This is an excerpt from Natural MicroSystems' <u>NaturalFax</u> <u>Developer's</u> <u>Reference</u> <u>Manual</u>. I have chosen a selection from the Programming Model chapter to show my ability to write conceptual API documentation for an audience of C programmers. I wrote the original version of this manual. Although I was only one of serveral writers who contributed to subsequent versions, I can say that 80% of this excerpt is my writing.

2.4 Working with Document Queues

NaturalFax functions can operate only on *document queues*, not on individual files. You must use a document queue for any fax operation, even when transmitting or receiving a single document.

A document queue contains a list of one or more document files (the document files must be in TIFF-F or TIFF-S format). NaturalFax has two kinds of document queues: *send queues* and *receive queues*. Use send queues to transmit documents, and receive queues to receive documents.

Each document queue is linked to a specific CTA context. Each CTA context may have multiple send and receive queues.

2.4.1 Building a Document Queue

To create a new document queue, call **nfxCreateQueue**. It returns a queue handle, which uniquely identifies the queue. When you call **nfxCreateQueue**, one of its arguments determines which kind of queue is created, send or receive.

After creating a *send queue*, use **nfxEnqueueDoc** to add document files to the queue. Only files that already exist may be added to a send queue. The same file can be placed in multiple send queues simultaneously.

NaturalFax sends each enqueued file as a separate message (refer to Appendix G for detailed information about T.30 messages). For example, if you enqueue a three page file and a five page file, the remote fax machine will receive a three page message followed by a five page message. NaturalFax will not send both files in a single eight page message.

Note: NaturalFax does not modify or delete any document files when sending. Only received document files are modified.

Each document to be received must have an entry in the *receive queue*. When adding files using **nfxEnqueueDoc**, the receive name may not be NULL, and the file must not already exist.

NaturalFax receives each multiple page message into a single file. The next document in the queue is used only if the remote fax machine sends a new message. This method of file management is specific to computer-based fax applications.

2.5 Transmitting and Receiving Faxes

Transmitting or receiving document queues constitutes an active fax session. A fax session can include the polling of a remote fax terminal or responding to a poll request from a remote fax terminal.

Once a document queue has been transmitted or received, the queue can be *reset*. Each page in a document in a send queue is flagged as "sent" when it has been successfully transmitted.

Note: You must continue processing events during an active fax session. Make sure that file I/O intensive operations, such as TIFF-F or TIFF-S format verification, do not interfere with the handling of events and cause the fax session to time out. Events must be processed within three seconds.

2.5.1 Transmitting Faxes

Use **nfxSendFax** to transmit all the documents in a specified send queue. You can track which documents are successfully sent by monitoring events during transmission.

NaturalFax typically ends a fax session by transmitting a DCN (disconnect) frame to the remote fax terminal and sending an NFXEVN_SESSION_DONE event to the application. The application can release the call as soon as it receives the NFXEVN_SESSION_DONE event; it does not need to wait for a response from the remote fax terminal. The application must use ADI service functions to release the call after the DONE event is received.

It is also possible to transmit a *procedure interrupt request* (PRI) frame to the receiving fax terminal after completing a send operation. PRI requests that the receiving fax terminal permit an operator action such as picking up the handset for voice. See **nfxSendFax** in Chapter 6 for more details about sending PRI requests.

2.5.2 Receiving Faxes

An application must create a receive queue before it can call **nfxReceiveFax** and receive a queue of documents. The receive queue cannot be empty; it must contain one or more file names of nonexistent files. The files must not exist when the receive queue is created. The files must not exist at the time **nfxReceiveFax** is invoked.

NaturalFax will store each fax document received in a separate file, using the list of file names specified by the NaturalFax receive queue. If the sending fax terminal indicates that it is starting a new document and NaturalFax has already used all available empty file names in the receive queue, the received document will be appended to the last file in the receive queue. This coiuld result in a TIFF file with unused image attributes.

Note: In the following examples, use QDIMGR instead of ADIMGR for QX 2000 boards.

Figure 2 depicts the functions involved in a typical application that can transmit or receive faxes. Note that the NaturalFax functions for transmitting and receiving a fax are invoked when a call is in the connected state. The document queue can be destroyed as soon as the fax session is complete, or after the call is disconnected.



Figure 2. Functions for a Typical Fax Application

Figure 3 depicts a typical fax and voice application. In this application, the document queue is created when the call is in the connected state.



Figure 3. Functions for a Typical Fax and Voice Application

2.5.3 Polling the Called Fax Terminal

The fax polling operation enables the called fax terminal to send a queue of documents to the calling fax terminal. A caller may send any number of documents in a single queue and then poll the remote fax terminal. All documents in the send queue are transmitted before the called fax terminal can be polled.

To request polling, call **nfxSendFax** with a non-NULL *receive_queue_handle* argument. Since the calling fax terminal will be receiving faxes, it must have a receive queue ready to accept the received document files.

The *receive_queue_handle* argument controls polling. A call to **nfxSendFax** with a NULL *send_queue_handle* and a non-NULL *receive_queue_handle* initiates a fax session that polls the called fax terminal without transmitting any documents first.

Figure 4 shows the exchanges between the application, the APIs, the hardware, and the remote fax terminal as an application transmits a fax, then receives the fax for which it sent a poll request:



Figure 4. Polling the Remote Receiver (one page document)

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2.5.4 Answering a Poll Request

To enable polling from the receiving fax terminal, make sure that pollingenabled is set to NFX_YES in NFX_RECEIVE_PARMS. The application is notified of a poll request when it receives an NFXEVN_POLLED event. Even with polling enabled, the application must decide if it will answer a poll request, and prepare a send queue or use an already-prepared send queue of documents.

An application uses **nfxAnswerFaxPoll** to transmit its send queue in response to a poll request, rather than **nfxSendFax**. **nfxAnswerFaxPoll** must be called within three seconds of the receipt of NFXEVN_POLLED event. If the application does not respond to the poll within three seconds, it receives NFXEVN_SESSION_DONE. Alternatively, **nfxStopSession** may be called to refuse the poll request from the remote fax terminal.

If polling is not enabled, the NFXEVN_POLLED event is not generated (even if a poll request is made by the remote transmitter) and the fax session terminates.

Figure 5 shows NaturalFax receiving a document, and then transmitting a document in response to a poll:



Figure 5. Responding to the Remote Transmitter's Poll (one page document)

2.5.5 Resetting a Document Queue

Once a document queue has been transmitted or received, it can be reset using **nfxResetQueue**.

Each page in a document is flagged as "sent" when it has been successfully transmitted. Resetting a send queue resets the flags for each page of each of its component documents to "unsent."

The application developer is free to choose how to use document queues. One scenario is to use one document queue per fax operation. For a fax broadcast application, you can use one send queue per broadcast session, and continue to reset the queue and resend its contents multiple times.

Resetting a receive queue changes the queue type to a send queue with all the pages flagged as "unsent." This use is typical of a fax store-and-forward application.

Note: Once a receive queue is changed to a send queue, it cannot be changed back to a receive queue.

2.6 Performing Offline Image Conversion

You can convert a file's image characteristics *offline*, before transmitting the fax, with **nfxConvertFileDirect**. When you invoke **nfxConvertFileDirect**, specify the input file, the output file, and the desired image characteristics. For example, you may wish to convert a file into TIFF-S format. For detailed information about image format characteristics, refer to Chapter 4.

Conversions of encoding type or page width do not affect image quality. Converting from a high to a lower resolution will affect image quality. Converting an image from a lower to a higher resolution is not recommended, since the image cannot be improved, and the resulting file will be larger than the original.

NaturalFax supports TIFF-F files with different image formats on its pages by converting the format of all pages in the file to the format of the first page. If the file requires an image format other than that of the first page, use **nfxConvertFileDirect** to convert all the pages in a file to a specific image format. You can also use **nfxSplitFile** to split the original file into multiple files, each of which contains one or more pages that have the same image format. Splitting the file does not alter the image format of any of its pages. You may want to use **nfxSplitFile** to preserve the original image quality if a document has different resolutions on different pages.

Use **nfxMergeFile** to combine multiple pages stored in separate files into a single document for transmission. Merging the file does not alter the image format of any of its pages.

To verify that a document is in the correct format for transmission by NaturalFax, use **nfxCheckTIFF**.

File format conversion is an I/O intensive operation. File I/O intensive operations, such as TIFF-F or TIFF-S conversion or verification, must not interfere with CT Access event processing. Delays in application event processing can cause the fax session to time out. Applications must process events within three seconds of receipt. An application must continue processing events during an active fax session.

2.7 Performing Online Image Conversion

Online (also known as *on-the-fly*) conversions take place while transmitting and receiving a fax. Since image conversion consumes significant processor time, you may want to perform file conversions offline using **nfxConvertFileDirect** in order to conserve CPU resources for processing events during an active fax session.

NaturalFax's receive and transmit parameter structures, NFX_RECEIVE_PARMS and NFX_TRANSMIT_PARMS, contain image format parameters for encoding, resolution, and page width. These parameters are used, in conjunction with the OTFmode parameter, to determine the format of the image being transmitted or received. For detailed information about image format characteristics, refer to Chapter 4.

NFX_RECEIVE_PARMS and NFX_TRANSMIT_PARMS each contain an on-thefly (OTF) conversion field, OTFmode, that controls when, and under what conditions, the application performs online image conversion. OTFmode can be set to any of the following values:

Value	Description
NFX_OTF_NEVER	Never convert on the fly.
NFX_OTF_ONLY_IF_FAIL	Convert only if the fax operation would fail otherwise.
NFX_OTF_ALWAYS	Always convert as directed by the image parameters.

When NaturalFax is receiving a fax, NFX_DOC_PARMS contains the image format parameters that determine how the image will be stored.

NFX_RECEIVE_PARMS contains the badlineaction parameter, which controls how the receiving fax terminal manages bad lines of data. The parameter can be set to any of the following values:

Value	Description
NFX_BAD_LINE_ACTION_NONE	Do not repair bad lines.
NFX_BAD_LINE_ACTION_DROP	Eliminate bad line.
NFX_BAD_LINE_ACTION_REPT	Repeat previous good line.
NFX_BAD_LINE_ACTION_TICK	Replace bad line with a blank line and add a tick mark in the margin.

2.7.1 Image Conversion During Fax Transmission

This section describes how NaturalFax uses the parameters from NFX_TRANSMIT_PARMS and the remote fax terminal's capabilities to determine the image format used during a fax transmission.

The first step in determining the final transmission format is based on the capabilities of the transmitting and receiving fax terminals. The remote receiver announces its capabilities in the DIS frame. NaturalFax uses the image format parameters in the NFX_TRANSMIT_PARMS structure and the receiver's capabilities to choose the initial transmission format. The initial transmission format is set to the NFX_TRANSMIT_PARMS value if the remote receiver is capable of supporting it; otherwise the nearest value supported by the receiver is chosen.

The next step in determining the transmission format is based on the value of OTFmode in NFX_TRANSMIT_PARMS. The format of the stored file is compared with the initial transmission format, and conversion takes place according to the following criteria:

- If OTFmode is set to NFX_OTF_NEVER, and the stored file format requires capabilities less than or equal to the initial transmission format, the stored image format is selected as the final transmission format. *No image conversion is performed.*
- If OTFmode is set to NFX_OTF_NEVER, and the stored file format requires more advanced capabilities than can be provided by the initial transmission format, the fax session fails, and NaturalFax returns NFXEVN_SESSION_DONE with the error NFXERR_CONVERSION_REQUIRED. No file is sent, since the system cannot satisfy the needs of the receiver without performing a conversion. *No image conversion is performed.*
- If OTFmode is set to NFX_OTF_ONLY_IF_FAIL, and the stored file format requires capabilities less than or equal to the initial transmission format, the stored file format is selected as the final transmission format. *No image conversion is performed.*
- If OTFmode is set to NFX_OTF_ONLY_IF_FAIL, and the stored file format requires more advanced capabilities than can be provided by the initial transmission format, the file is converted to match the initial transmission format. The initial transmission format is selected as the final transmission format. *NaturalFax performs on-the-fly image conversion*.

• If OTFmode is set to NFX_OTF_ALWAYS, the stored file format will always use the encoding format characteristics specified by the initial transmission format. If the stored file format does not match the initial transmission format, it will be converted. There will only be a conversion for resolution and page width if it is necessary to support a lesser transmission capability. *NaturalFax performs on-the-fly image conversion if required.*

Once the decision is made, the final transmission format is sent back to the receiver in the DCS frame. The application can retrieve the final transmission format by interrogating the NFX_DOC_STATUS and NFX_FAX_STATUS data structures.

For the best image quality, an application should use the best formatting that the receiving fax machine can support. Set NFX_TRANSMIT_PARMS to use NFX_ENCODE_MMR, NFX_RESOLUTION_SUPER_HIGH, and NFX_PAGE_WIDTH_A3 to use the best capabilities of the receiving fax machine.

OTFmode can be set to NFX_OTF_ONLY_IF_FAIL to minimize the host execution time, or to NFX_OTF_ALWAYS to minimize transmission time. Checking and replacement of bad lines is performed when OTFmode is set to NFX_OTF_ONLY_IF_FAIL or NFX_OTF_ALWAYS.

Figure 6 illustrates the image format decision process during fax transmission:





2.7.2 Image Conversion During Fax Reception

This section describes how NaturalFax uses the parameters from NFX_RECEIVE_PARMS and the remote fax terminal's capabilities to determine the image format stored during a fax receive operation.

When NaturalFax acts as the receiving fax terminal, it sends the image format values from NFX_RECEIVE_PARMS to the remote transmitter in a DIS frame to announce the receiver's capabilities to the transmitter. The transmitter sends back a DCS frame with the final transmission format. The remote transmitter controls the choice of the final transmission format.

Once the final transmission format is determined, the application uses the values from NFX_DOC_PARMS and the value for OTFmode in NFX_RECEIVE_PARMS to determine how the incoming image data is actually stored. Conversion will only take place if OTFmode is set to NFX_OTF_ALWAYS. Otherwise, the file is stored in the format received.

If OTFmode is set to NFX_OTF_ALWAYS, the NFX_DOC_PARMS values for the document determine the final storage format. A conversion from lower to higher resolution, and from narrower to wider pages will be performed if specified. Using NFX_OTF_ALWAYS is appropriate when your application requires a specific image format, and there are sufficient host CPU resources to support on-the-fly conversion.

To use the minimum host CPU resources when receiving a fax, accept the highest quality that the sender can provide, and save the image directly to a file without performing conversion. This can be accomplished by using NXF_ENCODE_MMR, NFX_RESOLUTION_SUPER_HIGH, NFX_PAGE_WIDTH_A3, and NFX_OTF_NEVER in NFX_RECEIVE_PARMS.

To retrieve the final storage format after the document is received, examine the NFX_DOC_STATUS or NFX_FAX_STATUS structures.

Figure 7 illustrates how the stored image format is selected during a fax receive operation.



Figure 7. Image Conversion Decision When Receiving a Fax

2.7.3 Generating TIFF-S Files on Receive

When receiving an image to be used in future T.37 operations, the application can choose to:

• Ensure that the image is transmitted in TIFF-S format by advertising only TIFF-S compatible capabilities, which minimizes CPU resources,

or

• Recieve the image in the fastest means possible, and use the OTF mode to convert the image to TIFF-S format after reception.

The following table summarizes how the document will be transmitted, as determined by OTFmode, when NFX_RECEIVE_PARMS.ENCODING = TIFF_S.

OTFmode	Advertised Parameters
NFX_OTF_NEVER	1D encoding low resolution A4 page width
NFX_OTF_ALWAYS	MMR encoding (if ECM is enabled) or MR (if ECM is disabled) low resolution A4 page width

2.8 Monitoring Fax Session Status

An application can monitor the progress of a fax session actively, by explicitly querying the status, and passively, by monitoring the NaturalFax events on a specified CTA context.

When an application receives an error as part of an event, it can decide whether it continues sending or receiving the remaining documents in the queue or aborts the fax session with **nfxStopSession**.

Use **nfxGetSessionStatus** to obtain a "snapshot" of the status of the current fax session. This function fills in an NFX_FAX_STATUS structure.