipt.

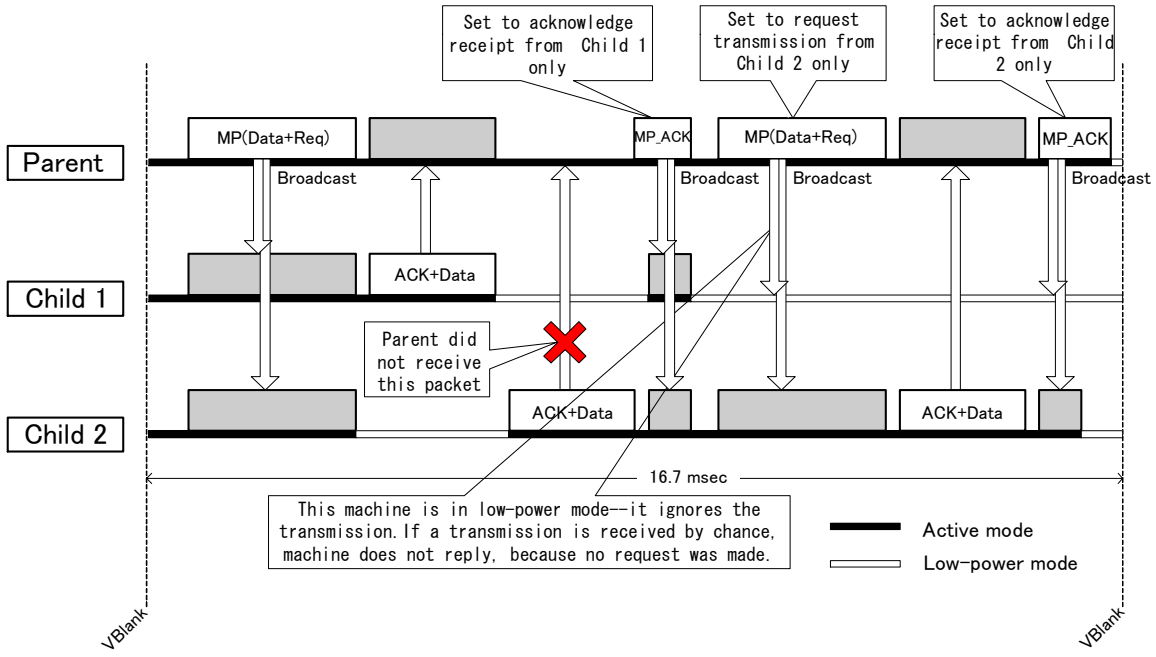
   This `MP_ACK` frame also has a field called `PollBitmap` that, unlike with MP frames, indicates from which children the parent failed to get either a Key response or a NULL response. Each child checks `PollBitmap` in the received `MP_ACK` frame to see whether the bit representing its own AID is enabled. If its AID bit is not enabled, it is guaranteed to send data to the parent successfully. If, however, its bit is enabled or if the child does not receive the `MP_ACK` frame within a set period of time, the transmission failed.

Because the wireless communication hardware consumes a lot of power when active, it enters low-power mode frequently during MP communication. This occurs automatically and normally, so the application can ignore the power mode.

Also, be aware of the child device designated with PollBitmap not being given the chance to respond. In order to secure a communications band from the child to the parent, designate all connected child devices on WM as PollBitmap and perform an MP sequence. However, there are exceptions when resending (described in the next section) and when special communications modes are designated.

3.4.3 Operations When Communications Fail

This graphic shows the flow of operations when the parent receives no acknowledgment from a child.



If reception fails, the `MP_ACK` frame indicates the children from which no response was received, and then an MP sequence for a resend is started. Note that the resend MP sequence targets only children from whom a response was not received. The resend MP sequence sends packets that need to be resent from the packets that just failed. Depending on the communication mode and the type of packet that was not received, the resend process may not be performed and the application is notified that a transmission failure occurred. The resend will continue while communications have failed and there are still packets that need to be resent.

If only the `MP_ACK` frame communications fail, the parent device will be unable to learn about the failure and the MP sequence for resending will not be performed. However, since the child device is unable to determine whether the send was a success, the failed packets will be resent in the next MP sequence.

The resend process differs depending on the type of communications packet. For more information, refer to 3.5.3 Raw Communications and Sequential Communications.

In addition, with the MP sequence for resending, the send destination is limited to the resend partner due to the `PollBitmap` setting. However, the rest of the process is the same as for a normal MP sequence, so receipt notifications are generated each time an MP frame is received.

Note: The Port Receive callback (described later) only gets called when new data is received.

3.4.4 Transmission Capacity

In MP communications, the parent determines the transmission capacity for both itself and the child

which are specified as the default values at the start of communications. To be specific, the default values for transmission capacity are set by the parent's parameter setting function `WM_SetParentParameter`. In the `WMParentParam` structure passed to the `WM_SetParentParameter` function, the `parentMaxSize` field indicates the default send capacity value for sending data from the parent to the child, and the `childMaxSize` field indicates the default send capacity value for sending data from the child to the parent. However, at the time of connection, the child initializes its own transmission capacity setting to the `childMaxSize` value found in the parent's beacon.

The transmission capacity value must meet these three requirements:

1. It must be a multiple of 2.
2. The maximum capacity cannot exceed 512 bytes for parent or child.
3. The time duration of one MP communication, as calculated from the parent and child transmission capacities, must not exceed 5600 microseconds. In other words, the following expression must be satisfied:

96+(24+4+[parent's transmission capacity]+6+4)*4+ (10+96+(24+[child's transmission capacity]+4+4)*4+6)*[number of children]
+10+96+(24+4+4)*4 <= 5600

⇔

[parent's transmission capacity]+([child's transmission capacity]+60)*[number of children] < 1280

(Programming Guidelines "6.3.3 Data Size of One MP Communication [Recommended]")

If the `WMParentParam.KS_Flag` is set to TRUE, the number of transmission bytes for Key Sharing will be added internally, so the actual value that can be set for the transmission capacity is smaller than what is calculated by the above expression. Include in your calculation the bytes that will get secured internally for Key Sharing, which is 36 bytes + 6 bytes (header and footer) for the parent and 6 bytes + 4 bytes (header and footer) for the child.

There is a script available for calculating restrictions on communications time. You can access it at `$NITROSDK_ROOT/man/ja_JP/wm/wm/wm_time_calc.html`.

The above expression is used to determine the maximum time that communications will require. The amount of time taken by each MP sequence will actually be shorter, depending upon the parent send data size. However, on the child side, the amount of time needed is based on the child send volume size. This happens because, when an MP sequence starts, the parent sets timing on the information it knows. A summary is shown below:

Amount of time needed to send parent data	Related to the time for the data size that the parent sent in the sequence. Not influenced by the parent send volume.
Amount of time needed to send child data	Related to the size that the parent configures as the child send volume. Not influenced by the size sent by the child.

3.4.5 Send and Receive Buffers for MP Communications

The Send buffer and the Receive buffer for MP communications are passed to the `WM_StartMP` function when MP communications begin. The sizes of these two buffers vary, depending on the parent

and child transmission capacities and the maximum number of connected children.

There are two ways to calculate the size of the Send and Receive buffers. One way is to call the `WM_GetMPSendBufferSize` or `WM_GetMPReceiveBufferSize` function in the PARENT state or the CHILD state. The other way is to make static calculations by passing the values for the transmission capacity and maximum number of connected children to the function macros shown in the table below.

The `WM_GetMPSendBufferSize` and `WM_GetMPReceiveBufferSize` functions dynamically calculate the sizes required of the Send and Receive buffers for MP communications based on the parent information being used in the current connection. For the parent information, the value that was set by the `WM_SetParentParameter` function prior to the start of communications is referenced. As for child, the information in the beacon obtained from the parent during connection is used. The point to note is that the value obtained by the child with these functions is a value obtained from an external source. If memory is to be secured based on this value, you must verify that the memory size you plan to secure is in the proper range or that the memory has been secured successfully.

See the Reference to read about these functions and function macros in detail.

The Send and Receive buffers for MP communications that get passed to the `WM_StartMP` function must have 32-byte alignment.

		Function macros for static calculations	Related communications parameters		
			Parent's transmission capacity	Child's transmission capacity	Max. number of connected children
Parent	Send Buffer size	`WM_SIZE_MP_PARENT_SEND_BUFFER`	○		
	Receive Buffer size	`WM_SIZE_MP_PARENT_RECEIVE_BUFFER`		○	○
Child	Send Buffer size	`WM_SIZE_MP_CHILD_SEND_BUFFER`		○	
	Receive Buffer size	`WM_SIZE_MP_CHILD_RECEIVE_BUFFER`	○		

3.4.6 V-Blank Synchronization

When MP communications start, the wireless communications library automatically synchronizes V-Blanks between the parent and the child. Be aware that the period between V-Blanks is longer than 16.7 ms while the timing of V-Blanks is being adjusted. Each frame is prolonged by as much as around 0.5 ms. At this time the V-Alarm count value varies between 200 and 213 counts, so do not use a V-Alarm with a count value in this range during communications.

The timing adjustment of V-Blank synchronization is mainly performed right after the connection is established, but it can also occur at any time during communications.

3.4.7 Frame Synchronous Communications Mode and Continuous Communications Mode

The parent device may be operating in either frame synchronous communications mode or continuous communications mode, depending on the timing that starts the MP sequence.

Frame synchronous communications mode is a communications mode that starts the MP sequence on a specific V-Count for each picture frame. After the MP sequence starts, the power-saving mode wait state is entered after the set number of MP sequences has continuously started.

Here, the number of MP sequences in the frame synchronous mode is counted as the number of times an ACK was received from the child devices. This count is done in order to secure a communications band for communications from the child devices. Even when there is no send data from the parent device, the MP sequence continues to be started so that the child devices can perform a prescribed number of sends. Also, if there is a failure in receiving the response frame from the child device, communications will be performed with the number of communications for resends tacked on to that prescribed number. If at this time there are too many communications and it goes into the next picture frame, the counter value for the remaining number of communications will increase cumulatively. However, if the counter exceeds a fixed value, it will not advance any further.

Continuous communications mode is a communications mode in which the next MP sequence starts immediately after the last MP sequence ends. This mode blocks transmissions and other instances where large volumes of data are sent at once. Be aware that this mode consumes relatively large amounts of power, because there is little opportunity to enter into power-saving mode.

The reason there is a time limit of 5600 microseconds on individual MP sequences is to keep operations stable even when multiple parents and children reside on the same channel. When numerous MP sequences run during the same picture frame, the exclusive time on the wireless channel lengthens which destabilizes operations with multiple parents and children on the channel. We recommend keeping the frequency of MP sequences to one per picture frame and work to minimize the frequency to the bare minimum for communications in your applications.

3.4.8 Restrictions on the Number of MP Communications Per Picture Frame

Regardless of whether frame synchronous communication or continuous communication is set, the number of MP communications that may occur in one picture frame is limited. The upper limit can be set using the `WM_SetMPParameter` function. The default value is six.

The MP frequency in frame synchronous communications mode is set to the number of communications to succeed in each picture frame. However, the limitation on the number of communications is a limit for the total number of communications, including those that failed.

This limit is set because in the case that few children are connected and the size of the parent send data temporarily becomes small, one MP communication becomes as short as a few hundred microseconds, and therefore, the frequency of MP communications could increase more than expected by the application.

This restriction feature is how the `fixFreqMode` argument of the `WM_StartMPEx` function gets realized. The `fixFreqMode` argument can be set to place an upper limit on the number of

communications. When the argument is set to TRUE, the upper limit is set to the same value as the MP frequency value.

3.4.9 Lifetime

If a communications partner suddenly disappears and communications do not take place for a fixed amount of time, the wireless communications driver will automatically disconnect from that partner in accordance with the current lifetime setting. There are two lifetimes for DS Wireless Play: `CAM` lifetime and the MP communications lifetime. Both can be configured with the `WM_SetLifeTime` function.

The `CAM` lifetime is a value that determines how long to wait before disconnecting if there is no wireless communications frame from the parent device to a child device, or from the child device to a parent device. It is normally set to 4 seconds.

The MP communications lifetime is a value that determines how long to wait before disconnecting if there is no `Key` response frame sent from the child device to a parent device, or no MP frame sent from the parent device to a child device. It is normally set to 4 seconds.

For the `CAM` lifetime only, the child ARM7 will not disconnect properly if it freezes. Because this depends on the freeze timing, the wireless communications hardware will automatically return a Null response frame in response to an MP frame. The MP communications lifetime was created to avoid this problem.

Even if a connection is established using `WM_StartParent` or `WM_StartConnect`, communications will not begin between the parent and child until the parent device calls the `WM_StartMP` function. So, there is a chance that the lifetime will run out. However, because the child device will not respond until the `WM_StartMP` function is called, there is the chance that the MP communications lifetime will run out. Make sure to call `WM_StartMP` immediately after communications begin.

It is possible to disable automatic disconnection according to the lifetime, but it should always be used with the standard values because it is required in certain situations (such as when the power of a communications partner is suddenly turned off during communications).

3.5 Port Communications

3.5.1 About Port Communications

Due to the multiplexing of communication pathways in MP communications, the concept of the port has been introduced in the Wireless Communications Library. Both parents and children have16 virtual ports. By designating a port number and sending data, the processes on the receiving end can be sorted.

3.5.2 Port Receive Callback

After the initialization of the wireless communications, the receiving end configures the reception callback function to the port number being used with the `WM_SetPortCallback` function. After that, once the send data set by the send side with the `WM_SetMPDataToPort*` function arrives via MP communication, the receive callbacks that correspond to the port number are called on the receive side.

If there is a new connection, or if a communications partner is disconnected, that fact is notified to the receive callbacks of all ports.

For details about notifications, see the section about the `WM_SetPortCallback` function in 3.7 - Event Notifications Returned from the Wireless Communications Library.

3.5.3 Raw Communications and Sequential Communications

There are two types of port communications, sort by the port to use. Ports 0-7 perform Raw communications, while ports 8-15 perform Sequential communications.

There are almost no communication controls performed on raw communications. Sometimes data will not arrive at the communications partner, or the same data will arrive several times. On the other hand, sequential communications performs guaranteed and non-repetitive communication by checking for duplication at the Wireless Communication Library level by attaching a sequence number to each packet and by using a low-level resend process.

If communications fail with raw communications, resends will be attempted up to the number specified in the `defaultRetryCount` argument of the `WM_StartMPEx` function. If `WM_StartMP` is used to start MP communications, no resends are attempted. Sequential communication resend until successful.

When communications are successful or when communications fail even after the specified number of resends, the send-complete callback, which is specified when calling the `WM_SetMPDataToPort*` function, is called. Do not overwrite the memory region where the send data specified with the `WM_SetMPDataToPort*` function is located until the send-complete callback arrives.

Unlike the relationship between TCP and UDP, latency and throughput for raw and sequential communications are similar. Select between them according to whether resends are required. Note that resends to a child device may become a bottleneck with sequential communications if that child device has a poor signal.

3.5.4 Priority and the Send Queue

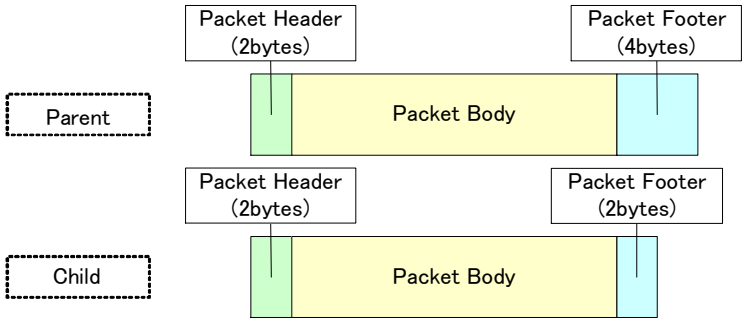
Port communications include the concept of four levels of priority, from 0-3. The send data set by the `WM_SetMPDataToPort*` function is processed with a FIFO (First In First Out) send queue, but there are four send queues with differing priorities. As long as a queue with a high priority is not empty, data will never be sent from a lower-priority queue. Communications that are more likely to be performed in real time, such as Data Sharing, are set to priority 1; the communications that are less likely to be performed in real time, such as block transfer, are set to priority 3.

With raw communications, the priority can be changed and data set while specifying the same port number; however with sequential communications, inconsistencies in the order control can be caused by the sequence number if data is set while changing the priority. Specifically, if higher priority data is set later, the send will be still performed in the order of priority, but lower priority items that were skipped may not be properly sent (in the current implementation, skipped data is sometimes discarded).

If the `WM_SetMPDataToPort*` function is called when the send queue is full, `WM_ERRCODE_SEND_QUEUE_FULL` will be returned to the callback and the function will fail. Up to 32 send packets of differing priorities can be placed in the queue. However, when performing controls that wait for the send-complete callback for the `WM_SetMPDataToPort*` function before setting the next data, only one level of the send queue is used, so it is unlikely that queue will overflow with normal use of this method. Data Sharing also uses a maximum of two levels.

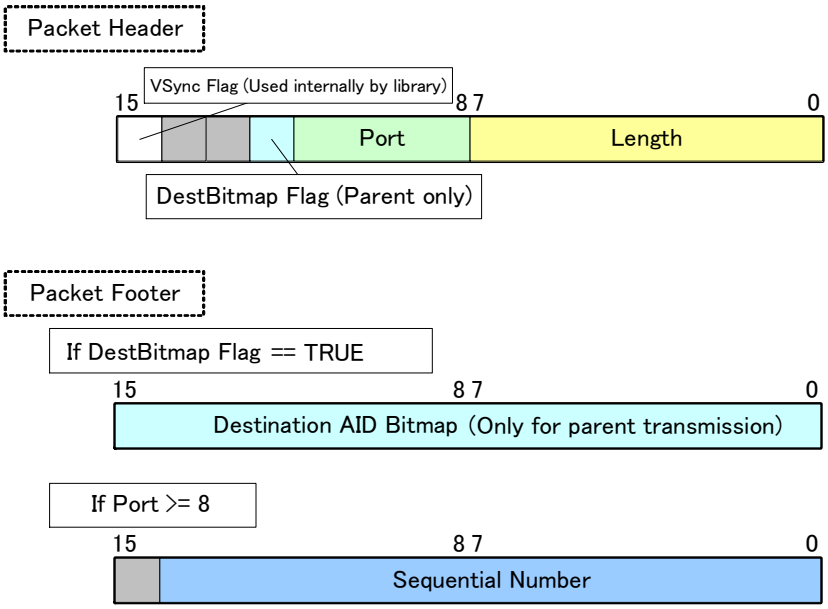
3.5.5 Packet Headers and Footers

In order to make port communications work, a data structure for communications known as a packet is used in the Wireless Communications Library layer.



A single packet consists of a two-byte header, the data to be sent, and a footer (a maximum of four bytes for a parent and two bytes for a child).

The bit assignments for headers and footers are shown here. When using the Wireless Communications Library, there is no need to be aware of the following structure:



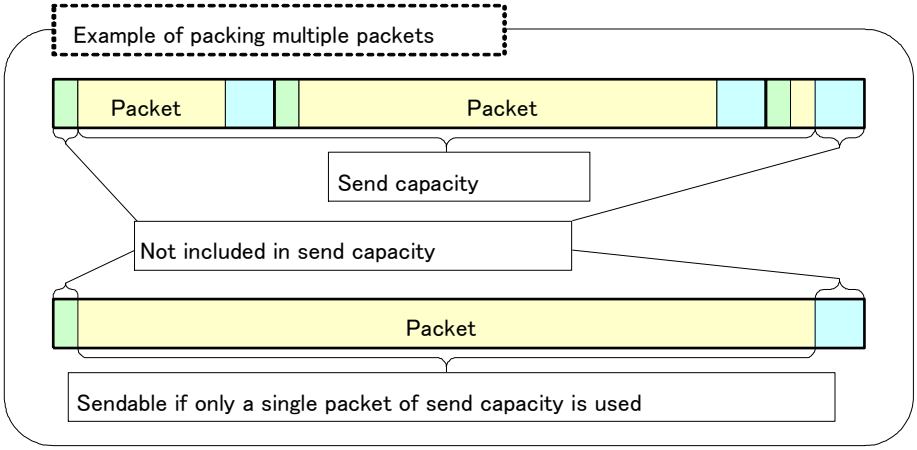
The header contains the data length (in two-byte units), port number, and control flags. The footer contains a bitmap of the destination children as well as sequential numbers. If the data length is 0, it is treated as 512 bytes.

Packets sent from parent to children normally contain a destination bitmap. However, if the header's `DestBitmap` Flag is set to 0, then the parent is broadcasting to all children and the footer does not contain a destination bitmap.

Also, the sequential number is used to control sequential communication. If the highest-order bit of the header's four-bit port number is enabled (i.e. the port number is 8 or higher), then a sequential number is added.

3.5.6 Packing Multiple Packets

In MP communications, only a method for transmission of a data payload has been defined, but with this method, small amounts of data cannot be transmitted efficiently. Therefore, on port communications, multiple packets are packed as much as the maximum transmission capacity will allow and then sent.



Note that the sizes of the header and footer portions of one packet are added internally, based on the value that has been set for the transmission capacity. The transmission capacity should be viewed as the maximum number of bytes available for user data.

Accordingly, when sending multiple packets, in addition to the actually transmitted data, the size of the headers and footers in-between uses more space. For each packet, the size for each packet addition is up to six bytes for a parent transmission and up to four bytes for a child transmission.

When sending multiple packets at the same time, determine the number of bytes using the following formula:

[The Number of Bytes Used] = [The Total User Data Size to Pack] + [Added Headers and Footers] x ([The Number of Packets to Pack]-1)

[Added Headers and Footers] = 6 bytes (in the case of the parent device) or 4 bytes (in the case of the child device)

To simplify this document, consistent numeric values are used for the bytes added to headers and footers which assume all packets are sent using sequential communications. However, the raw communications footer is two bytes smaller. In raw communications, you can send each packet with 2 fewer bytes than what is calculated in the above expression.

3.6 Data Sharing

3.6.1 Data Sharing

For games that rely on real-time communications, you can periodically share the same data (positional information, movement information, etc.) with all the participants. A Data Sharing library is available for situations like this. We are planning to discontinue Key Sharing and the current implementation that uses Data Sharing internally.

The Data Sharing and Key Sharing are both libraries that operate on ARM9 and use only the public Wireless Communications Library functions.

3.6.2 Directions for Use

```
#define DS_SIZE         8 // Share each 8 bytes
#define DS_MAX          8 // Max of 7 child devices + parent device
#define DS_BITMAP       0x00ff // aidBitmap for 8 devices

WMDataSharingInfo dsInfo; // this is an approx. 2kb structure, so be careful
where allocated
u16 sendData[DS_SIZE/sizeof(u16)]; // send data
WMDataSet receiveData;    // receive data
BOOL fUpdate;


... //  initialize wireless communications amd perform WM_StartMP()

WM StartDataSharing( &dsInfo, DS PORT, DS BITMAP, DS SIZE, TRUE );

//  main loop
while ( TRUE )
{
   OS_WaitIrq(TRUE, OS_IE_VBLANK); // V-blank wait

   ... // create sendData from PAD input, etc.

   if ( WM StepDataSharing( &dsInfo, sendData, &receiveData )
         == WM_ERRCODE_SUCCESS )
   {
      int i;
      for ( i=0; i<DS_MAX; i++ )
      {
         u16* p = WM GetSharedDataAddress( &dsInfo, &receiveData, i );
         if ( p != NULL )
         {
            ... // use p to configure the input from AID i
         }
      }
      fUpdate = TRUE;
   }
   else
   {
      fUpdate = FALSE;
   }

   ... // Execute the render process with the current internal state

   if ( fUpdate )
   {
      ...... // update the game state based on the input
   }
}
```

First, immediately after MP communications have been started with the `WM_StartMP` function, call the `WM_StartDataSharing` function to initialize Data Sharing. After that, data can be shared on the parent and child simply by calling the `WM_StepDataSharing` function at the start of each game frame.

If the `WM_StepDataSharing` function returns `WM_ERRCODE_SUCCESS`, it indicates that all participants in the Data Sharing are able to share data, so use that shared data to start a new game frame. The shared data can be obtained from the `WM_StepDataSharing` function as `WMDataSet` type data. Use

the WM_GetSharedDataAddress function to obtain data from this data set that was set by individual DS devices.

If on the other hand, WM_ERRCODE_NO_DATASET is returned, it indicates that one of the communications partners is experiencing performance problems, so delay the game frame update and wait one picture frame.

For details about this method, refer to the data sharing model demo in $NITROSDK_ROOT/build/demos/wm/dataShare-Model and the "Wireless Communications Tutorial (WmTutorial.pdf)".

3.6.3 Single Mode and Double Mode

There are two operations modes in Data Sharing: Single Mode and Double Mode. Designate them with the doubleMode argument of the WM_StartDataSharing function.

- **Single Mode**
  If the game frame is 30 fps, or if the game frame is 60 fps but the frequency of the MP sequence is twice or more per picture frame, single mode can be used. It obtains the data set with the previous WM_StepDataSharing function. When Data Sharing starts, a single empty data set that does not contain any AID data will be loaded.
- **Double Mode**
  Double mode is used when the game frame is 60 fps and the frequency of the MP sequence is once per picture frame. It takes in the data set with the second WM_StepDataSharing function. When Data Sharing starts, two empty data sets that do not contain any AID data will be loaded.

One of the characteristics of MP communications is that two MP sequences are needed to collect data from a child and then return that data to the child device. Therefore, if there is one MP sequence in one picture frame, in order to call the WM_StepDataSharing function at a frequency of 60 fps (in other words, 1 game frame = 1 picture frame), a single buffer must be placed in the interval. This mode is Double Mode.

For a diagram of the operations, refer to "3.6.7 General Information about the Internal Operations". Essentially, the difference between Single Mode and Double Mode is the initial preparation of some empty data sets for loading.

3.6.4 Communications Data Size

The send data size that Data Sharing uses is calculated as follows:

[The Parent Device Data Size] = [The Shared Data Size] x [The Number of Devices Sharing the Data(including the parent device)] + 4

[The Child Device Data Size] = [The Shared Data Size]

As a limitation on the library, the parent data size must be 512 bytes or less. This means that [the shared data size] * [number of shared devices] must be less than or equal to 508. Also, the shared data size must be an even number. For example, if there are 5 child devices, the shared data size is up to 84 bytes.

(84*6 + 4 = 508 <= 512, 86*6 + 4 = 520 > 512)

When the number of children is 6 or more, the 5600 µs limitation for the required communication time, as explained in 3.4.4 Transmission Capacity, determines the maximum size of shared data. For example, if there are 15 child devices, the shared data size is up to 12 bytes.

((12*16 + 4) + (12+60)*15 = 1276 < 1280, (14*16 + 4) + (14+60)*15 = 1338 >= 1280)

Following is a list of the maximum size of shared data for each number of child devices.

Number of Child Devices	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Maximum shared size by the restriction of the parent's data size <= 512 bytes.	**254**	**168**	**126**	**100**	**84**	72	62	56	50	46	42	38	36	32	30
Maximum shared size by the restriction of the required time for communication <= 5600 µs	-	-	-	-	-	**70**	**56**	**46**	**38**	**32**	**26**	**22**	**18**	**14**	**12**

When using this at the same time as a normal `WM_SetMPData*` function, multiple packets are packed.

Note: When calculating the respective maximum sizes for each parent and child device, the header and footer portion of the packet (6 bytes for the parent, 4 bytes for the child) must be added.

3.6.5 Cautions Related to Function Call Order

You must attempt to call the `WM_StartDataSharing` function immediately after calling the completion callback of the `WM_StartMP`, and you must attempt to call the `WM_EndDataSharing` function immediately before the `WM_EndMP` function. This is a current limitation for Data Sharing.

To delay the start of Data Sharing, you can try not calling the `WM_StepDataSharing` function. No alarms or timers are used inside Data Sharing; its processes are driven by library function calls and send/receive callbacks. Therefore, even after the `WM_StartDataSharing` function is performed, as long as the `WM_StepDataSharing` function is not called, extra processes and communications are not carried out.

However, since nothing along the lines of a timer is being used, there are limits to the timing that calls the `WM_StepDataSharing` function. In order to perform stable Data Sharing, the `WM_StepDataSharing` function must be called at the earliest timing possible after a V-blank interrupt. This is done so that the send data can be set up to the timing (in V-count terms, child device 240 / parent device 260) that will carry out the preparation of the next MPS sequence on ARM7.

3.6.6 Cautions When Operating at 30fps or Less

With an application that has a game frame of 30 fps, the `WM_StepDataSharing` function is called once every two frames, but if `WM_ERRCODE_NO_DATASET` is returned, the next call must be performed in the very next frame.

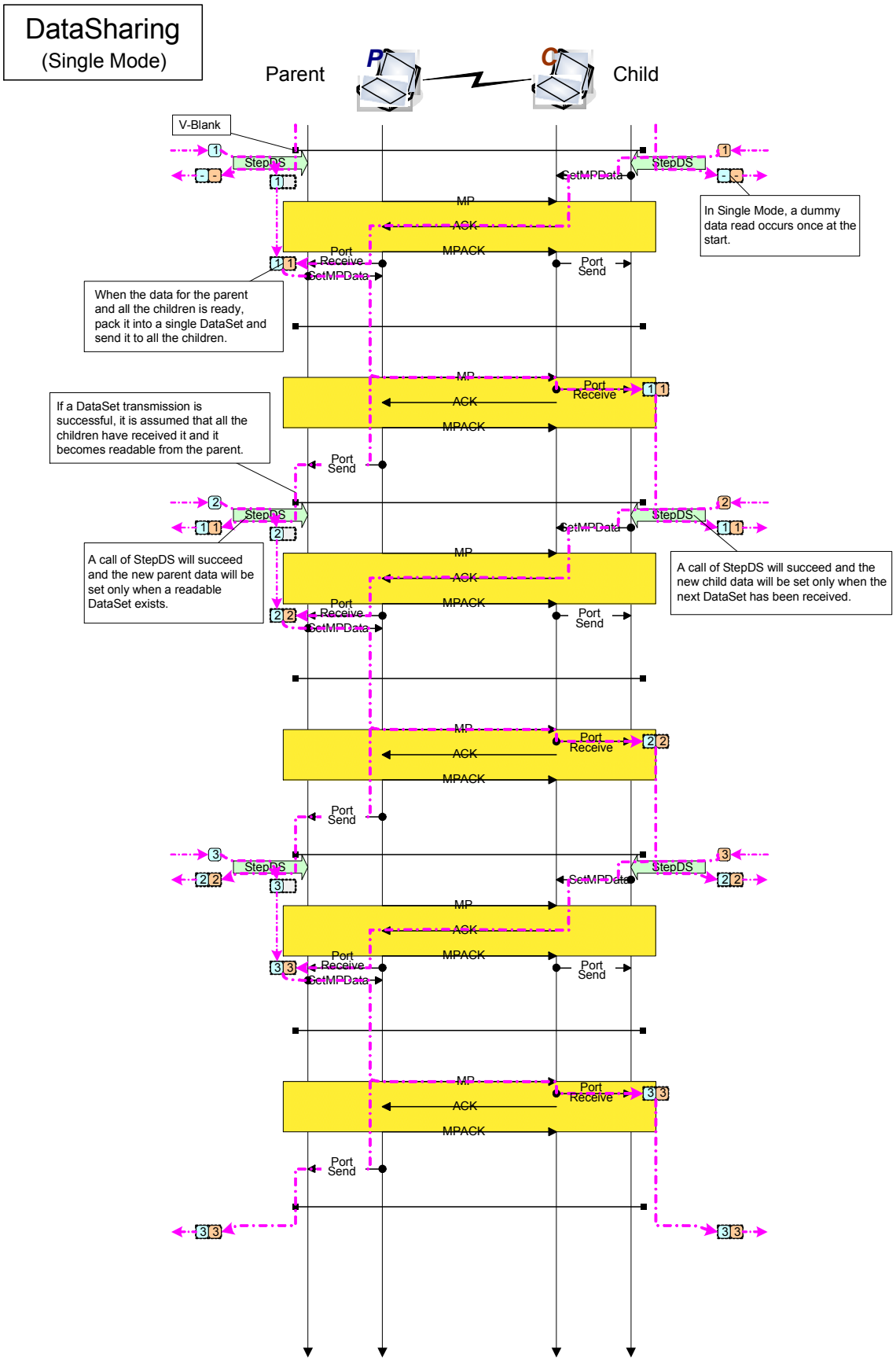
```
01: WM_StepDataSharing() == WM_ERRCODE_SUCCESS
02: ----
03: WM StepDataSharing() == WM ERRCODE SUCCESS
04: ----
05: WM_StepDataSharing() == WM_ERRCODE_NO_DATASET
06: WM StepDataSharing() == WM ERRCODE SUCCESS
07: ----
08: WM_StepDataSharing() == WM_ERRCODE_SUCCESS
09: ----
```

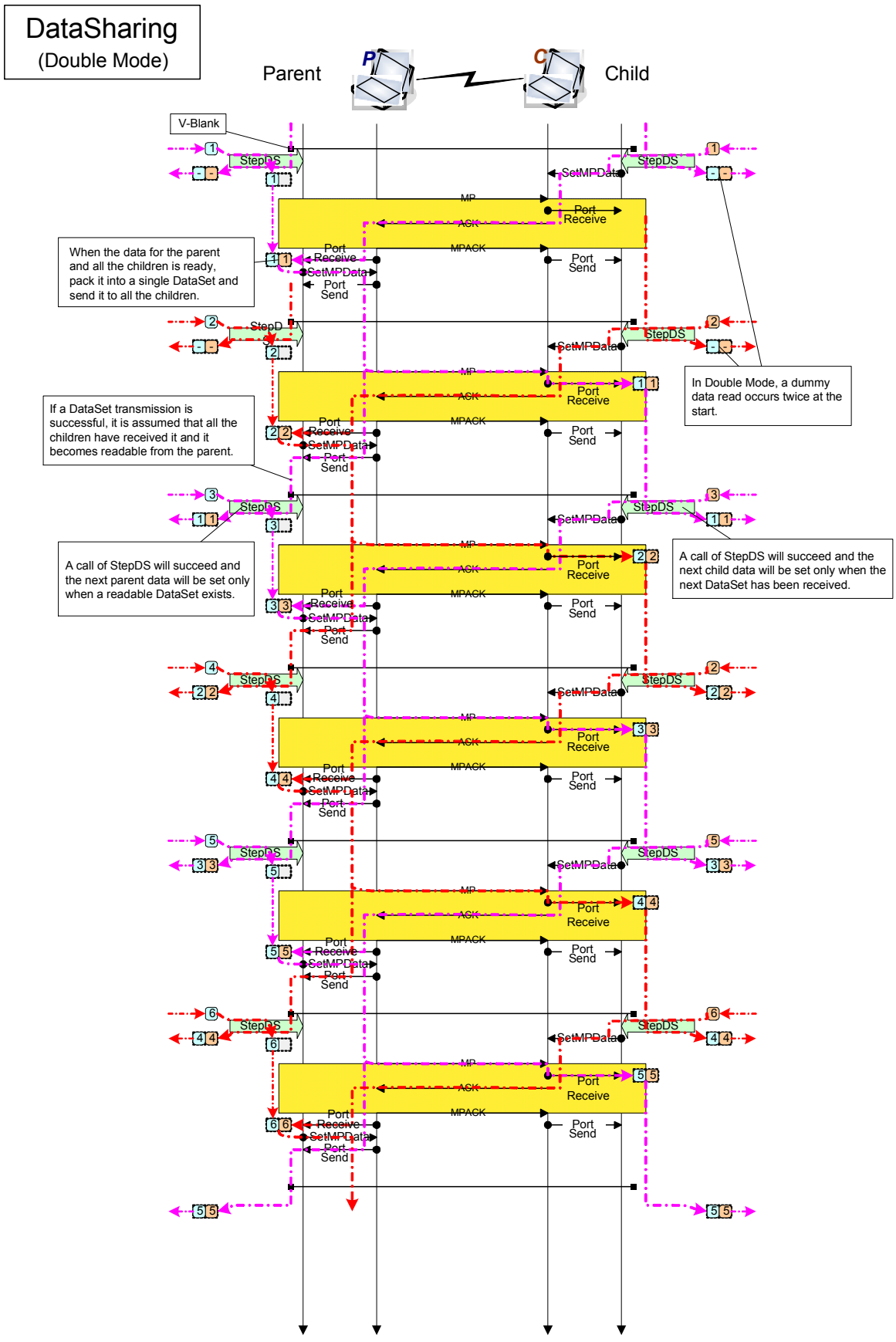
Perform the above process when there is a failure, and make sure that a one-frame interval is not placed in between the 5th frame and 6th frame. Otherwise, if the parent and child are off by one frame, any fixes will not work.

When at 30 fps and calling in the manner described above, the parent / child game frame timing discrepancy can be fixed, but at 20 fps and below, the timing cannot be completely brought into line. This is one of the current limitations for Data Sharing. However, even at 20fps and below, the consistency of the shared data is maintained. So, even if the timing is a bit off, if it is possible to share only the data and Data Sharing can be used.

3.6.7 General Information about the Internal Operations

Below are some diagrams that illustrate the internal operations of Data Sharing. The `WM_StepDataSharing` function is noted as StepDS in the diagrams.


DataSharing
(Single Mode)
Parent
P
C
Child
V-Blank
StepDS
SetMPData
StepDS
In Single Mode, a dummy data read occurs once at the start.
MP
ACK
MPACK
Port Receive
SetMPData
Port Send
When the data for the parent and all the children is ready, pack it into a single DataSet and send it to all the children.
If a DataSet transmission is successful, it is assumed that all the children have received it and it becomes readable from the parent.
A call of StepDS will succeed and the new parent data will be set only when a readable DataSet exists.
A call of StepDS will succeed and the new child data will be set only when the next DataSet has been received.


DataSharing
(Double Mode)
Parent
Child
P
C
V-Blank
StepPS
StepDS
SetMPData
MP
ACK
MPACK
Port Receive
Port Send
When the data for the parent and all the children is ready, pack it into a single DataSet and send it to all the children.
In Double Mode, a dummy data read occurs twice at the start.
If a DataSet transmission is successful, it is assumed that all the children have received it and it becomes readable from the parent.
A call of StepDS will succeed and the next parent data will be set only when a readable DataSet exists.
A call of StepDS will succeed and the next child data will be set only when the next DataSet has been received.

3.7 Event Notifications Returned from the Wireless Communications Library

For some asynchronous function callbacks, an event notification call from the Wireless Communications Library is issued in addition to the "operation complete" notification corresponding to the call. The trigger for the callback is stored as the value of the `WMStateCode` enumerated type in the state field of the `WM*Callback` structure of the callback argument.

The following table defines the notifications associated with various functions and the type of `WMStateCodes` for the notifications. With the exception of the `WM_SetMPData*` function, asynchronous functions have an internal table of callback functions by function, so do not assign a different callback function to the same function each time it is called.

Function	WMStateCodes
WM_StartParent	**WM_STATECODE_PARENT_START** An asynchronous notification that the function call is complete. **WM_STATECODE_BEACON_SENT** The beacon is sent. There is no special processing required. **WM_STATECODE_CONNECTED** A child device connected to the parent. At connection time, the following data is sent via callback: o The AID of the child connected to `WMStartParentCallback.aid` o The MAC address of the child in `WMStartParentCallback.macAddress` o The user region (the second 24 bytes) of the SSID declared by the child in `WMStartParentCallback.ssid` **WM_STATECODE_DISCONNECTED** A child disconnected from the parent. `WMStartParentCallback.aid` and `WMStartParentCallback.macAddress` behave as in `WM_STATECODE_CONNECTED`. **WM_STATECODE_DISCONNECTED_FROM_MYSELF** This notification is used when a WM function is called within an application and a parent disconnected its own child. The same values as used with WM_STATECODE_DISCONNECTED are used in notifications.

Function	WMStateCodes
WM_StartConnect **WM_StartConnectEx**	**WM_STATECODE_CONNECT_START** An asynchronous notification that the function call is complete. If no more entries are being received because the parent's entry flag is set to FALSE or the device has reached its maximum number of connections occurs, WM_ERRCODE_NO_ENTRY or WM_ERRCODE_OVER_MAX_ENTRY may be returned in errcode. Even if WM_ERRCODE_SUCCESS is returned in this state, be aware that it does not necessarily mean that the connection is complete. The completion of a connection is notified with WM_STATECODE_CONNECTED. Also, caution is also needed for the WM_ERRCODE_OVER_MAX_ENTRY returned when the parent device exceeds its maximum number of connections, since the notification is issued after a single WM_ERRCODE_SUCCESS is returned. **WM_STATECODE_BEACON_LOST** A connected parent device beacon fails to be received for a fixed amount of time. There is a high possibility that the signal has degraded and the V-blank period is damaged, but there is no further processing required. **WM_STATECODE_CONNECTED** A connection was made with the parent device. At connection time, the following data is sent via callback: o The AID of the child connected to WMStartConnectCallback.aid **WM_STATECODE_DISCONNECTED** A parent disconnected from a child. WMStartConnectCallback.aid behaves as in WM_STATECODE_CONNECTED. **WM_STATECODE_DISCONNECTED_FROM_MYSELF** This notification is used when a WM function is called within an application and a parent disconnected its own child. The same values as used with WM_STATECODE_DISCONNECTED are used in notifications.
WM_StartMP **WM_StartMPEx**	**WM_STATECODE_MP_START** An asynchronous notification that the function call is complete. **WM_STATECODE_MPEND_IND** The parent device sends out the MP_ACK frame and successive MP sequences are finished. Normally, there is no particular need to perform this process. Notifies the pointer to the WMMpRecvHeader structure that stores the contents of the frame received from the child in WMStartMPCallback.recvBuf. We recommend using the port receive callback to receive the data. However, since the recvBuf field is defined as a WMMpRecvBuf type, you must forcibly recast the field type. **WM_STATECODE_MP_IND** The child received the MP frame from the parent. Notifies the pointer to the WMMpRecvBuf structure that stores the contents of the frame received from the parent in WMStartMPCallback.recvBuf. We recommend using the port receive callback to receive the data. If the port was not assigned with the PollBitmap of the MP frame, the errcode is

Function	WMStateCodes
	WM_ERRCODE_INVALID_POLLBITMAP. Because this occurs most often when multiple child devices are connected, it should not be handled as an unrecoverable error. Also, if counting the header information and nothing was included in the received MP frame, WM_ERRCODE_NO_DATA is notified as the errcode. Normally, as long as the WM Library is operating, this cannot occur. **WM_STATECODE_MPACK_IND** The child received the MP_ACK frame from the parent device. Normally, there is no particular need to perform this process. The errcode is WM_ERRCODE_INVALID_POLLBITMAP if not primarily self-designated with the PollBitmap of the MP frame that corresponds to this MP_ACK. Since this occurs most often when multiple child devices are connected, it should not be handled as an unrecoverable error. Otherwise, if the parent is not notified with the PollBitmap field of the MPACK frame that the Key(Null) response frame was not received, the errcode is WM_ERRCODE_SEND_FAILED. Even if a given time passes after receiving the MP frame, if the MPACK frame could not be received, then this indication occurs, the errcode is WM_ERRCODE_TIMEOUT, and there is a notification.
WM_SetIndCallback	**WM_STATECODE_FIFO_ERROR** This WMStateCode is sent to the ARM7 when the execution control queue overflows due to a process overload on the ARM7. Treat as a non-recoverable fatal error. **WM_STATECODE_INFORMATION** Notification of some type of internal event. The notification is stored in WMIndCallback.reason. WM_INFOCODE_FATAL_ERROR, which is sent as notification when a fatal error occurs and the ignoreFatalError argument of the WM_StartMPEx function is set to TRUE, is defined as the value placed in reason. **WM_STATECODE_BEACON_RECV** The beacon from the connected parent is received. Normally, there is no need to perform this process. If WMIndCallback.state was this value, by recasting the type in WMBeaconRecvIndCallback, the GameInfo can be obtained from WMBeaconRecvIndCallback.gameInfoLength, WMBeaconRecvIndCallback.gameInfo, etc. **WM_STATECODE_DISASSOCIATE** Used for debugging. Normally, you can ignore this constant. **WM_STATECODE_REASSOCIATE** Used for debugging. Normally, you can ignore this constant. **WM_STATECODE_AUTHENTICATE** Used for debugging. Normally, you can ignore this constant.

Function	WMStateCodes
WM_SetPortCallback	**WM_STATECODE_PORT_INIT** This is called with the interrupts disabled while WM_SetPortCallback is called. This notification stores the AID bitmap for the partner currently connected to WMPortRecvCallback.connectedAidBitmap. If the connection has not started yet, 0 is stored in connectedAidBitmap. In addition, void* arg, passed to an argument to WMSetPortCallback, is passed to *.arg. **WM_STATECODE_PORT_RECV** Data is received from the communication partner. The following data is sent via callback: o The AID of the child connected to WMStartConnectCallback.aid o The AID of the send source in WMPortRecvCallback.aid o The pointer to the receive data in WMPortRecvCallback.data o The size of the receive data in WMPortRecvCallback.length o The void* arg given to the argument of the WMSetPortCallback in *.arg **WM_STATECODE_CONNECTED** Immediately after notification in the callbacks of the WMStartParent function and the WMStartConnect* function that the connection was established, similar notifications are sent to the receive callbacks of every port. Note that, regardless whether it's a parent or child, WMPortRecvCallback.aid always takes the AID of the connection partner at that time (the child device is fixed at 0, while the parent takes the AID of the connected child). Its own AID is stored in *.myAid. Also, the MAC address and user region SSID (for the parent device) of the respective communication partners are set to *.macAddress and *.ssid. **WM_STATECODE_DISCONNECTED** Immediately after notification in the callbacks of the WMStartParent function and the WMStartConnect function that the connection was terminated due to an external cause, similar notifications are sent to the receive callbacks of every port. The same notes apply to AID as to WM_STATECODE_CONNECTED. Also, the MAC address of the disconnected partner is stored in *.macAddress. **WM_STATECODE_DISCONNECTED_FROM_MYSELF** This notification is used when a WM function is called within an application and a parent disconnected its own child. The same values as used with WM_STATECODE_DISCONNECTED are used in notifications.
WM_SetMPData **WM_SetMPDataToPort** **WM_SetMPDataToPortEx**	**WM_STATECODE_PORT_SEND** Only one kind of WMStateCode is notified as the completion callback of an asynchronous function, but because it is an important notification in the communication controls, it is described separately here.

Function	WMStateCodes
	In WMPortSendCallback.errcode, the following data is sent via callback: o WM_ERRCODE_SUCCESS when the send succeeded o WM_ERRCODE_SEND_FAILED when the send failed o WM_ERRCODE_SEND_QUEUE_FULL when the send queue was full Basically, with Sequential communications, WM_ERRCODE_SEND_FAILED will not be returned except when communications have been terminated. The bitmap of the AID of the partner that must retry is stored in *.restBitmap. The AID bitmap of the communications partner for which the send was a success is stored in *.sentBitmap. Send destinations that are not connected or which become disconnected during a send are not included in either *.restBitmap or *.sentBitmap. The condition for WM_ERRCODE_SUCCEDD to return to *.errcode is that *.restBitmap is 0. In other words, communications are successfully sent to all designated send destinations which are still connected. In order to confirm that everything was sent to the designated send destination , re-check *.sentBitmap (with the exception of when the partner has called the WM_EndMP function). While it is guaranteed that the send is a success for communications partners that are included in *.sentBitmap, there is no such guarantee for communications partners that are not included there. Exactly one callback will be called each time the WM_SetMPData* function is called. At this time, during the interval from when the function is called to when the callback is called, do not overwrite the memory region for the send data. It is also possible to obtain the address of the set send data with WMPortSendCallback.data. The argument of the WM_SetMPDataToPortEx function is passed to *.arg.

3.8 Error Codes Returned from the Wireless Communications Library

3.8.1 Return Values of Functions that Return a WMErrCode Type

The rows in the following chart contain functions and the columns contain their return values. They are abbreviated by omitting the WM_ERRCODE_ prefix from the WMErrCode enumerated values.

Function Name	SUCCESS	FAILED	OPERATING	ILLEGAL_STATE	WM_DISABLE	NO_DATASET	INVALID_PARAM	NO_CHILD	FIFO_ERROR
WM_Initialize			○	○	○		○		○
WM_Init	○			○	○		○		
WM_Enable			○	○					○
WM_PowerOn			○	○					○
WM_End			○	○					○
WM_PowerOff			○	○					○
WM_Disable			○	○					○
WM_Finish	○			○					
WM_Reset			○	○					○
WM_StartMP*			○	○			○		○
WM_SetMPParameter			○	○					○
WM_SetMPData*			○	○			○	○[1]	○
WM_EndMP			○	○					○
WM_SetParentParameter			○	○			○		○
WM_StartParent			○	○					○
WM_EndParent			○	○					○
WM_StartScan*			○	○			○		○
WM_EndScan			○	○					○
WM_StartConnect*			○	○			○		○
WM_Disconnect			○	○			○	○[1]	○
WM_DisconnectChildren			○	○				○[1]	○
WM_SetIndCallback	○			○					
WM_SetPortCallback	○			○					
WM_StartDataSharing	○	○		○			○		
WM_EndDataSharing	○			○			○		
WM_StepDataSharing	○	○		○		○[1]	○		
WM_SetGameInfo			○	○			○		○
WM_SetBeaconIndication			○	○			○		○
WM_SetLifeTime			○	○					○
WM_MeasureChannel			○	○					○
WM_InitWirelessCounter			○	○					○
WM_GetWirelessCounter			○	○					○
WM_SetEntry			○	○					○
WM_StartKeySharing	○	○		○			○		
WM_EndKeySharing	○			○			○		
WM_GetKeySet	○	○		○		○[1]	○		
WM_ReadStatus	○			○			○		
WM_StartDCF			○	○			○		○
WM_SetDCFData			○	○			○		○
WM_EndDCF			○	○					○
WM_SetWEPKey			○	○			○		○
WM_SetWEPKeyEx			○	○			○		○

	SUCCESS	FAILED	OPERATING	ILLEGAL_STATE	WM_DISABLE	NO_DATASET	INVALID_PARAM	NO_CHILD	FIFO_ERROR

1: This is an errcode that is generated depending on a variety of conditions even if the application process is appropriate.
Communications will continue as normal, so this is not treated as a fatal error.

3.8.2 errcode Values Returned to the Callback Function

The rows in the following chart contain functions and the values of the state field of the `WM*Callback` structure returned to their callbacks. The columns contain the values of the errcode field of the `WM*Callback` structure. They are abbreviated by omitting the `WM_STATECODE_` and `WM_ERRCODE_` prefixes.

Δ indicates that the `WM*Callback.state` values are sometimes indefinite.

Function Name	WM*Callback.state	SUCCESS	FAILED	OPERATING	ILLEGAL_STATE	WM_DISABLE	NO_DATASET	INVALID_PARAM	NO_CHILD	FIFO_ERROR	TIMEOUT	SEND_QUEUE_FULL	NO_ENTRY	OVER_MAX_ENTRY	INVALID_POLLBITMAP	NO_DATA	SEND_FAILED	FLASH_ERROR
WM_Initialize		○	○							○								
WM_Enable		○								○								
WM_PowerOn		○	○		○					○								
WM_End		○	○		○					○								
WM_PowerOff		○	○		○					○								
WM_Disable		○			○					○								
WM_Reset		○	○							○								
WM_StartMP*	MP_START	○			○			○		Δ								
	$MPEND\_IND_1$	○																
	MP_IND_1	○													$○_2$	$○_3$		
	$MPACK\_IND_1$	○									$○_2$				$○_2$		$○_2$	
WM_SetMPParameter		○			○			○		○								
WM_SetMPData*	PORT_SEND	○			○			○		Δ		$○_2$					$○_2$	
WM_EndMP		○	○		○					○								
WM_SetParentParameter		○	○					○		○								
WM_StartParent	PARENT_START	○	Δ		○			○		Δ								
	$BEACON\_SENT_1$	○																
	CONNECTED	○																
	DISCONNECTED	○																
	DISCONNECTED_FROM_MYSELF	○																
WM_EndParent		○	○		○					○								
WM_StartScan*	PARENT_NOT_FOUND	○	Δ		○			○		Δ								
	PARENT_FOUND	○																
WM_EndScan		○	○		○					○								
WM_StartConnect*	CONNECT_START	○	Δ		○			○		Δ			○	$○_4$				
	CONNECTED	○																
	DISCONNECTED	○																
	DISCONNECTED_FROM_MYSELF	○																

		SUCCESS	FAILED	OPERATING	ILLEGAL_STATE	WM_DISABLE	NO_DATASET	INVALID_PARAM	NO_CHILD	FIFO_ERROR	TIMEOUT	SEND_QUEUE_FULL	NO_ENTRY	OVER_MAX_ENTRY	INVALID_POLLBITMAP	NO_DATA	SEND_FAILED	FLASH_ERROR
	BEACON_LOST[1]	○																
WM_Disconnect		○	○		○					○								
WM_DisconnectChildren		○	○		○					○								
WM_SetGameInfo		○	○							○								
WM_SetBeaconIndication		○	○							○								
WM_SetLifeTime		○	○							○								
WM_MeasureChannel		○	○		○					○								
WM_InitWirelessCounter		○	○							○								
WM_GetWirelessCounter		○	○							○								
WM_SetEntry		○	○							○								
WM_StartDCF	DCF_START	○								Δ								
	DCF_IND	○																
WM_SetDCFData		○	○							○								
WM_EndDCF		○								○								
WM_SetWEPKey		○								○								
WM_SetWEPKeyEx		○	○							○								
WM_SetIndCallback	FIFO_ERROR									○								
	INFORMATION	○																
	BEACON_RECV[1]	○																
	DISASSOCIATE[1]	○																
	REASSOCIATE[1]	○																
	AUTHENTICATE[1]	○																
	UNKNOWN																	○
WM_SetPortCallback	PORT_RECVINIT	○																
	PORT_RECV	○																
	CONNECTED	○																
	DISCONNECTED	○																
	DISCONNECTED_FROM_MYSELF	○																

1: It is OK if processing is not normally performed on this state notification.

2: This is an errcode that is generated depending on a variety of conditions even if the application process is appropriate.

Communications will continue as normal, so this is not treated as a fatal error.

3: This is an errcode that should not be generated as long as the library is operating normally.

4: After the WM_ERRCODE_SUCCESS notification arrives, there may be a notification for this error again.

3.9 Cautions When Using the Wireless Communications Library

This section describes cautions for using the Wireless Communications Library.

3.9.1 The Load from using Wireless Communications

Because the wireless communications driver in the current SDK is 100k or larger, the wireless communications driver codes can not be loaded into the ARM7 working memory and are stored in main memory. Therefore, when performing wireless communications, ARM7 frequently accesses main memory, which leads to a large overhead when there is continuous access from ARM9 to the main memory for rendering, etc (normally, ARM7 has a higher access priority to main memory than ARM9).

Conversely, if ARM9 is given priority to main memory access (e.g., when using HDMA), the execution of the wireless communication driver may be adversely impacted because ARM9 frequently accesses the main memory. In particular, there is a strong possibility that ARM7 program execution may be delayed for a long time if multipurpose DMA accesses main memory. If the wireless communications drivers are operated when ARM9 has the higher access priority to main memory, try not to use the multipurpose DMA.

One effective method is allocating VRAM-C or VRAM-D for use by ARM7 is to store the wireless communications driver. This method decreases the time for ARM7 to appropriate the main memory bus. For details, refer to the WVR library reference or the ichneumon component of the “Component Description (`AboutComponents.pdf`).”

3.9.2 The Callback

The callback is called inside the PXI interrupt handler. Functions that cannot be called when interrupts are forbidden and cannot be used. Also, try not to call any long-term processes. If another ARM9 interrupt is delayed, there are times when the ARM7 wireless communications driver waits for the ARM9 callback to finish. This wait time negatively impacts the wireless communications process.

3.9.3 The Cache Process

Forced cache storage is performed in some functions to pass data to ARM7. It is recommended to pass 32-byte aligned data to the relevant function and that the data region be allocated as a multiple of 32 bytes. If this is not done, the surrounding memory regions are also forcibly stored together in the cache and unforeseen operations might occur.

On the other hand, there are two kinds of data that are passed to the application from the library: data that is passed after the cache is invalidated and data that requires the cache to be invalidated by the application.

The given memory region is that which is stored in the internal cache of the library.	The `WM_SetParentParameterfunction` argument `pparaBuf` or `pparaBuf->userGameInfo`, `WM_StartConnect*`, `WM_SetMPData*`, `WM_StartDCF`, `WM_SetDCFData`, `WM_SetWEPKey*`

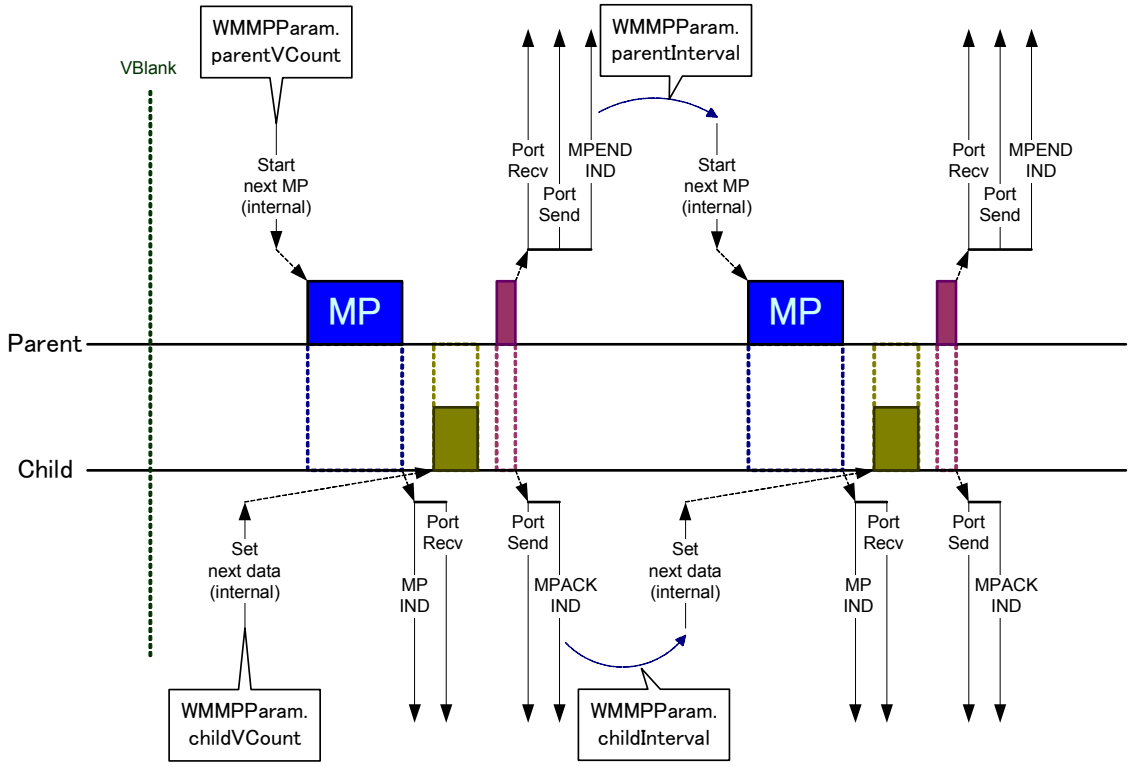
The given memory region is that which is not stored in the cache. (It is stored after being copied to an internal buffer)	`WM_SetGameInfo`, `WM_StartScan*`, `WM_SetMPParameter` Other functions that pass only small memory regions
The region which takes in the data is that which is passed after the cache is invalidated inside the library.	Data fields of the port reception callback set with the `WM_SetPortCallback` function, `WM_ReadStatus`
The region that takes in the data is that which is passed without the cache being invalidated inside the library.	The region designated with the `param->scanBuf` argument of the `WM_StartScan*` function NOTE: Passed after `WMStartScan*Callback` is invalidated

3.10 Taking Greater Control over Communications

This section describes higher-use wireless communications and ways to fine-tune performance.

3.10.1 Overview of Timing Control Parameter of MP Communications

The following figure displays the way a number of parameters can be used to control the timing of MP communications. Each of these parameters can be configured by setting their values in specific fields of the `WMMPParam` structure and calling the `WM_SetMPParentParameter` function.



3.10.2 parentVCount, childVCount

When in frame synchronous communications mode, `WMMPParam.parentVCoun` defines the V-Count

value for internally starting the first MP sequence in each frame. The default value is 260. Similarly, `WMMPParam.childVCount` defines the V-Alarm value for internally setting the first Response data in each frame on the child side. The default value is 240. These two values can also be set by the `WM_SetMPParameter` function's wrapper function `WM_SetMPTiming`.

By changing the values of `parentVCount` and `childVCount`, you can adjust the timing of MP sequence occurrences in frame synchronous communications mode. Because the wireless driver on the ARM7 side performs frequent accesses to main memory around the time of the MP sequence, applications on the ARM9 side will often stall when accessing main memory. You can sometimes lessen the impact of this stalling by adjusting the MP sequence to a time when the application on the ARM9 side is not heavily accessing main memory. Of course, the value of `parentVCount` is irrelevant to the timing of communications when the communications environment is poor or when communications are carried out in continuous communications mode. Also note that if the ARM7's internal processing is delayed, the MP sequence will actually occur later than the value set in `parentVCount`.

3.10.3 parentInterval, childInterval

When in frame synchronous communications mode, `WMMPParam.parentInterval` defines the interval (in microseconds) that passes between the end of one MP sequence by the parent and the internal start of the next. It affects the second and all subsequent MP sequences that occur. Similarly, `WMMPParam.childInterval` defines the interval between the end of one MP sequence and the internal setting of Response data for the next MP sequence by the child. The default value is 1000 microseconds for parentInterval and 0 microseconds for childInterval. Both of these values can also be set by the `WM_SetMPParameter` function's wrapper function `WM_SetMPInterval`.

Note If the ARM7's internal processing is delayed, the actual transmission interval between MP sequences during continuous communications will be longer than the value set in `parentInterval`.

In continuous communications, the Send data that will be transmitted in the next MP sequence is determined at the end of the interval period for both the parent and child, and is based on the Send data set in the Send queue. In current implementation, the interval period does not begin until the Port Receive callback and Port Send callback of the previous MP sequence have ended on the ARM9 side. Because of this specification, data that gets set in the Send queue by the `WM_SetMPDataToPort` function during these callbacks will be set in time for transmission in the next MP sequence.

The default interval period is longer for the parent than for the child because this ensures that the child's Response data is set in time for the next MP sequence. Setting the parent and child to the same interval period will result in numerous communication errors when the child has a weighty callback process. This happens because the wireless communications driver on the child's side waits for the ARM9's processing to end, so the next MP sequence can come before the child has had time to set the Response data. The child MP frame will stop responding until the response data is set, so the failure of the communications during that interval will be the result. An example of this can be observed in the wbt-fs demo, where sometimes the callback process on the child side takes around 700 microseconds, and communications fail with high frequency if the parent and child are set to have the same interval period.

If you know that the processing load inside the callbacks for parent and child will always be the same, then you can shorten parentInterval and raise the throughput of MP communications during continuous communications. Conversely, if the child's Port Send and Port Receive callback processes take longer than 1000 microseconds, then you will need to set parentInterval longer than the default value. Of course, you do not really want to have a process like a callback that takes longer than 1000 microseconds inside the interrupt handler. If this situation arises, you will need to rethink your design.

For heavy Send and Receive processes, limit your process requests from inside the Port Send and Receive callbacks to a thread for communications and immediately exit the callbacks. You can perform continuous communications without wasting time by using this thread to configure parentInterval & childInterval for the worst-case longest duration it should take to set the next Send data. Since the Send queue has 32 steps, an alternative strategy is to design things so there is always buffering of multiple sets of Send data in the Send queue.

To stabilize the communications process, there are future plans to modify the ARM7 wireless communication driver so the interval period can be entered immediately without waiting for the callback process on the ARM9 side, and increase the initial values for parentInterval and childInterval instead.

3.10.4 Dynamically Changing the Transmission Capacity

Communications normally proceed using the transmission capacities that were set by the parent in `parentMaxSize` and `childMaxSize` using the `WM_SetParentParameter` function. However, the parent can use the `WM_SetMPParentSize` and `WM_SetMPChildSize` functions as required to reconfigure the transmission capacities of the parent and the child.

Note: These the values cannot exceed the initial values as set by the `WM_SetParentParameter` function. Also, the child's transmission capacity gets updated to the value set by the parent every time the parent sends an MP sequence. As a result, even though the child can set its own transmission capacity using the `WM_SetMPChildSize` function, that value can only be used when preparing Send data for the immediately next MP sequence.

	Initial value	Maximum value that can be set	How to reset value on parent side	How to reset value on child side
Parent transmission capacity	The `parentMaxSize` value in the parent's beacon	Same as left	`WM_SetMPParentSize()`	(Only has meaning on the parent side)
Child transmission capacity	The `childMaxSize` value in the parent's beacon	Same as left	`WM_SetMPChildSize()`	`WM_SetMPChildSize()` Note that this gets overwritten by parent's setting when MP frame is received

Be careful about clashes between the child transmission capacity set for the child and the child transmission capacity configured in the parent for the child. Communications can proceed without trouble if the child's transmission capacity is set smaller than the setting configured in the parent for the child. But, if the child transmission capacity is set larger than this configuration, the parent will not give sufficient time for the sending child data and the data will not return from the child to the parent. For more information, see the description in 3.4.2 MP Communications Operations. In the example MP

sequence, the child transmission capacity on the child side gets updated by the MP sequence, so the subsequent resending of data proceeds with no problems in communication between parent and child. Unnecessary communications can be avoided by cooperation between parent and child and use of the `WM_SetMPChildSize` function to simultaneously update the child transmission capacity.

There are two cases where it would be meaningful to change the transmission capacity:

When you want to cut unnecessary child transmission capacity.

> As per the MP Communications specifications, if the child transmission capacity was set to 32 bytes, then each communication would consume an amount of time equal to 32 bytes x the number of children. This occurs even when the child is sending only 2 bytes of data each time. By designing the application to reduce the child transmission capacity according to the communications mode, you can reduce the overall time needed for communications, which will make communications more stable.
>
> There is no need to control the parent transmission capacity because the time spent for sending data in communications on the parent side only takes as long as is necessary for the amount of Send data.

When you want to maximize transmission capacity depending on the number of connected children.

> Assume the parent transmission capacity is 512 bytes and you want to connect a maximum of five children. When five children are connected to the parent, the child transmission capacity calculates out to 92 bytes, since the limitation on communications time is 5600 microseconds. If the transmission capacity is fixed, it does not change even when only one child is connected. But if transmission capacity is set dynamically, its can be maximized depending the number of connected children. With this setup, the transmission capacity calculates out to 512 bytes when there is one child, 322 bytes where there are two children and 194 bytes when there are three, etc. However, the NITRO-SDK does not have am upper-level protocol that can make use of this kind of dynamically set transmission capacity.

If your goal in changing the transmission capacity matches with case 1 you can use these functions relatively safely. However, if your goal is more in line with case 2, then you should be aware that there are many points you need to be careful about and it is normally recommended to avoid this method.

Here are some of the many points you need to be careful about in case 2. Normally, when the `WM_StartMP` function executes, a precheck is carried out on the transmission capacity and buffer size used for the maximum number of children. You must disable this precheck by setting `WMMPParam.ignoreSizePrecheckMode` to TRUE with the `WM_SetMPParameter` function.

Two things result from setting `ignoreSizePrecheckMode` to TRUE: the warning relating to the 5600-microsecond restriction on needed communications time is suppressed, and errors can be avoided by precalculating the receive buffer size. Taking case 2 as an example again, assume that WMParentParam sets the parent transmission capacity and the child transmission capacity both at 512 bytes and sets the maximum number of connected children at five. When `ignoreSizePrecheckMode` is set to FALSE, the precheck when the `WM_StartMP` function executes would display a warning for debug output because the communications time totals 13970 microseconds, exceeding the 5600-microsecond limitation. Also, the receive buffer size on the parent is

1408 bytes for having two children with the child send capacity of 322 bytes when actually changing the child send capacity within the 5600 microsecond limitation. However, when the WM_StartMP function runs the precheck, it calculates that 5312 bytes are required (i.e., the 512 bytes of child transmission capacity x 5 children). Thus, when a Receive buffer of 1408 bytes is passed to the WM_StartMP function it generates the error WM_ERRCODE_INVALID_PARAM. To avoid this error and fit the data into the smallest required buffer size, you need to set ignoreSizePrecheckMode to TRUE.

When the precheck is disabled, the parent will enter the MP_PARENT state even when the Receive buffer size appears to be too small. However, the MP sequence will not execute if a check is conducted at the time of communications to calculate the size of the Receive buffer based on the child transmission capacity and the number of children to which data are being sent. If the transmission capacity and other parameters are not corrected to the appropriate values, the MP lifetime will expire after a certain period and the connection will be dropped. If, however, the transmission capacity is immediately adjusted when more children are added so the size of the Receive buffer remains sufficient, then communications can proceed without problems. However, if the child's Receive buffer is too small, then communications will not operate normally and will not be able to proceed. Because of this, you need to prepare a Receive buffer for the child that can accommodate the maximum value for the parent transmission capacity as defined by parentMaxSize in the beacon. Unlike the parent's Receive buffer, the child's Receive buffer is not affected by the number of connected children. So, even if you prepare this maximum-size buffer, it will not always impact the amount of memory used. Further, with the precheck disabled, the library will not check the 5600-microsecond limitation on communications time. So, you will need to be very careful when setting parameters with your application.

As these points suggest, you need to be especially careful setting parameters values when you use ignoreSizePrecheckMode, because mistakes will cause strange behavior during execution. If any of these points are at all unclear, you should refrain from using ignoreSizePrecheckMode.

3.10.5 Controlling PollBitmap

The parent may want responses from all children or it may want responses from specific children. PollBitmap in the MP frame indicates from which children the parent wants a response. By controlling PollBitmap from the very start, you can cut down on overall communications time by having only required children make responses. However, a child not specified by PollBitmap cannot send out a Key Response frame, so be careful about that child not getting an opportunity to send data to the parent. For this reason, in normal MP communications the PollBitmap is always sent with the bit standing for all connected children at all times other than for retransmissions so that a window of opportunity exists for communications from each child.

To provide fine control over PollBitmap, the wireless communications library has prepared the operation flags minPollBmpMode and singlePacketMode in the WM_StartMPEx function and the WM_SetMPParameter function. But, in order to use these operating modes, the complex restrictions below must be cleared. It is important to have a detailed understanding of the wireless communications protocol so, under normal circumstances, you should not enable the flags.

When minPollBitmapMode is enabled, the parent device will designate the value taken by the logical

OR of the send destination for the packet to be sent in its sequence as PollBitmap. In such an event, use the flag along with singlePacketMode so there are no mistaken attempts to communicate with more partners than for which it is designed. If there is a communication condition where the parent's receive buffer overflowed as a result of more enabled PollBitmaps than intended, because of the assumption that the simultaneous communications partner is limited and a large send volume keeps on getting configured, an insufficient buffer will be detected when the MP sequence starts and the sending will stop. After this sort of stop, it is possible to recover by reducing the send volume and avoiding limitations on the receive buffer, but it is difficult to determine any causal factors from the application-side.

To use `minPollBmpMode`, you must perform communication once every 60 seconds with port 8 through 15 on every child so the sequence numbers used in Sequential communication do not cycle through. Further, use it with `singlePacketMode` so there are no mistaken attempts to communicate with more partners than designed.

3.11 FAQ

Some of the common questions asked by the Wireless Communications Library users are shown below in question and answer format.

3.11.1 Initialization process

Q: A valid value is not returned for the `WM_GetAllowedChannel` function.

A: The `WM_GetAllowedChannel` function does not return a valid value until after the `WM_Init` function is called. If it was called before the initialization, it returns 0x8000, which indicates an error.

3.11.2 Connection process

Q. How do I determine the values for transmission capacities, Send and Receive Buffer sizes, and all other communication parameters?

A. Here are procedures for determining typical parameter values:

Typical determinations	Example
Determine the maximum number of connected children.	Assuming that three children are connected to the parent, set `WMParentParam.maxEntry` to 3.
Determine the number of shared bytes if using data sharing.	Set 16 bytes for data sharing.
Use the expression described in 3.6.4 - Communications Data Size to calculate the data size used by parent and child for data sharing.	The data size used by the parent for data sharing is 16 x (3+1) +4 = 68 bytes. The data size for each child is 16 bytes.
Determine the number of packets and the size for communications in situations other than for data sharing. (When making these determinations, you need to be aware that by increasing the maximum data size that can be sent	To do a block transfer using WBT, have the parent use 128 bytes and each child use 14 bytes. For event notifications from the parent, use 32 bytes in an independent Sequential communication.

Typical determinations	Example
simultaneously from the children, the transmission time will always be consumed to this maximum value even when there is only a small amount of data to send.)	
Count up the number of packets that can be sent at the same time, and use the expression in 3.5.6 - Packing Multiple Packets to calculate the number of bytes needed for the parent's transmission capacity.	For the parent, data sharing is 68 bytes, WBT is 128 bytes, and the independent communication for event notification is 32 bytes. So, the total is 128 + 68 + 32 + 6 x 2 = 240 bytes. For the child, the total is 16 + 14 + 4 x 1 = 34 bytes. Note: WBT is normally used on ports 4-7 for RAW communications, so WBT is 2 bytes smaller, or 238 bytes for the parent and 32 bytes for the child.
Use the value calculated above for the parent's transmission capacity and the child's transmission capacity. Verify that you have not exceeded the 512-byte limitation for transmission capacity.	`WMParentParam.parentMaxSize` is set to 240 and `childMaxSize` is set to 34. Neither value exceeds 512 bytes, so it is OK.
Use the expression in 3.4.4 - Transmission Capacity to calculate the required time for one MP sequence based on the parent & child transmission capacities and the maximum number of connected children, and check whether the result exceeds the 5600-microsecond limit. If this limit is exceeded, redesign the data sizes so the result of the calculation falls within the limit.	The calculation is: 96+(24+4+240+6+4)*4+(10+96+(24+34+4+4)*4+6)*3+10+96+(24+4+4)*4 The result is 2570 microseconds. Since this is below the 5600-microsecond limit, there is no problem. (This expression is easy to calculate if you use the "Wireless Communications Time Calculation Sheet" in the "Figures, Tables & Information" part of the Function Reference.)
Calculate the sizes of the Send & Receive buffers needed for MP communications based on the maximum number of connected children and the patent and child transmission capacities.	For the parent, the size of the Receive buffer passed to the `WM_StartMP` function is `WM_SIZE_MP_PARENT_RECEIVE_BUFFER(36, 3, FALSE)`, and the Send buffer size is `WM_SIZE_MP_PARENT_SEND_BUFFER(240, FALSE)`. For the child, the Receive buffer size is `WM_SIZE_MP_CHILD_RECEIVE_BUFFER(240, FALSE)` and the Send buffer size is `WM_SIZE_MP_CHILD_SEND_BUFFER(36, FALSE)`.
Determine the frequency of MP communications.	The data volumes sent in block transfer are not very large, so there should not be a problem always performing MP communications at a frequency of once per picture frame. Set the `mpFreq` parameter passed to the function `WM_StartMP` to 1.
Determine the operations mode for data sharing, taking into consideration the frequency of MP communications and what the game frame fps will be.	The MP communications frequency set to 1, and you want the game frame to move at a rate of 60 fps, so set doubleMode passed to the `WM_StartDataSharing` function to TRUE.

Q: I don't know the value to set to `WMParentParam.tgid`.

A: Ideally, it should be a different value every time, even when the power is restored. For an easy and convenient way, a pseudo-random number can be generated by combining the return values of the `OS_GetVBlankCount` function and the `GX_GetVCount` function. Also, by using the value for seconds or minutes on RTC, it is possible to guarantee that value to be different for some time even after the power was restored. For the implementation which a child reconnects to the parent multiple times, a secure connection may be achieved by sending some bits of TGID to the phase information to prevent

a child from connecting to the parent with a different phase.

Q: When creating a list of parents from the scan result, a parent is sometimes difficult to find.

A: If all parents have the same beacon intervals and the beacon send timing happens immediately after the other parent's beacon, that parent may be difficult to find. Also, processing overhead can have an effect as well as the parent's beacon interval matching the child's scan interval.

As a preventative measure, it is possible to achieve an overall resolution of these sorts of problems by first using the WM_StartScanEx function, which can get multiple parent devices at one time.

You can also try to mix random numbers into the parent beacon interval and child scan interval.

The `WM_GetDispersionBeaconPeriod` function and the `WM_GetDispersionScanPeriod` function were prepared for this purpose. Each of these functions returns random values that are around 200 ms and 30 ms, respectively. By setting a value of `WM_GetDispersionBeaconPeriod` to `WMParentParam.beaconPeriod`, the frequency of getting the same beacon intervals on the parents can be reduced. Set the beacon interval only once when starting the parent device. Changing the beacon interval dynamically impacts the child device connection.
In the same way, variation in the timing for the child device scan can be achieved by resetting the `maxChannelTime` parameter to the `WM_GetDispersionScanPeriod` return value each time a child device calls the `WM_StartScan` function or the WM_StartScanEx function.

Q: The connection process with the `WM_StartConnect*` function is not stable.

A: Make sure that you did not forget to call `WM_Reset` when retrying a failed connection attempt. If the connection process has already made progress before failing, the internal state may be CLASS1, so `WM_Reset` must be used to restore the internal state to IDLE before `WM_StartConnect` is called again.

Also, unintentional connection to the child device after the parent stops accepting entries can be prevented by calling the `WM_SetEntry` function to disable the entry flag when the parent device stops accepting child device entries. The child device can check the `WM_ATTR_FLAG_ENTRY` bit of `gameInfo.gameNameCount_attribute` in the beacon before the actual connection is tried to determine if the parent is accepting entries.

Q: When I end the communication once and reconnected to the same parent, it sometimes fails.

A: When trying to reconnect after scanning, the timing of the child device reconnection process is too fast and there are cases where an old beacon from the pre-shutdown parent device gets picked up. Before connecting, use the beacon information to check whether or not the parent device has started a new connection. In order to figure out the parent device state from the beacon information, use a method such as including the parent device phase information in `userGameInfo` or checking the changes in the TGID. After starting up in DS Download Play, the child device re-scans the parent device, and makes a connection by checking the `WM_ATTR_FLAG_MB` of `gameInfo.gameNameCount_attribute`. This enables you can determine whether or not the parent device is still in a mode for DS Download Play.

If not rescanning, update TGID by the predetermined rule when reconnecting. Use some of the bits in TGID for the phase information of the parent and rewrite that section of `WMParentParam` and `WMBssDesc` on parent and child to reconnect. When doing so, the child cannot be reconnected if the

parent accidentally changed the channel with the connection immediately before.

Q: My application has a parent device for DS Wireless Play, rather than a parent device for DS Download Play. But, when I start it up the `mb_child_simple.srl` that started up on another DS responds (“GameInfo Receiving…” keeps appearing).

A: Check if the `multiBootFlag` field of the `WMParentParam` structure specified by `WM_SetParentParam` is set to other than 0. To wait for the DS Download Play child device, make sure that the `multiBootFlag` is not enabled on anything other than a parent that is sending out a beacon for DS Download Play.

3.11.3 General MP communications

Q: How do I send out data with the shortest delay for MP communication?

A: With the frame synchronization communication mode, the first MP sequence start process is performed when the V-Count is 260 lines. When a child receives the MP frame from the parent, the transmission data should already be set, so the transmission data setting process starts a little earlier at 240 lines. Therefore, call the `WM_SetMPDataToPort*` function just before 260 lines for the parent, and 240 lines for a child to reduce the latency as much as possible. However, immediate sending is not guaranteed because there can be unpredictable delays between when the library function is called from ARM9 and ARM7 wireless communication driver processing. Additionally, if there is other data in send queue, that data is sent first.

The values of 260 lines and 240 lines can be reconfigured using the `WM_SetMPTiming` function.
In continuous communications mode and in frame synchronization mode, the parent starts the next MP sequence and the child sets the next group of Response data after an interval following the previous MP sequence. By calling the `WM_SetMPDataToPort*` function during this waiting period, you can get the Response data set in time for the next MP sequence.

Note: Depending on the state of the ARM7 wireless communications library, the Response data may not get set in time. The waiting period can be configured using the `WM_SetMPInterval` function.

Q. I received unpredictable results when continuously calling the `WM_SetMPDataToPort` function.

A. Did `WM_ERRCODE_FIFO_ERROR` get returned as the return value of the function? If there is an overflow in the FIFO used for sending commands from ARM9 to ARM7, this error will be returned. Try to reduce the number and frequency of the calls so that the ARM7 processing can catch up.

Q. When I try to send large amounts of small data packets, the communications state degrades and things do not work well.

A. Is `WM_ERRCODE_FIFO_ERROR` being returned to some callback? When large amounts of small data packets are sent, the processing capacity of the child-side ARM7 is sometimes exceeded because the communication state degrades and remaining communications accumulate.

If `WM_ERRCODE_FIFO_ERROR` is returned to the callback in this way, there will be too many processes and the ARM7-side FIFO for internal processing will overflow. The communication state cannot generally be recovered from here, so try to immediately transition to the communications error screen to reset the communications.

If heavy processing is being performed inside a child device-side communications related callback, this problem will occur more frequently, since ARM7 is waiting for those processes to finish. Also, in comparison, there are times when the child device processes overflow if the parent device processing is too light. There are a variety of measures to avoid this problem, such as lightening the processing load inside the child device-side callback, avoiding sending large amounts of small data packets, and making sure that the lowest send interval for the parent is empty with the WM_SetMPInterval function.

3.11.4 Data Sharing

Q: The `WM_StepDataSharing` function frequently returns `WM_ERRCODE_NO_DATASET`.

A: There are a few possibilities. If either the parent or the child is always successful, the Step may fail because the device that continues to succeed experiences a performance slow down and the other device is waiting for the performance slow down. If `WM_StepDataSharing` is set to be called at every frame, and it always fails every other frame, check if `doubleMode` of the `WM_StartDataSharing` function is set to TRUE. If the `WM_StepDataSharing` function is set to be called every other frame and it fails on a regular basis, there may be a problem with the retry process if `WM_ERRCODE_NO_DATASET` was returned. Check to see if the next `WM_StepDataSharing` function is called in the frame immediately after the failure.

If it fails with parent and child randomly and at about the same frequency, the `WM_StepDataSharing` function is might be called using bad timing. Make sure to call the `WM_StepDataSharing` function at the earliest possible time immediately after the V blank. The `WM_StepDataSharing` function calls the `WM_SetMPDataToPort` function internally, but in order to perform data sharing with the least MP communication frequencies, it requires data to be on every MP sequence. Therefore, as explained in the previous item, data sharing may not be stable because of the communication timing, if it is not 260 lines with the parent and 240 lines with a child. This is the same with Key Sharing because it performs data sharing internally.

Q: The code does not work properly when pausing with the `WM_EndDataSharing` function and restarting with the `WM_StartDataSharing` function.

A: The `WM_EndDataSharing` function is designed to be called as a series of processes for ending communication, and it may cause a problem if the termination during MP communications and restarting were performed in a row. If you want to interrupt Data Sharing, set a flag in the shared data in advance, and once an interrupt timing is determined on the parent and child, you can simply stop calling the `WM_StepDataSharing` function. Unless the `WM_StepDataSharing` function is called, excess processing time and communications related to Data Sharing will not be generated. Be aware that when restarting, the last data that was set before the interruption will still get through.
In the future, the API for pausing will be provided.

Q: Can the shared data size be changed by using the same port?

A: This is planned for the future, but is not available now. Call the `WM_StartDataSharing` function and the `WM_EndDataSharing` function once for starting communication and ending communication respectively, and use one port for data sharing of the same setting during the communication. Instead, the same process is achieved by performing two sets of data sharing with different shared sizes at different ports, and switching them. Precautions for switching are as shown above.

3.11.5 Others

Q: The communication stops sometimes for an unknown reason.

A: There may be various causes such as the destruction of memory in the application. Check for the following.

- Are you using a process that takes a long period in the callback? Callback is in the interrupt handler, so it may be in interrupt prohibited state and the wireless communications driver of ARM7 may be waiting for the callback to complete. It would cause negative effects in some areas, so avoid using processes that takes some milliseconds.
- Are there multiple levels of nesting of function callbacks within a callback? Or, are you calling a function such as `OS_Printf` that consumes many stacks in a deeper level of nesting? Make sure to reduce the consumption of stacks because the IRQ stack used while the callback is executing is not very big. If it freezes during debug output, the situation may be improved by using the `OS_TPrintf` function instead of the `OS_Printf` function.
- Has the calling of the `WM_StartDataSharing` function been separated from calling of the `WM_StartMP*` function in the child? These child functions must be called consecutively because of the current restrictions on the implementation.

Q: Is there anything that requires special attention when debugging the wireless communication portion?

A: First, make sure to allocate enough time for debugging wireless communication. It may seem to be working properly, but a problem that occurs once every a few dozen times is very common.
For debugging, change to fixed channels by temporarily disabling the automatic channel selection feature, and start multiple groups of parent and children on the same channel. By repeating this test, you may have a better chance of recreating the problem.

3.12 Important Notes for Recent Releases

Several important changes to the Wireless Communications Library are explained below. Note that some changes are not obvious when compiling.

3.12.1 Changes in MP Frame Send Conditions (NITRO-SDK 2.2 PR and Later)

Previously, a parent in the MP_PARENT state sent MP frames regardless of the child's connection status. This has been changed so that nothing is sent if no child is connected. This eliminates occurrences of `MPEND` notifications when the number of connected children is 0. When using port send receive callbacks, there is no change in behavior. MP frames may be sent immediately after a child is disconnected, even though the number of connected children becomes 0.

A restriction was added so that no more that 6 MP frames will be sent in one picture frame. This restriction will normally not be an issue during meaningful communication. See 3.4.8 Restrictions on the Number of MP Communications Per Picture Frame.

3.12.2 Addition of Notification to WM_SetIndCallback Function Callback (NITRO-SDK 3.0PR2 and later)

WM_STATECODE_INFORMATION is now returned to the WM_SetIndCallback function callback. Its purpose is to provide notification of internal events. The type of event can be determined from WMIndCallback.reason, which is passed to the callback as an argument.

WM_INFOCODE_FATAL_ERROR is defined as the value placed in WMIndCallback.reason. This indicates that a fatal error occurred with the ignoreFatalError argument of the WM_StartMPEx function set to TRUE. In general, ignoreFatalError is set to FALSE, so there is no such notification.

3.12.3 Change in Null Response Condition (NITRO-SDK 3.0PR2 and later)

Previously, if processing by the ARM7 for a child device in the MP_CHILD state was not fast enough, a null response was issued when the MP frame was received. However, no response is returned now. If no response is returned, no MP receive notification is generated internally by the child device. Although this somewhat decreases transmission efficiency, it may alleviate overloading of the child device.

In addition, because return of no response can be guaranteed if the child device is not in the MP_CHILD state, there are no longer problems that result from gaps between the calls to the WM_StartConnect and WM_StartMP functions. However, be cautious; too much time between the calls will cause a disconnection due to lifetime expiration.

3.12.4 Addition of WM_STATECODE_DISCONNECT_FROM_MYSELF (NITRO-SDK 3.0RC and later)

Up to now, specifications did not include the generation of a disconnect notification when terminating one's own connection by explicitly calling the WM_DisconnectChildren, WM_Reset, WM_EndParent, or WM_Disconnect function. This has been changed by adding WM_STATECODE_DISCONNECTED_FROM_MYSELF to WMStateCode so that such notifications can be made.

WM_STATECODE_DISCONNECTED_FROM_MYSELF has the same callback structure as WM_STATECODE_DISCONNECTED and is used for notifications to the callback of the WM_StartParent, WM_StartConnect, and WM_SetPortCallback functions.

Since this change increases the state codes which may be used to fill the state field of WMStartParentCallback, WMStartConnectCallback, or WMPortRecvCallback, care must be taken in cases where programs have been coded so that the execution of a program is halted when anything other than an existing WM-STATE_CODE_* is received.

In addition, data sharing will no longer stop even when a child is explicitly disconnected from a parent using this notification.

3.12.5 Addition of WM_STATECODE_PORT_INIT (NITRO-SDK 3.0RC and later)

WM_STATECODE_PORT_INIT was added to WMStateCode and specifications were changed so a port

receive callback is called if this state code is in effect when `WM_SetPortCallback` is called. It is designed to be used for initialization processing that uses the `myAid` and `connectedAidBitmap` fields of `WMPortRecvCallback`.

Note: The value 0 is stored in both the `connectedAidBitmap` and `myAid` fields when the `WM_SetPortCallback` function was called before connection.

In order to maintain consistency among connection notifications, do not perform too much processing as calls made under `WM_STATECODE_PORT_INIT` are made while interrupts are disabled.