

IBM i  
7.3

*Programming  
IBM PASE for i*



**Note**

Before using this information and the product it supports, read the information in [“Notices” on page 65.](#)

This edition applies to IBM i 7.3 (product number 5770-SS1) and to all subsequent releases and modifications until otherwise indicated in new editions. This version does not run on all reduced instruction set computer (RISC) models nor does it run on CISC models.

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# IBM PASE for i

With IBM® Portable Application Solutions Environment for i (PASE for i), you can port IBM AIX® applications to the IBM i platform with minimal effort.

PASE for i provides an integrated runtime environment that allows you to run selected applications without the complexity of managing operating systems, such as AIX or Linux®. PASE for i also provides industry-standard and defacto-standard shells and utilities that provide you with a powerful scripting environment.

**Note:** By using the code examples, you agree to the terms of the [Code license and disclaimer information](#).

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## What's new for IBM i 7.3

Read about new or significantly changed information for the PASE for i topic collection.

The following changes have been made to PASE for i in IBM i 7.3:

- PASE for i is derived from AIX 7.1, Technology Level 3.

### How to see what's new or changed

To help you see where technical changes have been made, the information center uses:

- The  image to mark where new or changed information begins.
- The  image to mark where new or changed information ends.

In PDF files, you might see revision bars (|) in the left margin of new and changed information.

To discover other information about what's new or changed this release, see the [Memo to users](#).

### Related concepts

[Installing AIX compilers on IBM i](#)

You can use these AIX compilers to develop, compile, build, and run PASE for i applications entirely within the PASE for i environment on your system.

[IBM PASE for i shells and utilities](#)

PASE for i includes three shells (Korn, Bourne, and C shell) and provides many utilities that run as PASE for i programs. PASE for i shells and utilities provide an extensible scripting environment that includes a large number of industry-standard and defacto-standard commands.

### Related information

[Runtime functions for use by IBM PASE for i programs](#)

[IBM PASE for i locales](#)

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## PDF file for IBM PASE for i

You can view and print a PDF file of the information for PASE for i.

To view or download the PDF version of this document, select [PASE for i](#).

### Saving PDF files

To save a PDF on your workstation for viewing or printing:

1. Right-click the PDF link in your browser.
2. Click the option that saves the PDF locally.
3. Navigate to the directory in which you want to save the PDF.
4. Click **Save**.

## Related reference

Related information for IBM PASE for i

IBM Redbooks publications, Web sites, and other information center topic collections contain information that relates to the PASE for i topic collection. You can view or print any of the PDF files.

## IBM PASE for i overview

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PASE for i enables you to run many of your AIX applications on the IBM i operating system with little or no change, and effectively expands your platform solution portfolio.

Cross-platform application development and deployment are crucial components of any effective business computing environment. Equally important are the ease of use and integration of functions that your IBM i server offers. As your business moves into an increasingly open computing environment, you are likely to find that achieving these often divergent goals can be difficult, time-consuming, and expensive. For instance, you might want the benefit of a familiar application that runs on and makes use of the capabilities of the AIX operating system, but you do not want the added burden of managing both the AIX and IBM i operating systems.

This is where PASE for i helps.

## IBM PASE for i concepts

PASE for i is an integrated runtime environment for AIX applications running on the IBM i operating system.

PASE for i supports the application binary interface (ABI) of AIX and provides a broad subset of the support provided by AIX shared libraries, shells, and utilities. PASE for i also supports the direct processing of IBM PowerPC® machine instructions, so it does not have the drawbacks of an environment that only emulates the machine instructions.

PASE for i applications:

- Can be written in C, C++, Fortran, or PowerPC assembler
- Use the same binary executable format as AIX PowerPC applications
- Run in an IBM i job
- Use IBM i system functions, such as file systems, security, and sockets

Keep in mind that PASE for i is not a UNIX operating system on the IBM i operating system. PASE for i is designed to run AIX programs on the IBM i operating system with little or no change. Programs from any other environment, such as UNIX or Linux, need to be written such that they can be compiled on AIX as the first step toward running in PASE for i.

The PASE for i integrated run time runs on the Licensed Internal Code kernel on the IBM i operating system. The system provides integration of many common IBM i functions across PASE for i and other runtime environments (including Integrated Language Environment® (ILE) and Java™). PASE for i implements a broad subset of AIX system calls. System support for PASE for i enforces system security and integrity by controlling what memory an PASE for i program can access and restricting the program to use only unprivileged machine instructions.

## Rapid application deployment with minimal effort

In many cases, your AIX programs can run in PASE for i with little or no change. The level of AIX programming skills you need varies depending on the design of your AIX program. In addition, by providing additional IBM i application integration in your program design (for instance, with CL commands), you can minimize configuration concerns for your application users.

PASE for i adds another porting option for solution developers who want to share in the success of the IBM i marketplace. By providing a means to cut porting time significantly, PASE for i can improve the time to market and return on investment for solutions developers.

## A broad subset of AIX technology on IBM i

PASE for i implements an application run time that is based on a broad subset of AIX technology, including:

- Standard C and C++ run time (both threadsafe and non-threadsafe)
- Fortran run time (both threadsafe and non-threadsafe)
- pthreads threading package
- iconv services for data conversion
- Berkeley Software Distributions (BSD) equivalent support
- X Window System client support with Motif widget set
- Pseudo terminal (PTY) support

Applications are developed and compiled on an AIX workstation running a level of AIX that is compatible with a level supported by PASE for i, and then these applications are run on the IBM i operating system.

Alternatively, you can install one of the supported compiler products in the PASE for i environment to develop, compile, build, and run your applications completely within PASE for i.

PASE for i also includes the Korn, Bourne, and C shells and nearly 200 utilities that provide a powerful scripting environment.

PASE for i uses IBM investment in a common processor technology for the AIX and IBM i operating systems. The PowerPC processor switches from IBM i mode into AIX mode to run an application in the PASE for i run time.

Applications running in PASE for i are integrated with the IBM i integrated file system and Db2® for i. They can call (and be called by) Java and ILE applications. In general, they can take advantage of all aspects of the IBM i operating environment, such as security, message handling, communication, and backup and recovery. At the same time, they take advantage of application interfaces that are derived from AIX interfaces.

### Related concepts

#### IBM PASE for i shells and utilities

PASE for i includes three shells (Korn, Bourne, and C shell) and provides many utilities that run as PASE for i programs. PASE for i shells and utilities provide an extensible scripting environment that includes a large number of industry-standard and defacto-standard commands.

### Related reference

#### Compiling your AIX source

You can install one of the AIX compiler products that support installation on IBM i to compile your programs in the PASE for i environment.

## IBM PASE for i as a useful option for application development

You can use the API analysis tool to determine whether an application is suitable for PASE for i. PASE for i is not the best solution under some circumstances.

PASE for i provides considerable flexibility when you are deciding how to port your AIX applications to your system. Of course, PASE for i is only one of several options you can use to port AIX applications.

### API analysis

Your starting point for determining whether an application is suitable for PASE for i is an analysis of the application: the APIs, libraries, and utilities that the application uses and how effectively the application will run on the IBM i operating system. For more information about how code analysis fits into the procedures for porting applications to PASE for i, see [“Preparing programs to run in IBM PASE for i” on page 6](#).

## Characteristics of a potential PASE for i application

Here are some useful guidelines that you might consider when making the decision whether to use PASE for i:

- **Is the AIX application a highly computation-intensive application?**

PASE for i provides a good environment for running computation-intensive applications on the IBM i operating system by providing highly optimized math libraries.

- **Does the application rely heavily on functions that are supported only in PASE for i (or only partially supported in ILE), such as `fork()`, X Window System, or pseudo-terminal (PTY) support?**

PASE for i provides support for the `fork()` and `exec()` functions, which do not currently exist on the IBM i operating system (except through the `spawn()` function, which incorporates the `fork()` function with the `exec()` function).

- **Does the application use a complicated AIX system-based build process or testing environment?**

PASE for i lets you use AIX system-based build processes, which are especially useful when you have an existing, complicated process that is not readily transferred onto a new operating system.

- **Does the application have dependencies on an ASCII character set?**

PASE for i provides good support for applications with these needs.

- **Does the application do a lot of pointer manipulation, or does it convert (cast) integers to pointers?**

PASE for i supports both 32- and 64-bit AIX addressing models with low performance cost and the ability to convert integers to pointers.

## When PASE for i might not be the best solution

PASE for i is generally not a good choice for code that provides a large number of callable interfaces that must be called from ILE and that has any of the following characteristics:

- Code that needs higher performance call and return than provided by either starting or ending PASE for i on each call or by calling an PASE for i procedure in an already-active PASE for i program (using the `Qp2CallPase()` API).
- Code that needs to share memory or namespace between an ILE caller and the library code. An PASE for i program does not implicitly share memory or namespace with ILE code that called it. (However, ILE code that is called from PASE for i can share or use PASE for i memory.)

## Installing IBM PASE for i

PASE for i is an optionally installable component of the operating system. You need to install PASE for i to use it or to run some software that requires PASE for i support.

Some system software, such as the enhanced Domain Name System (DNS) server and the ILE C++ compiler, requires PASE for i support; therefore, you might still need to install PASE for i even if you are not planning to directly use PASE for i.

PASE for i is free of charge on all IBM i servers.

To install PASE for i on your system, follow these steps:

1. On an IBM i command line, enter `GO LICPGM`.
2. Select 11 (Install licensed program).
3. Select Option 33 (5770-SS1 - Portable Application Solutions Environment).
4. Optional: Install additional locales.

The PASE for i product installs only the locale objects that are associated with the language features that you have installed on the IBM i operating system. If you need locales that are not included with the language features on your system, you need to order and install additional IBM i language features.

**Licensing note for software developers who are porting an application to PASE for i:**

PASE for i provides a subset of the AIX runtime libraries on the IBM i system. The IBM i license authorizes you to use any library code shipped with IBM i. This license does not imply a license to AIX libraries that were not shipped with PASE for i. All AIX products are separately licensed by IBM.

As you begin porting your own applications to PASE for i, you might find that your application has dependencies on AIX libraries that were not shipped with PASE for i. Before porting these libraries to the IBM i system, you should determine which software product provided those libraries and examine the terms and conditions of the license agreement for that software product. It might be necessary to work with IBM or a third party to port additional middleware dependencies to the IBM i system. You should investigate every licensing agreement involved with the code you are porting before you start porting. If you need to find out about license agreements in place against libraries that you believe belong to IBM, contact your IBM marketing representative, one of the IBM porting centers, the Custom Technology Center in Rochester, or PartnerWorld® for Developers.

### Related concepts

#### Globalization

Because the PASE for i run time is based on the AIX run time, PASE for i programs can use the same rich set of programming interfaces for locales, character string manipulation, date and time services, message catalogs, and character encoding conversions supported on AIX.

### Related information

#### IBM PASE for i locales

## Planning for IBM PASE for i

PASE for i provides an AIX runtime environment on the IBM i operating system so that you can port your AIX applications to the system with minimal effort.

In fact, many AIX programs run in PASE for i with no change. This is because PASE for i supplies many of the same shared libraries that are available on AIX, and it provides a broad subset of AIX utilities that run directly on the IBM i PowerPC processor in the same way that they run on the System p PowerPC processor.

Keep in mind these points as you begin to work with PASE for i:

- **There is a correlation between the target AIX binary release and the release of PASE for i where the binary application will run.**

If you compile your PASE for i applications on AIX, the binary version of the application created on AIX needs to be compatible with the version of PASE for i in which you want to run the application. The following table shows which AIX binary versions are compatible with different versions of PASE for i. For example, an application created for AIX release 5.3 can only run in PASE for i on IBM i 5.4 and subsequent releases. Similarly, an application created for AIX release 6.1 can run on IBM i 7.1, but not on any of the previous releases.

| AIX release         | IBM i 6.1 | IBM i 7.1 | IBM i 7.2 | IBM i 7.3 |
|---------------------|-----------|-----------|-----------|-----------|
| 5.1 (32- or 64-bit) | X         | X         | X         | X         |
| 5.2 (32- or 64-bit) | X         | X         | X         | X         |
| 5.3 (32- or 64-bit) | X         | X         | X         | X         |
| 6.1 (32- or 64-bit) |           | X         | X         | X         |
| 7.1 (32- or 64-bit) |           |           | X         | X         |

- **PASE for i does not provide the AIX kernel on the IBM i operating system.**

Instead, any low-level system functions that are needed by a shared library are routed to the IBM i kernel or to the integrated IBM i functions. In this regard, PASE for i bridges the gap across the AIX and IBM i operating systems. Your code uses the same syntax for the APIs in the shared libraries as you can find on AIX, but your PASE for i program runs within an IBM i job and is managed by the IBM i operating system just like any other IBM i job.

- **In most cases, the APIs you call in PASE for i behave in exactly the same manner as they do on AIX.**

Some APIs, however, might behave differently in PASE for i, or might not be supported in PASE for i. Because of this, your plan for preparing PASE for i programs should begin with a thorough code analysis. For more information about code analysis, see [“Analyzing program compatibility with IBM PASE for i”](#) on page 6.

- **Consider some of the differences that exist between the AIX and IBM i platforms:**

- AIX is generally case-sensitive, but certain IBM i file systems are not.
- AIX generally uses ASCII for data encoding, but the IBM i operating system generally uses Extended Binary Coded Decimal Interchange Code (EBCDIC). This is a consideration if you want to manage the details of calling ILE code from your PASE for i program. For example, you must explicitly code PASE for i programs to handle character encoding conversions on strings when you make calls from PASE for i to arbitrary ILE procedures. PASE for i runtime support includes the `iconv()`, `iconv_close()`, and `iconv_open()` functions for character encoding conversion.

**Note:** PASE for i and ILE have independent implementations of `iconv()` interfaces, each with its own translation tables. The translations supported by PASE for i `iconv()` support can be modified and extended by users because they are stored as byte stream files in the integrated file system.

- AIX applications expect that lines (for example, in files and shell scripts) will end with a line feed (LF), but personal computer (PC) software and IBM i software typically end lines with a carriage return and line feed (CRLF).
- Some of the scripts and programs you use on AIX might use hardcoded paths to standard utilities, and you might need to modify the path to reflect the paths you are using in PASE for i. You should analyze your program's compatibility with the IBM i operating system.

PASE for i automatically handles some of these issues. For example, when you use the PASE for i runtime service that the system provides (including any system call or runtime function in a shared library shipped with IBM i option 33), PASE for i performs ASCII-to-EBCDIC conversions as needed, although generally no conversions are done for data that is read or written to a file descriptor (byte stream file or socket).

You can use other low-level functions, such as `_ILECALL()`, to extend the functionality of your PASE for i program with calls to ILE functions and APIs, but as mentioned above you might need to handle data conversion. Also, coding these extensions into your program requires the use of additional header and export files.

### **Related concepts**

[Analyzing program compatibility with IBM PASE for i](#)

The first step in an assessment of the portability of a C application to the IBM i operating system is the analysis of the interfaces that are used in your application.

## **Preparing programs to run in IBM PASE for i**

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The steps to prepare AIX programs to run effectively on the IBM i operating system vary with the nature of your program and your actual needs for IBM i system-unique interfaces and functions.

If you are attempting to port an application to PASE for i, you must first ensure that the application will compile using an AIX compiler. In some cases, you need to modify your program to achieve this requirement.

### **Analyzing program compatibility with IBM PASE for i**

The first step in an assessment of the portability of a C application to the IBM i operating system is the analysis of the interfaces that are used in your application.

- Obtain a list of libraries used by your application.

Library analysis helps identify some of the middleware APIs that your application uses. You can run the following command against each of your commands and shared objects to get a list of libraries required by your application:

```
dump -H binary_name
```

- Check your code for hardcoded path names.

If you run programs that change credentials or want your programs or scripts to run even when the PASE for i environment variable `PASE_EXEC_QOPENSYS=N`, you might need to change hardcoded path names.

Because `/usr/bin/ksh` is an absolute path (starting at the root), if it is not found or if it is not a byte stream file, PASE for i searches the `/QOpenSys` file system for path name `/QOpenSys/usr/bin/ksh`. QShell utility programs are not byte stream files, so PASE for i searches the `/QOpenSys` file system even when the original (absolute) path is a symbolic link to a QShell utility program, such as `/usr/bin/sh`.

- Check for unsupported system calls.

The PASE for i kernel exports some system calls that are implemented by the AIX kernel but are unsupported by PASE for i. The default behavior for an unsupported system call is to send exception message MCH3204 that contains the name of the unsupported system call. Additionally, the system will deliver PASE for i signal SIGILL to the calling process.

You may need to modify your application source to avoid use of any unsupported system calls. You can also use the `PASE_SYSCALL_NOSIGILL` environment variable to alter the system behavior for unsupported system calls.

### **Related concepts**

[Planning for IBM PASE for i](#)

PASE for i provides an AIX runtime environment on the IBM i operating system so that you can port your AIX applications to the system with minimal effort.

### **Related information**

[PASE for i environment variables](#)

## **Compiling your AIX source**

You can install one of the AIX compiler products that support installation on IBM i to compile your programs in the PASE for i environment.

When your program uses AIX interfaces only, you can compile with any required AIX headers and link with AIX libraries to prepare binary files for PASE for i. Keep in mind that PASE for i does not support applications that are statically bound with AIX system-supplied shared libraries.

PASE for i programs are structurally identical to AIX programs for PowerPC.

PASE for i (option 33 of the operating system) does not include a compiler. You use an AIX system to compile PASE for i programs, or you can optionally install one of the AIX compiler products that support installation in PASE for i to compile your programs in the PASE for i environment.

### **Using AIX compilers on the System p platform**

You can build PASE for i programs using any AIX compiler and linker that generate output that is compatible with the AIX application binary interface (ABI) for PowerPC. PASE for i provides instruction emulation support for binary files that use POWER® architecture instructions that do not exist in PowerPC (except for IBM POWER instructions for cache management).

### **Using AIX compilers in PASE for i**

IBM i supports the installation of the following separately available AIX compilers in the PASE for i environment:

- IBM XL C/C++ for AIX
- IBM XL C for AIX
- IBM XL Fortran for AIX

Using these products, you can develop, compile, build, and run your PASE for i applications entirely within the PASE for i environment on your system.

## Development tools

Many development tools that you use on AIX (for example, `ld`, `ar`, `make`, `yacc`) are included with PASE for i. Many AIX tools from other sources (for instance, the open-source tool `gcc`) can also work in PASE for i. More information on open source solutions can be found at <http://ibm.biz/ibmi-oss-docs>.

## Compiler notes for handling of pointers

- The `xlc` compiler provides limited support for 16-byte alignment (for type long double) by using the combination of `-qlngdbl128` and `-qalign=natural`. Type *ILEpointer* requires these compiler options to ensure that machine interface (MI) pointers are 16-byte aligned within structures. Using option `-qldbl128` forces type long double to be a 128-bit type that requires use of `libc128.a` to handle operations like `printf` for long double fields.

An easy way to get option `-qlngdbl128` and link with `libc128.a` is to use the `xlc128` command instead of the `xlc` command.

- The `xlc/xlc` compiler currently does not provide a way to force 16-byte alignment for static or automatic variables. The compiler only guarantees relative alignment for 128-bit long double fields within structures. The PASE for i version of `malloc` always provides 16-byte aligned storage, and you can arrange 16-byte alignment of stack storage.
- Header file `as400_types.h` also relies on type `long long` to be a 64-bit integer. `xlc` compiler option `-qlonglong` ensures this geometry (which is not the default for all commands that run the `xlc` compiler).

## Examples

The following examples are intended for use when you are compiling your PASE for i programs on an AIX system. If you are using a compiler installed in PASE for i to compile your programs, you do not need to specify compiler options for the locations of IBM i system-unique header files or IBM i system-unique exports because these files will be found in their default path locations of `/usr/include/` and `/usr/lib/` on an IBM i system.

### Example 1

The following command on an AIX system creates an PASE for i program named `testpgm` that can use IBM i system-unique interfaces exported by `libc.a`:

```
xlc -o testpgm -qldbl128 -qlonglong -qalign=natural  
-bI:/mydir/as400_libc.exp testpgm.c
```

This example assumes that the IBM i system-unique header files are copied to the AIX directory `/usr/include` and that the IBM i system-unique exports files are copied to the AIX directory `/mydir`.

### Example 2

The following example assumes IBM i system-unique headers and export files are in `/pase/lib`:

```
xlc -o as400_test -qldbl128 -qlonglong -qalign=natural -H16  
-l c128  
-I /pase/lib  
-bI:/pase/lib/as400_libc.exp as400_test.c
```

### Example 3

The following example builds the same program as example 2 with the same options; however, the `xlc_r` command is used for a multithreaded program to ensure that the compiled application links with threadsafe runtime libraries:

```
xlc_r -o as400_test -qldbl128 -qlonglong -qalign=natural -H16
      -l c128
      -I /pase/lib
      -bI:/pase/lib/as400_libc.exp as400_test.c
```

In the examples, if you are using PASE for i support for IBM Db2 for i call level interfaces (CLIs), you also need to specify `-bI:/pase/include/libdb400.exp` on your build command.

The `-bI` directive tells the compiler to pass the parameter to the `ld` command. The directive specifies an export file containing exported symbols from a library to be imported by the application.

### Related concepts

[IBM PASE for i concepts](#)

PASE for i is an integrated runtime environment for AIX applications running on the IBM i operating system.

[IBM PASE for i shells and utilities](#)

PASE for i includes three shells (Korn, Bourne, and C shell) and provides many utilities that run as PASE for i programs. PASE for i shells and utilities provide an extensible scripting environment that includes a large number of industry-standard and defacto-standard commands.

## Installing AIX compilers on IBM i

You can use these AIX compilers to develop, compile, build, and run PASE for i applications entirely within the PASE for i environment on your system.

You can install any of the following separately available AIX compilers on IBM i for use by the PASE for i environment:

- IBM XL C/C++ for AIX
- IBM XL C for AIX
- IBM XL Fortran for AIX

### Related concepts

[What's new for IBM i 7.3](#)

Read about new or significantly changed information for the PASE for i topic collection.

### Related information

[XL C/C++ for AIX](#)

[XL C for AIX](#)

[XL Fortran for AIX](#)

### *Installing the AIX compilers from the installation media*

PASE for i does not support the AIX `smit` or `installp` utilities, which are typically used to install applications on systems running AIX. Installation of the XL C/C++ for AIX, XL C for AIX, or XL Fortran for AIX product is accomplished through a non-default installation script that is included in the respective compiler's installation media.

In addition to the compiler installation media, you also need the following programs installed on your system to successfully install and use the compiler:

- 5770-SS1 Option 33 - PASE for i
- 5770-SS1 Option 13 - System Openness Includes, containing the compiler header files found in the `/usr/include` integrated file system directory
- Perl

The compiler installation scripts require Perl. Here are two ways to install Perl:

- Install [open source solutions](#) and use "yum install perl" to set up Perl on your system.
- [CPAN Perl Ports \(Binary Distributions\) Web site](#)  (www.cpan.org/ports/#os400) - A Perl Port binary distribution for PASE for i.

To install the XL C/C++ for AIX, XL C for AIX, or XL Fortran for AIX product on IBM i, follow the steps documented in the related AIX compiler documentation.

1. Select a version of the compiler to be updated.

For XL C/C++ for AIX, go to the IBM [XL C/C++ for AIX](#)  documentation and select a version of XL C/C++ for AIX compiler.

**Note:** XL C/C++ for AIX 13.1.2 is the recommended minimum release.

For XL C for AIX, go to the IBM [XL C for AIX](#)  documentation and select a version of XL C for AIX compiler.

**Note:** XL C for AIX 13.1.2 is the recommended minimum release.

For XL Fortran for AIX, go to the IBM [XL Fortran for AIX](#)  documentation and select a version of XL Fortran for AIX compiler.

**Note:** XL Fortran for AIX 15.1.2 is the recommended minimum release.

2. Click on the **Basic Installation** link.
3. Click on the **Advanced Installation** link.
4. Click on the **Tasks for advanced installation** link.
5. Click on the **Installing on an IBM i PASE System** link and follow the instructions for installation from CD.

The compiler is now installed for use in PASE for i. Here are some example directory locations which will vary depending on the AIX compiler version installed:

- The XL C/C++ for AIX version 13.1.2 compiler commands (for example, **xlc**) can be found in directory /QOpenSys/xlc/opt/IBM/xlc/13.1.2/bin.
- The XL C for AIX version 13.1.2 compiler commands (for example, **xlc**) can be found in directory /QOpenSys/xlc/opt/IBM/xlc/13.1.2/bin.
- The XL Fortran for AIX compiler commands (for example, **xlf**) can be found in directory /QOpenSys/xlf/opt/IBM/xlf/15.1.2/bin.

**Note:** You can add the directory that contains the compiler commands to the \$PATH environment variable. The \$PATH environment variable specifies the directories to be searched to find a command. For example, if you have installed XL C/C++ for AIX version 13.1.2, you can change the \$PATH environment variable as follows to avoid specifying the command path when you use the compiler commands:

```
export $PATH=$PATH:/QOpenSys/xlc/opt/IBM/xlc/13.1.2/bin
```

## Related information

[XL C/C++ for AIX](#)

[XL C for AIX](#)

[XL Fortran for AIX](#)

## PTF update instructions

Installation of program temporary fixes (PTFs) for the XL C/C++ for AIX, XL C for AIX, or XL Fortran for AIX product is accomplished through the same non-default installation script that is used for the initial compiler installation.

Before installing the PTFs, you must have already installed the compilers using the previous steps in this topic.

To install PTFs for the XL C/C++ for AIX, XL C for AIX, or XL Fortran for AIX product on IBM i, follow the steps documented in the related AIX compiler documentation.

1. Select a version of the compiler to be updated.

For XL C/C++ for AIX, go to the IBM [XL C/C++ for AIX](#)  documentation and select a version of XL C/C++ for AIX compiler.

**Note:** XL C/C++ for AIX 13.1.2 is the recommended minimum release.

For XL C for AIX, go to the IBM [XL C for AIX](#)  documentation and select a version of XL C for AIX compiler.

**Note:** XL C for AIX 13.1.2 is the recommended minimum release.

For XL Fortran for AIX, go to the IBM [XL Fortran for AIX](#)  documentation and select a version of XL Fortran for AIX compiler.

**Note:** XL Fortran for AIX 15.1.2 is the recommended minimum release.

2. Click on the **Basic Installation** link.
3. Click on the **Advanced Installation** link.
4. Click on the **Tasks for advanced installation** link.
5. Click on the **Installing on an IBM i PASE System** link.
6. Click on the **Installing PTF updates on the PASE system** link and follow the instructions.

#### **Related information**

[XL C/C++ for AIX](#)

[XL C for AIX](#)

[XL Fortran for AIX](#)

## **Copying the IBM PASE for i program to your system**

You must copy the AIX binary files that you want to run in PASE for i into the integrated file system.

All of the file systems that are available in the integrated file system are available within PASE for i.

When you move files across operating systems, be aware of your application's sensitivity to mixed case and of the difference between line-terminating characters that AIX uses and those that the IBM i operating system uses. These differences might create problems for you.

You can transfer your PASE for i program and related files to and from your system by using File Transfer Protocol (FTP), Server Message Block (SMB), or remote file systems.

#### **Related reference**

[Copying header files](#)

Use this information to copy header files from the system running IBM i to the system running AIX.

[Copying export files](#)

Use this information to copy the export files from the system running IBM i to an AIX directory.

#### **Related information**

[Integrated file system](#)

## **Case sensitivity**

If your application is sensitive to mixed case, move it into the /Q0penSys file system, or into a user-defined file system that has been created as case-sensitive.

The interfaces of operating systems, such as AIX and Linux, generally differentiate between uppercase and lowercase letters. On the IBM i operating system, that is not always the case. You should be aware of several situations in particular where case sensitivity might cause complications with existing codes.

Case sensitivity on a directory or file basis depends on the file system you are using on the IBM i operating system. The /QOpenSys file system is case-sensitive, and you can create a user-defined file system (UDFS) that is case-sensitive.

## Examples

The following examples are problems stemming from case sensitivity that you might encounter.

### Example 1

In this example, the shell does a character comparison of the generic name prefix against what is returned by `readdir()`. However, the QSYS.LIB file system returns directory entries in uppercase, so none of the entries matches the lowercase generic name prefix.

```
$ ls -d /qsys.lib/v4r5m0.lib/qwobj*  
/qsys.lib/v4r5m0.lib/qwobj* not found  
$ ls -d /qsys.lib/v4r5m0.lib/QWOBJ*  
/qsys.lib/v4r5m0.lib/QWOBJ.FILE
```

### Example 2

This example is similar to the first example except that, in this case, the `find` utility is doing the comparison, and not the shell.

```
$ find /qsys.lib/v4r5m0.lib/ -name 'qwobj*' -print  
$ find /qsys.lib/v4r5m0.lib/ -name 'QWOBJ*' -print  
/qsys.lib/v4r5m0.lib/QWOBJ.FILE
```

### Example 3

The `ps` utility expects user names to be case-sensitive and therefore does not recognize a match between the uppercase name specified for the `-u` option and lowercase names returned by the PASE for i runtime function `getpwuid()`:

```
$ ps -uTIMMS -f  
UID PID PPID C STIME TTY TIME CMD  
$ ps -utimms -f  
UID PID PPID C STIME TTY TIME CMD  
timms 617 570 0 10:54:00 - 0:00 /QOpenSys/usr/bin/-sh -i  
timms 660 617 0 11:14:56 - 0:00 ps -utimms -f
```

## Related information

[File system comparison](#)

## Line-terminating characters in integrated file system files

The AIX and IBM i operating systems use different line-terminating characters in text files; for example, in files and shell scripts.

The AIX applications that are the source for your PASE for i programs expect that lines (for example, in files and shell scripts) will end with a line feed (LF). However, PC software and typical IBM i software often ends lines with a carriage return and line feed (CRLF).

## CRLF used with FTP

One example of where this difference can cause problems is when you use File Transfer Protocol (FTP) to transfer source files and shell scripts from the AIX operating system to the IBM i operating system. The FTP standard calls for data sent in text mode to use carriage return and line feed (CRLF) at the end of a line. On AIX, the FTP utility removes carriage returns (CRs) when it processes an inbound file in text mode. IBM i FTP always writes exactly what is presented in the data stream and always retains CRLF for text mode, which causes problems with the PASE for i run time and utilities.

Where possible, use binary mode transfer from an AIX operating system to avoid this problem. Text files transferred from personal computers will, in most cases, have CRLF delimiting lines in the file. Transferring the files first to AIX will correct the problem. The following command can be used as a means to remove the CR from files in the current directory:

```
awk '{ gsub( /\r$/, "" ); print $0 }' < oldfile > newfile
```

## CRLF used with IBM i and PC editors

You can also experience problems when you edit your files or shell scripts with editors on your system or with editors on your workstation (such as Windows Notepad editor). These editors use CRLF as a new line separator, and not the LF that PASE for i expects.

Numerous editors are available (for instance, the ez editor) that do not use CRLF as new line separators.

## Transferring files

You can transfer your PASE for i program and related files to and from your system, using File Transfer Protocol, Server Message Block, or remote file systems.

- [Copying programs using File Transfer Protocol](#)
- [Copying programs using Server Message Block](#)
- [Copying programs using remote file systems](#)

## Copying programs using File Transfer Protocol

You can use the IBM i File Transfer Protocol (FTP) daemon and client to transfer a file into or out of the IBM i integrated file system. Transfer your files in binary mode. Use the FTP subcommand `binary` to set this mode.

You must use naming format 1 (the `NAMEFMT 1` subcommand of the IBM i FTP command) when placing files into the integrated file system. This format allows the use of path names, and transfers the files into stream files. To enter into naming format 1, you can either:

- Change the directory using path names.

This automatically puts the session into name format 1. Using this method, the first directory is prefaced by a slash (/). For example:

```
cd /QOpenSys/usr/bin
```

- Use the FTP subcommand `quote site namefmt 1` for a remote client, or use `namefmt 1` as a local client.

## Copying programs using Server Message Block

The IBM i operating system supports Server Message Block (SMB) client and server components. With NetServer configured and running, PASE for i has access to SMB servers in the network through the /QNTC file system. On an AIX or a Linux operating system, a SAMBA server is required to provide the same service. Installing a configured and operational operating system, such as AIX, can make directories and files available to PASE for i.

## Copying programs using remote file systems

On the IBM i operating system, you can mount Network File System (NFS) file systems to a mount point in the integrated file system file space. AIX supports NFS, as well as Distributed File System (DFS) and Andrew File System (AFS®) (using DFS-to-NFS and AFS-to-NFS translators) so that these file systems can be exported and mounted by the IBM i operating system. This, in turn, lets PASE for i applications use these file systems. Security authorization is validated through the user ID number and group ID number of IBM i user profile for the directory path or file being accessed. You might want to ensure that a user

profile that is intended to be the same person across multiple platforms has the same user ID on all of the systems.

The IBM i operating system is best used as an NFS server. In this case, you need to mount NFS file systems from your AIX operating system onto a directory in the IBM i integrated file system, and AIX writes programs directly onto the IBM i operating system when they build.

**Note:** IBM i NFS is currently not supported in multithreaded applications.

#### **Related information**

[File Transfer Protocol](#)

## **Customizing IBM PASE for i programs to use IBM i functions**

If you want your AIX application to take advantage of IBM i functions that are not directly supported by system-supplied PASE for i shared libraries, you need to perform some additional steps to prepare your application.

Complete the following steps to do the preparation:

1. Code your AIX application to call any required PASE for i runtime functions that coordinate your access to the IBM i system-unique functions.
2. If you are compiling your PASE for i programs on an AIX system, perform the following steps before you compile your customized application:
  - a) Copy required IBM i system-unique header files to your AIX system.
  - b) Copy required IBM i system-unique export files to your AIX system.

#### **Related concepts**

[Calling IBM i programs and procedures from your IBM PASE for i programs](#)

PASE for i provides methods for calling ILE procedures, Java programs, OPM programs, IBM i APIs, and CL commands that give you integrated access to IBM i functions.

[How IBM PASE for i programs interact with IBM i](#)

As you customize your PASE for i programs to use IBM i functions, you need to consider the ways in which your program will interact with them.

#### **Related information**

[Runtime functions for use by IBM PASE for i programs](#)

## **Copying header files**

Use this information to copy header files from the system running IBM i to the system running AIX.

PASE for i augments standard AIX run time with header files for IBM i system-unique support. These are provided by PASE for i and the IBM i operating system.

## **Copying the header files from IBM i to AIX in the header file search path**

You can copy the header file into the /usr/include AIX directory, or to any other directory on the header file search path for your compiler.

If you use a directory other than /usr/include, you can add it to the header file search path with the -I option on the AIX compiler command.

## **Copying PASE for i header files**

The PASE for i header files are located in the following IBM i directory: /QOpenSys/QIBM/ProdData/OS400/PASE/include

PASE for i provides the following header files.

| Header file    | Explanation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| as400_protos.h | This header file provides miscellaneous PASE for i system-unique functions to ILE.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| as400_types.h  | <p>This header file declares unique IBM i parameter types for calls to ILE.</p> <p>This header file declares type <code>ILEpointer</code> for 16-byte machine interface (MI) pointers, which relies on type long double to be a 128-bit field.</p> <p>Other types declared in <code>as400_types.h</code> rely on type long long to be a 64-bit integer. AIX compilers must be run with options <code>-qlngdbl128</code>, <code>-qalign=natural</code>, and <code>-qlonglong</code> to ensure proper size and alignment of types declared in <code>as400_types.h</code>.</p> |
| os400msg.h     | This header file declares the functions to send and receive IBM i messages.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

## Copying IBM i header files

If you plan to access other IBM i functions in your PASE for i application, you might find it helpful to copy to your development machine the header files for the IBM i functions that you are using. Note that generally you cannot run an IBM i program or procedure directly from an PASE for i application.

IBM i system-provided header files are located in the `/QIBM/include` directory.

If your application needs any of the IBM i API header files, you must first convert them from EBCDIC to ASCII before you copy the converted files to an AIX directory.

One way to convert an EBCDIC text file to ASCII is to use the PASE for i `Rfile` utility.

The following example uses the PASE for i `Rfile` utility to read IBM i header file `/QIBM/include/qusec.h`, convert the data to the PASE for i coded character set identifier (CCSID), strip trailing blanks from each line, and then write the result into byte stream file `ascii_qusec.h`:

```
Rfile -r /QIBM/include/qusec.h > ascii_qusec.h
```

## Related concepts

### Database

PASE for i supports the Db2 for i call level interfaces (CLIs). DB2 CLIs on AIX and IBM i are not exact subsets of each other, so there are minor differences in a few interfaces. Some APIs in one implementation might not exist in another.

### Calling IBM i programs and procedures from your IBM PASE for i programs

PASE for i provides methods for calling ILE procedures, Java programs, OPM programs, IBM i APIs, and CL commands that give you integrated access to IBM i functions.

## Related tasks

### Calling ILE procedures

You can follow these steps to prepare and call ILE procedures from your PASE for i programs.

## Related reference

### Copying the IBM PASE for i program to your system

You must copy the AIX binary files that you want to run in PASE for i into the integrated file system.

## Copying export files

Use this information to copy the export files from the system running IBM i to an AIX directory.

The export files, located in the following IBM i directory, are the suggested way to build your applications that require access to IBM i system-specific functions:

```
/QOpenSys/QIBM/ProdData/OS400/PASE/lib
```

You can copy these files to any AIX directory. Use the `-bI:` option on the `AIX ld` command (or compiler command) to define symbols not found in the shared libraries on the AIX system.

PASE for i provides the following export files.

| Export file    | Function                                                                                                                                                                                                                             |
|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| as400_libc.exp | This file is the export file for IBM i system-unique functions in libc.a.<br><br>The as400_libc.exp file defines all the exports from the PASE for i version of libc.a that are not exported by the AIX versions of those libraries. |
| libdb400.exp   | This file is the export file for IBM i database functions.<br><br>The libdb400.exp file defines the exports from the PASE for i libdb400.a library (Db2 for i call level interfaces (CLIs) support).                                 |

### Related concepts

#### Database

PASE for i supports the Db2 for i call level interfaces (CLIs). DB2 CLIs on AIX and IBM i are not exact subsets of each other, so there are minor differences in a few interfaces. Some APIs in one implementation might not exist in another.

### Related reference

#### [Copying the IBM PASE for i program to your system](#)

You must copy the AIX binary files that you want to run in PASE for i into the integrated file system.

## IBM PASE for i APIs for accessing IBM i functions

PASE for i provides a number of APIs for accessing ILE code and other IBM i functions. Which ones you use depends on how much preparation and structure building you want to do yourself as opposed to how much you want the compiler to do for you.

### Related information

#### [IBM PASE for i APIs](#)

## Using IBM PASE for i programs in the IBM i environment

Your PASE for i program can call other IBM i programs running in your job, and other IBM i programs can call procedures in your PASE for i program.

## Running IBM PASE for i programs and procedures

You can start an PASE for i program in a job and call PASE for i procedures from your ILE programs.

You can run your PASE for i program in any of several ways:

- Within an IBM i job
- From an PASE for i interactive shell environment
- As a called program from an ILE procedure

**Note:** When you run an PASE for i program on the IBM i operating system, keep in mind that the PASE for i environment variables are independent of ILE environment variables. Setting a variable in one environment has no effect on the other environment.

## ILE procedures that let you work with PASE for i programs

PASE for i provides a number of ILE procedure APIs that allow your ILE code to access PASE for i services (without special programming in your PASE for i program):

- Qp2dlclose
- Qp2dlerror
- Qp2dlopen
- Qp2dlsym
- Qp2errnop

- Qp2free
- Qp2jobCCSID
- Qp2malloc
- Qp2paseCCSID
- Qp2ptrsize

## Calling a procedure in an PASE for i program from ILE code

You can call a procedure in an PASE for i program from ILE code that runs in a thread that was not created by PASE for i (for example, a Java thread or a thread created by ILE pthread\_create()). Qp2CallPase() automatically attaches the ILE thread to PASE for i (creating corresponding PASE for i pthread structures), but only if the PASE for i environment variable PASE\_THREAD\_ATTACH was set to Y when the PASE for i program started.

## Returning results from PASE for i to IBM i programs

Using the IBM i \_RETURN() function, you can call an PASE for i program and return results without ending the PASE for i environment. This allows you to start an PASE for i program and then call procedures in that program (using Qp2CallPase()) after the QP2SHELL2 (but not QP2SHELL) or Qp2RunPase() API returns.

### Related information

[IBM PASE for i ILE Procedure APIs](#)

[\\_RETURN\(\)--Return Without Exiting IBM PASE for i](#)

## Running an IBM PASE for i program with QP2SHELL()

You use QP2SHELL or QP2SHELL2 programs to run an PASE for i program from any IBM i command line and within any high-level language program, batch job, or interactive job.

These programs run an PASE for i program in the job that calls it. The name of the PASE for i program is passed as a parameter on the program.

The QP2SHELL() program runs the PASE for i program in a new activation group. The QP2SHELL2() program runs in the caller's activation group.

**Note:** Neither the QP2SHELL program nor the QP2SHELL2 program does the special setup for standard streams that most shells require for reliable operation (stdin, stdout, and stderr must be forkable file descriptors). Therefore, the QP2SHELL and QP2SHELL2 programs must be used with additional programming to run a shell or shell script. You can run a shell script without additional programming by using either the API program QP2TERM or the QSH CL command.

The following example runs the ls command from the IBM i command line:

```
call qp2shell parm('/QOpenSys/bin/ls' '/')
```

If you pass values into QP2SHELL() using CL variables, the variables must be null-terminated. For example, you need to code the above example in the following way:

```
PGM DCL VAR(&CMD) TYPE(*CHAR) LEN(20) VALUE('/QOpenSys/bin/ls')
DCL VAR(&PARM1) TYPE(*CHAR) LEN(10) VALUE('/')
DCL VAR(&NULL) TYPE(*CHAR) LEN(1) VALUE(X'00')

CHGVAR VAR(&CMD) VALUE(&CMD *TCAT &NULL)
CHGVAR VAR(&PARM1) VALUE(&PARM1 *TCAT &NULL)

CALL PGM(QP2SHELL) PARM(&CMD &PARM1)

ENDIT:
ENDPGM
```

## Related information

[QP2SHELL\(\) and QP2SHELL2\(\)--Run an IBM PASE for i Shell Program](#)

## Running an IBM PASE for i program with QP2TERM()

You use this IBM i program to run an PASE for i program in an interactive shell environment.

Start an PASE for i interactive terminal session with the QP2TERM() program.

The following command writes the default Korn shell prompt (/Q0penSys/usr/bin/sh) to the screen:

```
call qp2term
```

From this prompt, you run an PASE for i program in a separate batch job. QP2TERM() uses the interactive job to display output and to accept input for files stdin, stdout, and stderr in the batch job.

The Korn shell is the default, but you can optionally specify the path name of any PASE for i program that you want to run, as well as any argument strings to pass to the program.

You can run any PASE for i program and any of the utilities from the interactive session that you start with QP2TERM(); stdout and stderr are written and scrolled in the terminal screen.

## Related concepts

IBM PASE for i shells and utilities

PASE for i includes three shells (Korn, Bourne, and C shell) and provides many utilities that run as PASE for i programs. PASE for i shells and utilities provide an extensible scripting environment that includes a large number of industry-standard and defacto-standard commands.

## Related information

[QP2TERM\(\)--Run an IBM PASE for i Terminal Session](#)

## Running an IBM PASE for i program from within IBM i programs

You can call the Qp2CallPase() and Qp2CallPase2() ILE procedures from within other ILE procedures to start and run an PASE for i program.

Use the Qp2RunPase() API to run an PASE for i program.

You specify the program name, argument strings, and environment variables.

The Qp2RunPase() API runs an PASE for i program in the job where it is called. It loads an PASE for i program (including any necessary shared libraries) and then transfers control to the program.

This API gives you more control over how PASE for i runs than QP2SHELL() and QP2TERM().

## Related information

[Qp2RunPase\(\)--Run an IBM PASE for i Program](#)

## Examples: Running an IBM PASE for i program from within IBM i programs

These examples show an ILE program that calls an PASE for i program, and the PASE for i program that is called by the ILE program.

**Note:** By using the code examples, you agree to the terms of the [Code license and disclaimer information](#).

### Example 1: An ILE program that calls an PASE for i program

The following ILE program calls an PASE for i program. Following this example is an example of the PASE for i code that this program calls.

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <stdio.h>
#include <unistd.h>

/* include file for QP2RunPase(). */
```

```

#include <qp2user.h>

/*****
Sample:
A simple ILE C program to invoke an PASE
for i program using QP2RunPase() and
passing one string parameter.
Example compilation:
  CRTCMOD MODULE(MYLIB/SAMPLEILE) SRCFILE(MYLIB/QCSRC)
  CRTPGM PGM(MYLIB/SAMPLEILE)
*****/

void main(int argc, char*argv[])
{
    /* Path name of PASE program */
    char *PasePath = "/home/samplePASE";
    /* Return code from QP2RunPase() */
    int rc;
    /* The parameter to be passed to the
       i5/OS PASE program */
    char *PASE_parm = "My Parm";
    /* Argument list for i5/OS PASE program,
       which is a pointer to a list of pointers */
    char **arg_list;
    /* allocate the argument list */
    arg_list =(char**)malloc(3 * sizeof(*arg_list));
    /* set program name as first element. This is a UNIX convention */
    arg_list[0] = PasePath;
    /* set parameter as first element */
    arg_list[1] = PASE_parm;
    /* last element of argument list must always be null */
    arg_list[2] = 0;
    /* Call i5/OS PASE program. */
    rc = Qp2RunPase(PasePath, /* Path name */
        NULL, /* Symbol for calling to ILE, not used in this sample */
        NULL, /* Symbol data for ILE call, not used here */
        0, /* Symbol data length for ILE call, not used here */
        819, /* ASCII CCSID for i5/OS PASE */
        arg_list, /* Arguments for i5/OS PASE program */
        NULL); /* Environment variable list, not used in this sample */
}

```

## Example 2: The PASE for i program that is called in the ILE program

The following PASE for i program is called by the above ILE program.

```

#include <stdio.h>

/*****
Sample:
A simple PASE for i Program called from
ILE using QP2RunPase() and accepting
one string parameter.
The ILE sample program expects this to be
located at /home/samplePASE. Compile on
AIX, then ftp to IBM i.
To ftp use the commands:
> binary
> site namefmt 1
> put samplePASE /home/samplePASE
*****/

int main(int argc, char *argv[])
{
    /* Print out a greeting and the parameter passed in. Note argv[0] is the program
       name, so, argv[1] is the parameter */
    printf("Hello from PASE for i program %s. Parameter value is \"%s\".\n", argv[0], argv[1]);

    return 0;
}

```

## Calling an IBM PASE for i procedure from within IBM i programs

You can call the `Qp2CallPase()` and `Qp2CallPase2()` ILE procedures from within other ILE procedures to run an PASE for i program in a job where the PASE for i environment is already running.

The `Qp2RunPase()` API initially starts and runs an PASE for i program in a job. It returns an error if PASE for i is already active in that job.

To call PASE for i procedures in a job that is already running an PASE for i program, you use the `Qp2CallPase()` and `Qp2CallPase2()` APIs.

### Related information

[Qp2CallPase\(\)--Call an IBM PASE for i Procedure](#)

### Example 1: Calling an IBM PASE for i procedure from within IBM i programs

This example shows an ILE program calling an PASE for i procedure.

**Note:** By using the code examples, you agree to the terms of the [Code license and disclaimer information](#).

```
#include <stdio.h>
#include <qp2shell2.h>
#include <qp2user.h>
#define JOB_CCSID 0

int main(int argc, char *argv[])
{
    QP2_ptr64_t id;
    void *getpid_pase;
    const QP2_arg_type_t signature[] = { QP2_ARG_END };
    QP2_word_t result;

    /*
     * Call QP2SHELL2 to run the PASE for i program
     * /usr/lib/start32, which starts PASE for i in
     * 32-bit mode (and leaves it active on return)
     */
    QP2SHELL2("/usr/lib/start32");

    /*
     * Qp2dlopen opens the global name space (rather than
     * loading a new shared executable) when the first
     * argument is a null pointer. Qp2dlsym locates the
     * function descriptor for the PASE for i getpid
     * subroutine (exported by shared library libc.a)
     */
    id = Qp2dlopen(NULL, QP2_RTLD_NOW, JOB_CCSID);
    getpid_pase = Qp2dlsym(id, "getpid", JOB_CCSID, NULL);

    /*
     * Call Qp2CallPase to run the PASE for i getpid
     * function, and print the result. Use Qp2errno
     * to find and print the PASE for i errno if the
     * function result was -1
     */
    int rc = Qp2CallPase(getpid_pase,
                        NULL, // no argument list
                        signature,
                        QP2_RESULT_WORD,
                        &result)
    printf("PASE for i getpid() = %i\n", result);
    if (result == -1)
        printf("IBM i errno = %i\n", *Qp2errno());

    /*
     * Close the Qp2dlopen instance, and then call
     * Qp2EndPase to end PASE for i in this job
     */
    Qp2dlclose(id);
    Qp2EndPase();
    return 0;
}
```

## Example 2: An IBM i ILE program that uses pointer arguments in a call to an IBM PASE for i procedure

In this example, an IBM i ILE program uses two different techniques to allocate and share memory storage with the PASE for i procedure that it calls.

**Note:** By using the following code examples, you agree to the terms of the [Code license and disclaimer information](#).

```
/* Name: ileMain.c
 *
 * Call an PASE for i procedure from ILE
 *
 * This example uses the Qp2dlopen, Qp2dlsym, and Qp2CallPase2 ILE
 * functions to call an PASE for i function passing in parameters
 *
 * Compile like so:
 *
 * CRTBNDC PGM(mylib/ilemain)
 * SRCFILE(mylib/mysrcpf)
 * TERASPACE(*YES *TSIFC)
 */
#include <stdio.h>
#include <stddef.h>
#include <errno.h>
#include <qp2user.h>
/* Use EBCDIC default job CCSID in Qp2dlopen and Qp2dlsym calls */
#define JOB_CCSID 0

/* start PASE for i in this process */
void startPASE(void) {
    /* start64 starts the 64 bit version of PASE for i */
    char *start64Path="/usr/lib/start64";
    char *arg_list[2];

    arg_list[0] = start64Path;
    arg_list[1] = NULL;
    Qp2RunPase(start64Path,
               NULL,
               NULL,
               0,
               819,
               (char**)&arg_list,
               NULL);
}

/* open a shared library */
QP2_ptr64_t openlib(char * libname) {
    QP2_ptr64_t id;
    int * paseErrno;

    /* Qp2dlopen dynamically loads the specified library returning an
     * id value that can be used in calls to Qp2dlsym and Qp2dlclose */
    id = Qp2dlopen(libname,
                   (QP2_RTLD_NOW |
                    QP2_RTLD_MEMBER ),
                   JOB_CCSID);

    if (id == 0) {
        printf("Qp2dlopen failed. ILE errno=%i\n", errno);
        if ((paseErrno=Qp2errnop()) != NULL)
            printf("Qp2dlopen failed. PASE for i errno=%i\n", *paseErrno);
        printf("Qp2dlopen failed. Qp2dlerror = %s\n", Qp2dlerror());
    }

    return(id);
}

/* find an exported symbol */
void * findsym(const QP2_ptr64_t id, const char * functionname) {
    void * symbol;
    int * paseErrno;

    /* Qp2dlsym locates the function descriptor for the
     * specified function */
    symbol = Qp2dlsym(id, functionname, JOB_CCSID, NULL);
    if (symbol == NULL) {
```

```

        printf("Qp2dlsym failed. ILE errno = %i\n", errno);
        if ((paseErrno=Qp2errnop()) != NULL)
            printf("Qp2dlsym failed. PASE for i errno=%i\n", *paseErrno);
        printf("Qp2dlsym failed. Qp2dlerror = %s\n", Qp2dlerror());
    }
    return(symbol);
}

/* call PASE for i procedure */
int callPASE(const void * functionsymbol,
            const void * arglist,
            const QP2_arg_type_t * signature,
            const QP2_result_type_t result_type,
            void * buf,
            const short buflen) {
    int * paseErrno;
    int rc;

    /* Call Qp2CallPase2 to run the unction function */
    rc = Qp2CallPase2(functionsymbol,
                    arglist,
                    signature,
                    result_type,
                    buf,
                    buflen);

    if (rc != 0) {
        printf("Qp2CallPase failed. rc=%i, ILE errno=%i\n", rc, errno);
        if ((paseErrno=Qp2errnop()) != NULL)
            printf("Qp2CallPase failed. PASE for i errno=%i\n", *paseErrno);
        printf("Qp2CallPase failed. Qp2dlerror=%s\n", Qp2dlerror());
    }
}

int main(int argc, char *argv[])
{
    /* we will call a function in PASE for i named "paseFunction"
     * the prototype for the function looks like this:
     * int paseFunction(void * input, void * output ) */

    /* "signature" is the argument signature for the PASE routine "paseFunction" */
    const QP2_arg_type_t signature[] = {QP2_ARG_PTR64, QP2_ARG_PTR64, QP2_ARG_END};

    /* "paseFunctionArglist" are the arguments for the PASE routine "paseFunction" */
    struct {
        QP2_ptr64_t inputPasePtr;
        QP2_ptr64_t outputPasePtr;
    } paseFunctionArglist;

    /* "inputString" will be one of the arguments to the PASE routine
     * "paseFunction" we will call
     * This is the string "input" in ASCII */
    const char inputString[] = {0x69, 0x6e, 0x70, 0x75, 0x74, 0x00};

    /* "outputILEPtr" will be a pointer to storage malloc'd from PASE heap */
    char * outputILEPtr;

    /* "id" is the identifier for the library opened by Qp2dlopen */
    QP2_ptr64_t id;

    /* "paseFunction_ptr" is the pointer to the routine "paseFunction" in PASE */
    void * paseFunction_ptr;

    /* "inputAndResultBuffer" is the buffer of storage shared between ILE and PASE
     * by Qp2CallPase2. This buffer contains space for the PASE function result */
    struct {
        QP2_dword_t result;
        char inputValue[6];
    } inputAndResultBuffer;

    int rc;
    int * paseErrno;

    /* start PASE for i in this process */
    startPASE();

    id = openlib("/home/joeuser/libpasefn.a(shr64.o)");

    if (id !=0) {
        /* Locate the symbol for "paseFunction" */
        paseFunction_ptr = findsym(id, "paseFunction");
    }
}

```

```

    if (paseFunction_ptr != NULL) {

        /* set input arguments for the call to paseFunction() */

        /* copy the inputString into the inputAndResultBuffer */
        strcpy(inputAndResultBuffer.inputValue, inputString);

        /* by setting inputPasePtr argument to the offset of the
        * inputValue by-address argument data in the
        * inputAndResultbuffer structure and OR'ing that with
        * QP2_ARG_PTR_TOSTACK QP2CallPase2 will "fixup" the
        * actual argument pointer passed to the PASE function
        * to point to the address (plus the offset) of the
        * copy of the inputAndResultbuffer that Qp2CallPase2
        * copies to PASE for i storage */
        paseFunctionArglist.inputPasePtr =
        (QP2_ptr64_t)((offsetof(inputAndResultBuffer, inputValue))
        | QP2_ARG_PTR_TOSTACK);

        /* allocate memory from the PASE for i heap for an output
        * argument. Qp2malloc will also set the PASE for i address
        * of the allocated storage in the outputPasePtr
        * argument */
        outputILEPtr = Qp2malloc(10, &(paseFunctionArglist.outputPasePtr));

        /* Call the function in PASE for i */
        rc = callPASE(paseFunction_ptr,
                    &paseFunctionArglist,
                    signature,
                    QP2_RESULT_DWORD,
                    &inputAndResultBuffer,
                    sizeof(inputAndResultBuffer));

        if (rc != 0) {

            printf("output from paseFunction = >%s<\n",
                (char*)outputILEPtr);
            printf("return code from paseFunction = %d\n",
                (int)inputAndResultBuffer.result);
        } /* rc != 0 */
    } /* paseFunction_ptr != NULL */
} /* id != 0 */

/* Close the Qp2dlopen instance, and then call Qp2EndPase
 * to end PASE for i in this job */
Qp2dlclose(id);
Qp2EndPase();
return 0;
}

```

Source code for the IBM i Procedure paseFunction that is called by the ileMain.c program:

```

/* PASE for i function to be called from ILE
 *
 * Compile with something like:
 * xlc -q64 -c -o paseFunction.o paseFunction.c
 * ld -b64 -o shr64.o -bnoentry -bexpall -bM:SRE -lc paseFunction.o
 * ar -X64 -r /home/joeuser/libpasefn.a shr64.o
 *
 * The ILE side of this example expects to find libpasefn.a in
 * /home/joeuser/libpasefn.a
 *
 * The compiler options -qalign=natural and -qldbl128 are
 * necessary only when interacting with IBM i ILE programs
 * to force relative 16-byte alignment of type long double
 * (used inside type ILEpointer)
 */

#include <stdlib.h>
#include <stdio.h>
int paseFunction(void * inputPtr, void * outputPtr)
{
    /* An output string to return from PASE for i to ILE *
    * this is the string "output" in EBCDIC */
    const char outputValue[] = {0x96, 0xa4, 0xa3, 0x97, 0xa4, 0xa3, 0x00};

    printf("Entered paseFunction The input is >%s<\n",
        (char*)inputPtr);

    /* copy the output results to the outputPtr argument */
    memcpy(outputPtr, outputValue, sizeof(outputValue));
}

```

```

    return(52); /* return something more interesting than 0 */
}

```

## Various functions used in the ILE portion of example 2

### • The startPASE() function

Before PASE for i can be used in a process, it must be started. This is done automatically by calling the main entry point of an PASE for i application using the APIs; for example, QP2SHELL, QP2TERM, or Qp2RunPase.

However, because this example is calling an PASE for i function exported from a shared library (not a main entry point), you must manually start PASE for i. Two PASE for i starter utilities are available for this purpose: `/usr/lib/start32` (to start the 32-bit version of PASE for i) and `/usr/lib/start64` (to start the 64-bit version of PASE for i).

Be aware that each IBM i process can only have a single instance of PASE for i running. The `Qp2ptrsize()` API can be used to determine whether PASE for i is already running.

- `Qp2ptrsize()` will return 0 if PASE for i is not currently active in the process.
- `Qp2ptrsize()` will return 4 if PASE for i is active in 32-bit mode.
- `Qp2ptrsize()` will return 8 if PASE for i is active in 64-bit mode.

### • The `openlib()` and `findsym()` functions

These functions open the IBM i shared library and obtain a pointer to the function you want to call using the `Qp2dlopen()` and `Qp2dlsym()`. These functions are similar to the `dlopen()` and `dlsym()` routines on many platforms.

### • Set up arguments for the `Qp2CallPase2` call

Before calling `Qp2CallPase2()` through the `callPASE()` function, the `main()` routine sets up the following variables that define the interface between ILE and the PASE for i function:

- The signature-array variable defines the arguments for the PASE for i function. The elements in the array are typically set using the `#define` found in the `qsysinc/h.qp2user` include file.
- The `paseFunctionArglist` structure contains the ILE variables that the PASE for i run time will map into the arguments that will be passed to the PASE for i function when the function is called. The members in `paseFunctionArglist` correspond to the signature of the PASE for i function declared in the signature array.
- The `inputAndResultBuffer` structure contains the ILE variables that the PASE for i run time will use as a sort of shared buffer between ILE and the PASE for i function when the function is called.

The first member of the structure (*result* in this example) will contain the return value from the PASE for i function. This variable must match the result-type argument provided as the fourth argument in the call to the `Qp2CallPase2()` API. Anything after this first element represents storage that will be copied into the PASE for i environment when the function is called.

In this example, the `inputValue` element of the `inputAndResultBuffer` structure will contain the by-address argument data that will be pointed at by the first argument for the PASE for i function.

- This example uses two different ways of setting pointer arguments for the PASE for i function that is being called.
  - The second argument to the function, `paseFunctionArglist.outputPasePtr`, is set by calling the `Qp2malloc()` function. `Qp2malloc()` allocates memory from the PASE for i runtime heap and returns both an ILE pointer and an PASE for i pointer to the allocated storage.
  - The first argument, `paseFunctionArglist.inputPasePtr`, is set to the offset of the `inputValue` element of the `inputAndResultBuffer` structure that is connected with the `qp2user.h` `#define` `QP2_ARG_PTR_TOSTACK` by OR.

This tells the PASE for i run time to modify the actual pointer value provided on the call to the PASE for i function with the address where the inputAndResultBuffer.inputValue was copied into PASE for i memory.

- **The callPASE() function**

This function calls the PASE for i function using the Qp2CallPase2() API and the arguments set in the main() routine.

- **End PASE for i in the process**

After the call to the PASE for i function, the Qp2d1close() API is called to unload the PASE for i shared library and Qp2EndPase() is called to end the start64 program called at the beginning of the example.

## Using IBM PASE for i native methods from Java

You can use PASE for i native methods running in the PASE for i environment from your Java programs.

Support for PASE for i native methods includes full use of the native IBM i Java Native Interface (JNI) from PASE for i native methods and the ability to call PASE for i native methods from the native IBM i Java virtual machine (JVM).

### Related information

[IBM IBM PASE for i native methods for Java](#)

## Working with environment variables

PASE for i environment variables are independent of ILE environment variables. Setting a variable in one environment has no effect on the other environment.

However, you can copy variables from ILE into PASE for i, depending on the method you use to run your PASE for i program.

### Environment variables in an interactive PASE for i session

ILE environment variables are passed to PASE for i only when it is started with QP2SHELL() and QP2TERM(). Use the Work with Environment Variables (WRKENVVAR) command to change, add, or delete environment variables as needed before starting PASE for i.

### Environment variables in a called PASE for i session

When PASE for i is started from a program call (with the Qp2RunPase() API), you have complete control over the environment variables. You can pass environment variables that bear no relationship to the ILE environment from which you called the PASE for i program.

## Copying environment variables to ILE before running a CL command

You can copy PASE for i environment variables to the ILE environment before you run a CL command using an option on the systemCL() runtime function. This is also the default behavior of the PASE for i system utility.

### Related information

[QP2SHELL\(\) and QP2SHELL2\(\)--Run an IBM PASE for i Shell Program](#)

[QP2TERM\(\)--Run an IBM PASE for i Terminal Session](#)

[systemCL\(\)--Run a CL Command for IBM PASE for i](#)

[IBM PASE for i environment variables](#)

## Calling IBM i programs and procedures from your IBM PASE for i programs

PASE for i provides methods for calling ILE procedures, Java programs, OPM programs, IBM i APIs, and CL commands that give you integrated access to IBM i functions.

### General configuration requirements for IBM i programs and procedures

When you make calls from the PASE for i program environment to the IBM i environment, you should generally ensure that the program that is being called is compiled with \*CALLER for the activation group, for the following reasons:

- Only code that runs in the activation group that started PASE for i (called by the Qp2RunPase API) can use ILE APIs, such as Qp2CallPase, to interact with the PASE for i program.
- The ILE run time might end the entire job (also ending PASE for i) if it needs to destroy an activation group in a multithreaded job (and all jobs created by PASE for i fork are multithread-capable). By using ACTGRP(\*CALLER), you can prevent your job from ending before you want it to end.

You can avoid problems with running in a multithread-capable job by using the `systemCL()` runtime function to run a CL command (including the CALL command) in a separate job that is not multithread-capable.

### Related tasks

[Customizing IBM PASE for i programs to use IBM i functions](#)

If you want your AIX application to take advantage of IBM i functions that are not directly supported by system-supplied PASE for i shared libraries, you need to perform some additional steps to prepare your application.

## Calling ILE procedures

You can follow these steps to prepare and call ILE procedures from your PASE for i programs.

When you call ILE procedures from your PASE for i programs, you should first prepare the procedure by enabling it for teraspace, converting text to the appropriate CCSID, and setting up variables and structures.

### 1. Enable ILE procedures for teraspace

All ILE modules that you call from PASE for i must be compiled with the teraspace option set to \*YES. If your ILE modules are not compiled in this way, you will receive the MCH4443 error message (Invalid storage model for target program &2) in the job log for your PASE for i application.

### 2. Convert text to appropriate CCSID

Text being passed between ILE and PASE for i might need to be converted to the appropriate CCSIDs before being passed. Not doing such conversions causes your character variables to contain undecipherable values.

### 3. Set up variables and structures

To make calls to ILE from your PASE for i programs, you need to set up variables and structures. You must ensure that the required header files are copied to your AIX system, and you must set up a signature, a result type, and an argument list variable:

- **Header files:** Your PASE for i program should include the header files `as400_types.h` and `as400_protos.h` to make calls to ILE. The `as400_type.h` header file contains the definition of the types used for i5/OS system-unique interfaces.
- **Signature:** The signature structure contains a description of the sequence and types of arguments passed between PASE for i and ILE. The encoding for the types mandated by the ILE procedure that you are calling can be found in the `as400_types.h` header file. If a signature contains fixed-point

arguments shorter than 4 bytes or floating point arguments shorter than 8 bytes, your ILE C code needs to be compiled with the following pragma:

```
#pragma argument(ileProcedureName, nowiden)
```

Without this pragma, standard C linking for ILE requires 1- and 2-byte integer arguments to be widened to 4 bytes and requires 4-byte floating-point arguments to be widened to 8 bytes.

- **Result type:** The result type is straightforward and works much like a return type in C.
- **Argument list:** The argument list must be a structure with the correct sequence of fields with types specified by entries in the signature array. You can use the `size_ILEarglist()` and `build_ILEarglist()` APIs to dynamically build the argument list based on the signature.

To call ILE procedures from your PASE for i programs, make the following API calls in your code:

1. Load the bound program into the ILE activation group that is associated with the procedure that started PASE for i. You use the `_ILELOADX()` API to do this.

This step can be unnecessary if the bound program is already active in the activation group that started PASE for i. In this case, you can proceed to the `_ILESVMX()` step, using a value of zero for the activation mark parameter to search all symbols in all active bound programs in the current activation group.

2. Find the exported symbol in the activation of the ILE bound program and return a 16-byte tagged pointer to the data or procedure for the symbol. You use the `_ILESVMX()` API to do this.
3. Call the ILE procedure to transfer control from your PASE for i program to the ILE procedure. You use the `_ILECALL()` or `_ILECALLX()` API to do this.

### Related reference

#### [Copying header files](#)

Use this information to copy header files from the system running IBM i to the system running AIX.

### Related information

[size\\_ILEarglist\(\)](#)--Compute ILE Argument List Size for IBM PASE for i()

[build\\_ILEarglist\(\)](#)--Build an ILE Argument List for IBM PASE for i

[\\_ILELOADX\(\)](#)--Load an ILE Bound Program for IBM PASE for i

[\\_ILESVMX\(\)](#)--Find an Exported ILE Symbol for IBM PASE for i

[\\_ILECALLX\(\)](#)--Call an ILE Procedure for IBM PASE for i

[ILE Concepts PDF](#)

### Examples: Calling ILE procedures

These code examples show the PASE for i code making a call to an ILE procedure that is part of a service program, and show the compiler commands that create the programs.

There are two procedures within the following code examples. Each procedure demonstrates different ways of working with an ILE procedure, but both procedures call the same ILE procedure. The first procedure demonstrates building your data structures for the `_ILECALL()` API using PASE for i system-provided methods. The second procedure then builds the argument list manually.

**Note:** By using the code examples, you agree to the terms of the [Code license and disclaimer information](#).

### Example 1: PASE for i C code

Interspersed in the following example code are comments that explain the code. Make sure to read these comments as you enter or review the example.

```
/* Name: PASEtoILE.c
 *
 * You must use compiler options -qalign=natural and -qldbl128
 * to force relative 16-byte alignment of type long double
 * (used inside type ILEpointer)
 *
 */
#include <stdlib.h>
```

```

#include <malloc.h>
#include <sys/types.h>
#include <stdio.h>
#include "as400_types.h"
#include "as400_protos.h"

/*
 * init_pid saves the process id (PID) of the process that
 * extracted the ILEpointer addressed by ILEtarget.
 * init_pid is initialized to a value that is not a
 * valid PID to force initialization on the first
 * reference after the exec() of this program
 *
 * If your code uses pthread interfaces, you can
 * alternatively provide a handler registered using
 * pthread_atfork() to re-initialize ILE procedure
 * pointers in the child process and use a pointer or
 * flag in static storage to force reinitialization
 * after exec()
 */

pid_t init_pid = -1;
ILEpointer*ILEtarget; /* pointer to ILE procedure */

/*
 * ROUND_QUAD finds a 16-byte aligned memory
 * location at or beyond a specified address
 */

#define ROUND_QUAD(x) (((size_t)(x) + 0xf) & ~0xf)

/*
 * do_init loads an ILE service program and extracts an
 * ILEpointer to a procedure that is exported by that
 * service program.
 */

void do_init()
{
    static char ILEtarget_buf[sizeof(ILEpointer) + 15];
    unsigned long long actmark;
    int rc;

    /* _ILELOADX() loads the service program */
    actmark = _ILELOADX("SHUPE/ILEPASE", ILELOAD_LIBOBJ);
    if (actmark == -1)
        abort();

    /*
     * xlc does not guarantee 16-byte alignment for
     * static variables of any type, so we find an
     * aligned area in an oversized buffer. _ILESVMX()
     * extracts an ILE procedure pointer from the
     * service program activation
     */

    ILEtarget = (ILEpointer*)ROUND_QUAD(ILEtarget_buf);
    rc = _ILESVMX(ILEtarget, actmark, "ileProcedure");
    if (rc == -1)
        abort();

    /*
     * Save the current PID in static storage so we
     * can determine when to re-initialize (after fork)
     */
    init_pid = getpid();
}

/*
 * "aggregate" is an example of a structure or union
 * data type that is passed as a by-value argument.
 */
typedef struct {
    char filler[5];
} aggregate;

/*
 * "result_type" and "signature" define the function
 * result type and the sequence and type of all
 * arguments needed for the ILE procedure identified
 * by ILEtarget
 */

```

```

* NOTE: The fact that this argument list contains
* fixed-point arguments shorter than 4 bytes or
* floating-point arguments shorter than 8 bytes
* implies that the target ILE C procedure is compiled
* with #pragma argument(ileProcedureName, nowiden)
*
* Without this pragma, standard C linkage for ILE
* requires 1-byte and 2-byte integer arguments to be
* widened to 4-bytes and requires 4-byte floating-point
* arguments to be widened to 8-bytes
*/
static result_type_t result_type = RESULT_INT32;
static arg_type_t signature[] =
{
    ARG_INT32,
    ARG_MEMPTR,
    ARG_FLOAT64,
    ARG_UINT8, /* requires #pragma nowiden in ILE code */
    sizeof(aggregate),
    ARG_INT16,
    ARG_END
};

/*
* simple_wrapper accepts the same arguments and returns
* the same result as the ILE procedure it calls. This
* example does not require a customized or declared structure
* for the ILE argument list. This wrapper uses malloc
* to obtain storage. If an exception or signal occurs,
* the storage may not be freed. If your program needs
* to prevent such a storage leak, a signal handler
* must be built to handle it, or you can use the methods
* in best_wrapper.
*/
int simple_wrapper(int arg1, void *arg2, double arg3,
                  char arg4, aggregate arg5, short arg6)
{
    int result;
    /*
    * xlc does not guarantee 16-byte alignment for
    * automatic (stack) variables of any type, but
    * malloc() always returns 16-byte aligned storage.
    * size_ILEarglist() determines how much storage is
    * needed, based on entries in the signature array
    */
    ILEarglist_base *ILEarglist;
    ILEarglist = (ILEarglist_base*)malloc( size_ILEarglist(signature) );

    /*
    * build_ILEarglist() copies argument values into the ILE
    * argument list buffer, based on entries in the signature
    * array.
    */
    build_ILEarglist(ILEarglist, &arg1, signature);

    /*
    * Use a saved PID value to check if the ILEpointer
    * is set. ILE procedure pointers inherited by the
    * child process of a fork() are not usable because
    * they point to an ILE activation group in the parent
    * process
    */
    if (getpid() != init_pid)
        do_init();

    /*
    * _ILECALL calls the ILE procedure. If an exception or signal
    * occurs, the heap allocation is orphaned (storage leak)
    */
    _ILECALL(ILEtarget, ILEarglist, signature, result_type);
    result = ILEarglist->result.s_int32.r_int32;
    if (result == 1) {
        printf("The results of the simple wrapper is: %s\n", (char *)arg2);
    }
    else if (result == 0)
        printf("ILE received other than 1 or 2 for version.\n");
    else
        printf("The db file never opened.\n");
    free(ILEarglist);
    return result;
}

```

```

/*
 * ILEarglistSt defines the structure of the ILE argument list.
 * xlc provides 16-byte (relative) alignment of ILEpointer
 * member fields because ILEpointer contains a 128-bit long
 * double member. Explicit pad fields are only needed in
 * front of structure and union types that do not naturally
 * fall on ILE-mandated boundaries
 */
typedef struct {
    ILEarglist_base base;
    int32 arg1;
    /* implicit 12-byte pad provided by compiler */
    ILEpointer arg2;
    float64 arg3;
    uint8 arg4;
    char filler[7]; /* pad to 8-byte alignment */
    aggregate arg5; /* 5-byte aggregate (8-byte align) */
    /* implicit 1-byte pad provided by compiler */
    int16 arg6;
} ILEarglistSt;

/*
 * best_wrapper accepts the same arguments and returns
 * the same result as the ILE procedure it calls. This
 * method uses a customized or declared structure for the
 * ILE argument list to improve execution efficiency and
 * avoid heap storage leaks if an exception or signal occurs
 */
int best_wrapper(int arg1, void *arg2, double arg3,
                 char arg4, aggregate arg5, short arg6)
{
    /*
     * xlc does not guarantee 16-byte alignment for
     * automatic (stack) variables of any type, so we
     * find an aligned area in an oversized buffer
     */
    char ILEarglist_buf[sizeof(ILEarglistSt) + 15];
    ILEarglistSt *ILEarglist = (ILEarglistSt*)ROUND_QUAD(ILEarglist_buf);
    /*
     * Assignment statements are faster than calling
     * build_ILEarglist()
     */
    ILEarglist->arg1 = arg1;
    ILEarglist->arg2.s.addr = (address64_t)arg2;
    ILEarglist->arg3 = arg3;
    ILEarglist->arg4 = arg4;
    ILEarglist->arg5 = arg5;
    ILEarglist->arg6 = arg6;
    /*
     * Use a saved PID value to check if the ILEpointer
     * is set. ILE procedure pointers inherited by the
     * child process of a fork() are not usable because
     * they point to an ILE activation group in the parent
     * process
     */
    if (getpid() != init_pid)
        do_init();
    /*
     * _ILECALL calls the ILE procedure. The stack may
     * be unwound, but no heap storage is orphaned if
     * an exception or signal occurs
     */
    _ILECALL(ILEtarget, &ILEarglist->base, signature, result_type);
    if (ILEarglist->base.result.s_int32.r_int32 == 1)
        printf("The results of best_wrapper function is: %s\n", arg2);
    else if (ILEarglist->base.result.s_int32.r_int32 == 0)
        printf("ILE received other than 1 or 2 for version.\n");
    else
        printf("The db file never opened.\n");
    return ILEarglist->base.result.s_int32.r_int32;
}

void main () {
    int version, result2;
    char dbText[ 25 ];
    double dblNumber = 5.999;
    char justChar = 'a';
    short shrtNumber = 3;
    aggregate agg;
    strcpy( dbText, "none" );

    for (version =1; version <= 2; version++)

```

```

    {
        if (version == 1) {
            result2= simple_wrapper(version, dbText, dblNumber, justChar, agg, shrtNumber);
        } else {
            result2= best_wrapper(version, dbText, dblNumber, justChar, agg, shrtNumber);
        }
    }
}

```

## Example 2: ILE C code

You now write the ILE C code for this example on your IBM i system. You need a source physical file in your library in which to write the code. Again, in the ILE example, comments are interspersed. These comments are critical to understanding the code. You should review them as you enter or review the source.

```

#include <stdio.h>
#include <math.h>
#include <recio.h>
#include <iconv.h>
#include <string.h>
#include <stdlib.h>
#include <errno.h>

typedef struct {
    char        filler[5];
} aggregate;

#pragma mapinc("datafile","SHUPE/PASEDATA(*all)","both",,,")
#include "datafile"
#pragma argument(ileProcedure, nowiden) /* not necessary */

/*
 * The arguments and function result for this ILE procedure
 * must be equivalent to the values presented to _ILECALL
 * function in the i5/OS program
 */
int ileProcedure(int      arg1,
                  char     *arg2,
                  double   arg3,
                  char     arg4[2],
                  aggregate arg5,
                  short     arg6)
{
    char        fromcode[33];
    char        tocode[33];
    iconv_t     cd;      /* conversion descriptor */
    char        *src;
    char        *tgt;
    size_t      srcLen;
    size_t      tgtLen;
    int         result;

    /*
     * Open a conversion descriptor to convert CCSID 37
     * (EBCDIC) to CCSID 819 (ASCII), that is used for
     * any character data returned to the caller
     */
    memset(fromcode, 0, sizeof(fromcode));
    strcpy(fromcode, "IBMCCSID0003700000000");
    memset(tocode, 0, sizeof(tocode));
    strcpy(tocode, "IBMCCSID00819");
    cd = iconv_open(tocode, fromcode);
    if (cd.return_value == -1)
    {
        printf("iconv_open failed\n");
        return -1;
    }

    /*
     * If arg1 equals one, return constant text (converted
     * to ASCII) in the buffer addressed by arg2. For any
     * other arg1 value, open a file and read some text,
     * then return that text (converted to ASCII) in the
     * buffer addressed by arg2
     */
    if (arg1 == 1)
    {
        src = "Sample 1 output text";
    }
}

```

```

        srclen = strlen(src) + 1;
        tgt = arg2; /* iconv output to arg2 buffer */
        tgtlen = srclen;
        iconv(cd, &src, &srclen, &tgt, &tgtlen);

        result = 1;
    }
    else
    {
        FILE *fp;
        fp = fopen("SHUPE/PASEDATA", "r");
        if (!fp) /* if file open error */
        {
            printf("fopen(\"SHUPE/PASEDATA\", \"r\") failed, "
                   "errno = %i\n", errno);
            result = 2;
        }
        else
        {
            char buf[25];
            char *string;
            errno = 0;
            string = fgets(buf, sizeof(buf), fp);
            if (!string)
            {
                printf("fgets() EOF or error, errno = %i\n", errno);
                buf[0] = 0; /* null-terminate empty buffer */
            }
            src = buf;
            srclen = strlen(buf) + 1;
            tgt = arg2; /* iconv output to arg2 buffer */
            tgtlen = srclen;
            iconv(cd, &src, &srclen, &tgt, &tgtlen);

            fclose(fp);
        }
        result = 1;
    }
}
/*
 * Close the conversion descriptor, and return the
 * result value determined above
 */
iconv_close(cd);
return result;
}

```

### Example 3: Compiler commands to create the programs

When you compile your PASE for i program, you must use compiler options `-qalign=natural` and `-qldbl128` to force relative 16-byte alignment of type long double, which is used inside type `ILEpointer`. This alignment is required by ILE in IBM i. For option `-bI:`, you should enter the path name in which you saved `as400_libc.exp`:

```

xlc -o PASEtoILE -qldbl128 -qalign=natural
    -bI:/afs/rich.xyz.com/usr1/shupe/PASE/as400_libc.exp
    PASEtoILE.c

```

When you compile your ILE C module and service program, compile them with the `teraspace` option. Otherwise, PASE for i cannot interact with them:

```

CRTCMOD MODULE(MYLIB/MYMODULE)
        SRCFILE(MYLIB/SRCCPF)
        TERASPACE(*YES *TSIFC)

CRTSRVPGM SRVPGM(MYLIB/MYSRVPGM)
        MODULE(MYLIB/MOMODULE)

```

Finally, you must compile your DDS and propagate at least one record of data:

```

CRTPF FILE(MYLIB/MYDATAFILE)
        SRCFILE(MYLIB/SRCDDSF)
        SRCMBR(MYMEMBERNAME)

```

## Calling IBM i programs from IBM PASE for i

You can take advantage of existing IBM i programs (\*PGM objects) when you create your PASE for i applications. In addition, you can use the `systemCL()` function to run the CL CALL command.

Use the `_PGMCALL()` runtime function to call an IBM i program from within your PASE for i program.

This method provides for faster processing than the `systemCL()` runtime function, but it does not perform automatic conversion of character string arguments (unless you specify `PGMCALL_ASCII_STRINGS`), and it does not give you the capability of calling the program in a different job.

### Related tasks

[Running IBM i commands from IBM PASE for i](#)

You can extend the capabilities of your PASE for i program by running control language (CL) commands that use IBM i functions.

### Related information

[\\_PGMCALL\(\)--Call an IBM i Program for IBM PASE for i](#)

### **Example: Calling IBM i programs from IBM PASE for i**

This example shows how you call programs in an PASE for i program using the `_PGMCALL` runtime function.

Interspersed in the following example code are comments that explain the code. Make sure to read these comments as you enter or review the example.

**Note:** By using the code examples, you agree to the terms of the [Code license and disclaimer information](#).

```
/* This example uses the IBM i PASE _PGMCALL function to call the IBM i
API QSZRTVPR. The QSZRTVPR API is used to retrieve information about
i5/OS software product loads. Refer to the QSZRTVPR API documentation
for specific information regarding the input and output parameters needed
to call the API */

#include <stdlib.h>
#include <stdio.h>
#include <string.h>
#include "as400_types.h"
#include "as400_protos.h"

int main(int argc, char * argv[])
{
    /* IBM i API's (including QSZRTVPR) typically expect character
    parameters to be in EBCDIC. However, character constants in
    PASE for i programs are typically in ASCII. So, declare some
    CCSID 37 (EBCDIC) character parameter constants that will be
    needed to call QSZRTVPR */

    /* format[] is input parameter 3 to QSZRTVPR and is
    initialized to the text 'PRDR0100' in EBCDIC */
    const char format[] =
        {0xd7, 0xd9, 0xc4, 0xd9, 0xf0, 0xf1, 0xf0, 0xf0};

    /* prodinfo[] is input parameter 4 to QSZRTVPR and is
    initialized to the text '*OPSYS *CUR 0033*CODE ' in EBCDIC

    This value indicates we want to check the code load for Option 33
    of the currently installed i5/OS release */
    const char prodinfo[] =
        {0x5c, 0xd6, 0xd7, 0xe2, 0xe8, 0xe2, 0x40, 0x5c, 0xc3,
        0xe4, 0xd9, 0x40, 0xf0, 0xf0, 0xf3, 0xf3, 0x5c,
        0xc3, 0xd6, 0xc4, 0xc5, 0x40, 0x40, 0x40, 0x40, 0x40};

    /* installed will be compared with the "Load State" field of the
    information returned by QSZRTVPR and is initialized to the text
    '90' in EBCDIC */
    const char installed[] = {0xf9, 0xf0};

    /* rcvr is the output parameter 1 from QSZRTVPR */
    char rcvr[108];

    /* rcvrln is input parameter 2 to QSZRTVPR */
```

```

int rcvrlen = sizeof(rcvr);

/* errcode is input parameter 5 to QSZRTVPR */
struct {
    int bytes_provided;
    int bytes_available;
    char msgid[7];
} errcode;

/* qszrtvpr_pointer will contain the IBM i 16-byte tagged
   system pointer to QSZRTVPR */
ILEpointer qszrtvpr_pointer;

/* qszrtvpr_argv6 is the array of argument pointers to QSZRTVPR */
void *qszrtvpr_argv[6];

/* return code from _RSL0BJ2 and _PGMCALL functions */
int rc;

/* Set the IBM i pointer to the QSYS/QSZRTVPR *PGM object */
rc = _RSL0BJ2(&qszrtvpr_pointer,
             RSL0BJ_TS_PGM,
             "QSZRTVPR",
             "QSYS");

/* initialize the QSZRTVPR returned info structure */
memset(rcvr, 0, sizeof(rcvr));

/* initialize the QSZRTVPR error code structure */
memset(&errcode, 0, sizeof(errcode));
errcode.bytes_provided = sizeof(errcode);

/* initialize the array of argument pointers for the QSZRTVPR API */
qszrtvpr_argv[0] = &rcvr;
qszrtvpr_argv[1] = &rcvrlen;
qszrtvpr_argv[2] = &format;
qszrtvpr_argv[3] = &prodinfo;
qszrtvpr_argv[4] = &errcode;
qszrtvpr_argv[5] = NULL;

/* Call the IBM i QSZRTVPR API from PASE for i */
rc = _PGMCALL(&qszrtvpr_pointer,
             (void*)&qszrtvpr_argv,
             0);

/* Check the contents of bytes 63-64 of the returned information.
   If they are not '90' (in EBCDIC), the code load is NOT correctly
   installed */
if (memcmp(&rcvr[63], &installed, 2) != 0)
    printf("IBM i Option 33 is NOT installed\n");
else
    printf("IBM i Option 33 IS installed\n");

return(0);
}

```

## Running IBM i commands from IBM PASE for i

You can extend the capabilities of your PASE for i program by running control language (CL) commands that use IBM i functions.

Use the `systemCL` runtime function to run an IBM i command from within an PASE for i program.

When you run IBM i commands from PASE for i the `systemCL` runtime function handles ASCII-to-EBCDIC conversion of character string arguments, and lets you call the program in a different job.

### Related tasks

[Calling IBM i programs from IBM PASE for i](#)

You can take advantage of existing IBM i programs (\*PGM objects) when you create your PASE for i applications. In addition, you can use the `systemCL()` function to run the CL CALL command.

### Related information

[systemCL\(\)--Run a CL Command for IBM PASE for i](#)

### **Example: Running IBM i commands from IBM PASE for i**

This example shows how to run CL commands in an PASE for i program.

**Note:** By using the code examples, you agree to the terms of the [Code license and disclaimer information](#).

The following example shows how you call commands in an PASE for i program:

```
/* sampleCL.c
example to demonstrate use of sampleCL to run a CL command
Compile with a command similar to the following.
xlc -o sampleCL -I /whatever/pase -bI:/whatever/pase/as400_libc.exp sampleCL.c
Example program using QP2SHELL() follows.
call qp2shell ('sampleCL' 'wrkactjob') */

#include <stdio.h>
#include <stdlib.h>
#include <errno.h>
#include <as400_types.h> /* PASE header */
#include <as400_protos.h> /* PASE header */

void main(int argc, char* argv[])
{
    int rc;

    if (argc!=2)
    {
        printf("usage: %s \"CL command\"\n", argv[0]);
        exit(1);
    }
    printf("running CL command: \"%s\"\n", argv[1]);

    /* process the CL command */
    rc = systemCL(argv[1], /* use first parameter for CL command */
                  SYSTEMCL_MSG_STDOUT
                  SYSTEMCL_MSG_STDERR ); /* collect messages */

    printf("systemCL returned %d. \n", rc);
    if (rc != 0)
    {
        perror("systemCL");
        exit(rc);
    }
}
```

## **How IBM PASE for i programs interact with IBM i**

As you customize your PASE for i programs to use IBM i functions, you need to consider the ways in which your program will interact with them.

### **Related tasks**

[Customizing IBM PASE for i programs to use IBM i functions](#)

If you want your AIX application to take advantage of IBM i functions that are not directly supported by system-supplied PASE for i shared libraries, you need to perform some additional steps to prepare your application.

## **Communications**

PASE for i is generally compatible with AIX and Linux in sockets communications.

PASE for i supports the same syntax as AIX for sockets communications. This cannot match other operating systems, such as Linux, in every detail.

PASE for i sockets support is comparable to the AIX implementation of sockets, but PASE for i uses the IBM i implementation of sockets (instead of the AIX kernel implementation of sockets), and this forces some minor differences from AIX behavior.

The IBM i implementation of sockets supports both UNIX 98 and Berkeley Software Distributions (BSD) sockets. In most cases, PASE for i resolves differences in these styles by adopting the behavior of the AIX implementation.

In addition, the user profile for a running application must have the \*IOSYSCFG special authority to specify the level parameter as IPPROTO\_IP and the option\_value parameter as IP\_OPTIONS on socket APIs.

### Related information

[Socket programming](#)

[Berkeley Software Distributions compatibility](#)

[UNIX 98 compatibility](#)

## Database

PASE for i supports the Db2 for i call level interfaces (CLIs). DB2 CLIs on AIX and IBM i are not exact subsets of each other, so there are minor differences in a few interfaces. Some APIs in one implementation might not exist in another.

Because of this, you should consider the following points:

- Code can be generated, but not tested, on AIX itself. Instead, you must test your code across platforms within PASE for i.
- You must compile with the IBM i version of header file `sqlcli.h`. A program compiled using the AIX version of this header file will not run in PASE for i.

IBM i is an EBCDIC-encoded system by default, while AIX is based on ASCII. This difference often requires data conversions between the IBM i database (Db2 for i) and the PASE for i application.

In the PASE for i implementation of DB2 CLIs, PASE for i system-provided library routines automatically perform data conversions from ASCII to Extended Binary Coded Decimal Interchange Code (EBCDIC) and back for character data. The conversions are made based on the tagged CCSID of the data being accessed and the ASCII CCSID under which the PASE for i program is running. If the database is tagged, or if it is tagged with a CCSID of 65535, no automatic conversion takes place. It is left to the application to understand the encoding format of the data and to do any necessary conversion.

## Working with CCSIDs

When you use the `Qp2RunPase()` API, you must explicitly specify the PASE for i CCSID.

You can control the PASE for i CCSID by setting both of these variables in the ILE before you call API program `QP2TERM`, `QP2SHELL`, or `QP2SHELL2`:

- `PASE_LANG`
- `QIBM_PASE_CCSID`

If the ILE omits either or both of these variables, `QP2TERM`, `QP2SHELL`, and `QP2SHELL2` by default set the PASE for i CCSID and PASE for i environment variable `LANG` with the best PASE for i equivalents of the language and CCSID attributes of your job.

Extensions to `libc.a` give the PASE for i application the ability to change the running CCSID of the application, using the `_SETCCSID()` function.

Another extension gives the PASE for i application the ability to override the DB2 CLI internal conversion without changing the CCSID of the application. The `SQLOverrideCCSID400()` function accepts an integer of the override CCSID as a single parameter.

**Note:** The CCSID override function `SQLOverrideCCSID400()` must be called before any other `SQLx()` API for the override to take effect; otherwise, the request is ignored.

## Using Db2 for i CLIs in PASE for i programs

To use DB2 CLIs in your PASE for i programs, you need to copy the `sqlcli.h` header file and the `libdb400.exp` export file to your AIX system before you compile your source. The DB2 CLI library routines are in `libdb400.a` for the PASE for i environment, and are implemented using `pthread` interfaces,

providing thread safety. Most PASE for i CLI functions call corresponding ILE CLI functions to perform the required operation.

**Note:** When you use DB2 CLIs in your PASE for i programs, consider the following points:

- SQLGetSubString always returns an EBCDIC string when sub-stringing the CLOB/DBCLOB field. The SQLGetSubString is used only for LOB data types.
- SQLTables, column 4 of the result set (table type), is always returned as EBCDIC.
- To render graphic-typed data in an PASE for i program, the data must be typed in the program as `wchar`; this causes the database to convert from a graphic and pure double-byte character to Unicode/UCS-2. Otherwise, the database converts between the CCSID of the data and the CCSID of the IBM i job. The database does not support conversion between EBCDIC graphic and the CCSID (either from the `Qp2RunPase()` API or the `SQLOverrideCCSID400()` API).

### Related reference

#### Copying header files

Use this information to copy header files from the system running IBM i to the system running AIX.

#### Copying export files

Use this information to copy the export files from the system running IBM i to an AIX directory.

### Related information

QP2TERM()--Run an IBM PASE for i Terminal Session

QP2SHELL() and QP2SHELL2()--Run an IBM PASE for i Shell Program

\_SETCCSID()--Set IBM PASE for i CCSID

SQLOverrideCCSID400()--Override SQL CLI CCSID for IBM PASE for i

SQL call level interface

### ***Example: Calling Db2 for i CLI functions in an PASE for i program***

This example shows an PASE for i program that accesses Db2 for i using the Db2 for i SQL call level interfaces.

**Note:** By using the code examples, you agree to the terms of the [Code license and disclaimer information](#).

```
/* i5/OS PASE DB2 for i5/OS example program
 *
 * To show an example of an PASE for i program that accesses
 * DB2 for i via SQL CLI
 *
 * Program accesses System i Access database, QIWS/QCUSTCDT, that
 * should exist on all systems
 *
 * Change system name, userid, and password in fun_Connect()
 * procedure to valid parms
 *
 * Compilation invocation:
 *
 * xlc -I./include -bI:./include/libdb400.exp -o paseclib4 paseclib4.c
 *
 * FTP in binary, run from QP2TERM() terminal shell
 *
 * Output should show all rows with a STATE column match of MN */
/* Change Activity: */
/* End Change Activity */

#define SQL_MAX_UID_LENGTH 10
#define SQL_MAX_PWD_LENGTH 10
#define SQL_MAX_STM_LENGTH 255

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include "sqlcli.h"

SQLRETURN fun_Connect( void );
SQLRETURN fun_DisConnect( void );
SQLRETURN fun_ReleaseEnvHandle( void );
SQLRETURN fun_ReleaseDbcHandle( void );
SQLRETURN fun_ReleaseStmHandle( void );
SQLRETURN fun_Process( void );
```

```

SQLRETURN fun_Process2( void );
void fun_PrintError( SQLHSTMT );

SQLRETURN nml_ReturnCode;
SQLHENV nml_HandleToEnvironment;
SQLHDBC nml_HandleToDatabaseConnection;
SQLHSTMT nml_HandleToSqlStatement;
SQLINTEGER Nmi_vParam;
SQLINTEGER Nmi_RecordNumberToFetch = 0;
SQLCHAR chs_SqlStatement01[ SQL_MAX_STM_LENGTH + 1 ];
SQLINTEGER nmi_PcbValue;
SQLINTEGER nmi_vParam;
char *pStateName = "MN";

void main( ) {
    static
        char*pszId = "main()";
        SQLRETURN nml_ConnectionStatus;
        SQLRETURN nml_ProcessStatus;

        nml_ConnectionStatus = fun_Connect();
        if ( nml_ConnectionStatus == SQL_SUCCESS ) {
            printf( "%s: fun_Connect() succeeded\n", pszId );
        } else {
            printf( "%s: fun_Connect() failed\n", pszId );
            exit( -1 );
        } /* endif */

        printf( "%s: Perform query\n", pszId );
        nml_ProcessStatus = fun_Process();
        printf( "%s: Query complete\n", pszId );
        nml_ConnectionStatus = fun_DisConnect();
        if ( nml_ConnectionStatus == SQL_SUCCESS ) {
            printf( "%s: fun_DisConnect() succeeded\n", pszId );
        } else {
            printf( "%s: fun_DisConnect() failed\n", pszId );
            exit( -1 );
        } /* endif */

        printf( "%s: normal exit\n", pszId );
    } /* end main */

SQLRETURN fun_Connect()
{
    static char *pszId = "fun_Connect()";
    SQLCHAR chs_As400System[ SQL_MAX_DSN_LENGTH ];
    SQLCHAR chs_UserName[ SQL_MAX_UID_LENGTH ];
    SQLCHAR chs_UserPassword[ SQL_MAX_PWD_LENGTH ];
    nml_ReturnCode = SQLAllocEnv( &nml_HandleToEnvironment );
    if ( nml_ReturnCode != SQL_SUCCESS ) {
        printf( "%s: SQLAllocEnv() succeeded\n", pszId );
        fun_PrintError( SQL_NULL_HSTMT );
        printf( "%s: Terminating\n", pszId );
        return SQL_ERROR;
    } else {
        printf( "%s: SQLAllocEnv() succeeded\n", pszId );
    } /* endif */

    strcpy( chs_As400System, "AS4PASE" );
    strcpy( chs_UserName, "QUSER" );
    strcpy( chs_UserPassword, "QUSER" );
    printf( "%s: Connecting to %s userid %s\n", pszId, chs_As400System, chs_UserName );

    nml_ReturnCode = SQLAllocConnect( nml_HandleToEnvironment,
                                     &nml_HandleToDatabaseConnection );

    if ( nml_ReturnCode != SQL_SUCCESS ) {
        printf( "%s: SQLAllocConnect\n", pszId );
        fun_PrintError( SQL_NULL_HSTMT );
        nml_ReturnCode = fun_ReleaseEnvHandle();
        printf( "%s: Terminating\n", pszId );
        return SQL_ERROR;
    } else {
        printf( "%s: SQLAllocConnect() succeeded\n", pszId );
    } /* endif */

    nml_ReturnCode = SQLConnect( nml_HandleToDatabaseConnection,
                                chs_As400System,
                                SQL_NTS,
                                chs_UserName,
                                SQL_NTS,
                                chs_UserPassword,

```

```

                                SQL_NTS );
if ( nml_ReturnCode != SQL_SUCCESS ) {
    printf( "%s: SQLConnect(%s) failed\n", pszId, chs_As400System );
    fun_PrintError( SQL_NULL_HSTMT );
    nml_ReturnCode = fun_ReleaseDbcHandle();
    nml_ReturnCode = fun_ReleaseEnvHandle();
    printf( "%s: Terminating\n", pszId );
    return SQL_ERROR;
} else {
    printf( "%s: SQLConnect(%s) succeeded\n", pszId, chs_As400System );
    return SQL_SUCCESS;
} /* endif */
} /* end fun_Connect */

SQLRETURN fun_Process()
{
    static
        char*pszId = "fun_Process()";
        charcLastName[ 80 ];

    nml_ReturnCode = SQLAllocStmt( nml_HandleToDatabaseConnection,
                                   &nml_HandleToSqlStatement );
    if ( nml_ReturnCode != SQL_SUCCESS ) {
        printf( "%s: SQLAllocStmt() failed\n", pszId );
        fun_PrintError( SQL_NULL_HSTMT );
        printf( "%s: Terminating\n", pszId );
        return SQL_ERROR;
    } else {
        printf( "%s: SQLAllocStmt() succeeded\n", pszId );
    } /* endif */

    strcpy( chs_SqlStatement01, "select LSTNAM, STATE " );
    strcat( chs_SqlStatement01, "from QIWS.QCUSTCDT " );
    strcat( chs_SqlStatement01, "where " );
    strcat( chs_SqlStatement01, "STATE = ? " );

    nml_ReturnCode = SQLPrepare( nml_HandleToSqlStatement,
                                 chs_SqlStatement01,
                                 SQL_NTS );
    if ( nml_ReturnCode != SQL_SUCCESS ) {
        printf( "%s: SQLPrepare() failed\n", pszId );
        fun_PrintError( nml_HandleToSqlStatement );
        nml_ReturnCode = fun_ReleaseStmHandle();
        printf( "%s: Terminating\n", pszId );
        return SQL_ERROR;
    } else {
        printf( "%s: SQLPrepare() succeeded\n", pszId );
    } /* endif */

    Nmi_vParam = SQL_TRUE;
    nml_ReturnCode = SQLSetStmtOption( nml_HandleToSqlStatement,
                                       SQL_ATTR_CURSOR_SCROLLABLE,
                                       ( SQLINTEGER * ) &Nmi_vParam );
    if ( nml_ReturnCode != SQL_SUCCESS ) {
        printf( "%s: SQLSetStmtOption() failed\n", pszId );
        fun_PrintError( nml_HandleToSqlStatement );
        nml_ReturnCode = fun_ReleaseStmHandle();
        printf( "%s: Terminating\n", pszId );
        return SQL_ERROR;
    } else {
        printf( "%s: SQLSetStmtOption() succeeded\n", pszId );
    } /* endif */

    Nmi_vParam = SQL_TRUE;
    nml_ReturnCode = SQLSetStmtOption( nml_HandleToSqlStatement,
                                       SQL_ATTR_FOR_FETCH_ONLY,
                                       ( SQLINTEGER * ) &Nmi_vParam );
    if ( nml_ReturnCode != SQL_SUCCESS ) {
        printf( "%s: SQLSetStmtOption() failed\n", pszId );
        fun_PrintError( nml_HandleToSqlStatement );
        nml_ReturnCode = fun_ReleaseStmHandle();
        printf( "%s: Terminating\n", pszId );
        return SQL_ERROR;
    } else {
        printf( "%s: SQLSetStmtOption() succeeded\n", pszId );
    } /* endif */

    nmi_PcbValue = 0;
    nml_ReturnCode = SQLBindParam( nml_HandleToSqlStatement,
                                   1,
                                   SQL_CHAR,
                                   SQL_CHAR,

```

```

                2,
                0,
                ( SQLPOINTER ) pStateName,
                ( SQLINTEGER *) &nmi_PcbValue );

if ( nml_ReturnCode != SQL_SUCCESS ) {
    printf( "%s: SQLBindParam() failed\n", pszId );
    fun_PrintError( nml_HandleToSqlStatement );
    nml_ReturnCode = fun_ReleaseStmHandle();
    printf( "%s: Terminating\n", pszId );
    return SQL_ERROR;
} else {
    printf( "%s: SQLBindParam() succeeded\n", pszId );
} /* endif */

nml_ReturnCode = SQLExecute( nml_HandleToSqlStatement );
if ( nml_ReturnCode != SQL_SUCCESS ) {
    printf( "%s: SQLExecute() failed\n", pszId );
    fun_PrintError( nml_HandleToSqlStatement );
    nml_ReturnCode = fun_ReleaseStmHandle();
    printf( "%s: Terminating\n", pszId );
    return SQL_ERROR;
} else {
    printf( "%s: SQLExecute() succeeded\n", pszId );
} /* endif */

nml_ReturnCode = SQLBindCol( nml_HandleToSqlStatement,
                             1,
                             SQL_CHAR,
                             ( SQLPOINTER ) &cLastName,
                             ( SQLINTEGER ) ( 8 ),
                             ( SQLINTEGER * ) &nmi_PcbValue );

if ( nml_ReturnCode != SQL_SUCCESS ) {
    printf( "%s: SQLBindCol() failed\n", pszId );
    fun_PrintError( nml_HandleToSqlStatement );
    nml_ReturnCode = fun_ReleaseStmHandle();
    printf( "%s: Terminating\n", pszId );
    return SQL_ERROR;
} else {
    printf( "%s: SQLBindCol() succeeded\n", pszId );
} /* endif */

do {
    memset( cLastName, '\0', sizeof( cLastName ) );
    nml_ReturnCode = SQLFetchScroll( nml_HandleToSqlStatement,
                                    SQL_FETCH_NEXT,
                                    Nmi_RecordNumberToFetch );
    if ( nml_ReturnCode == SQL_SUCCESS ) {
        printf( "%s: SQLFetchScroll() succeeded, LastName(%s)\n", pszId, cLastName);
    } else {
    } /*endif */
} while ( nml_ReturnCode == SQL_SUCCESS );
if ( nml_ReturnCode != SQL_NO_DATA_FOUND ) {
    printf( "%s: SQLFetchScroll() failed\n", pszId );
    fun_PrintError( nml_HandleToSqlStatement );
    nml_ReturnCode = fun_ReleaseStmHandle();
    printf( "%s: Terminating\n", pszId );
    return SQL_ERROR;
} else {
    printf( "%s: SQLFetchScroll() completed all rows\n", pszId );
} /* endif */

nml_ReturnCode = SQLCloseCursor( nml_HandleToSqlStatement );
if ( nml_ReturnCode != SQL_SUCCESS ) {
    printf( "%s: SQLCloseCursor() failed\n", pszId );
    fun_PrintError( nml_HandleToSqlStatement );
    nml_ReturnCode = fun_ReleaseStmHandle();
    printf( "%s: Terminating\n", pszId );
    return SQL_ERROR;
} else {
    printf( "%s: SQLCloseCursor() succeeded\n", pszId );
} /* endif */

return SQL_SUCCESS;
} /* end fun_Process */

SQLRETURN fun_DisConnect()
{
    static
        char*pszId = "fun_DisConnect()";

    nml_ReturnCode = SQLDisconnect( nml_HandleToDatabaseConnection );
    if ( nml_ReturnCode != SQL_SUCCESS ) {

```

```

        printf( "%s: SQLDisconnect() failed\n", pszId );
        fun_PrintError( SQL_NULL_HSTMT );
        printf( "%s: Terminating\n", pszId );
        return 1;
    } else {
        printf( "%s: SQLDisconnect() succeeded\n", pszId );
    } /* endif */

    nml_ReturnCode = fun_ReleaseDbcHandle();
    nml_ReturnCode = fun_ReleaseEnvHandle();

    return nml_ReturnCode;
} /* end fun_DisConnect */

SQLRETURN fun_ReleaseEnvHandle()
{
    static
        char*pszId = "fun_ReleaseEnvHandle()";

    nml_ReturnCode = SQLFreeEnv( nml_HandleToEnvironment );
    if ( nml_ReturnCode != SQL_SUCCESS ) {
        printf( "%s: SQLFreeEnv() failed\n", pszId );
        fun_PrintError( SQL_NULL_HSTMT );
        return SQL_ERROR;
    } else {
        printf( "%s: SQLFreeEnv() succeeded\n", pszId );
        return SQL_SUCCESS;
    } /* endif */
} /* end fun_ReleaseEnvHandle */

SQLRETURN fun_ReleaseDbcHandle()
{
    static
        char*pszId = "fun_ReleaseDbcHandle()";

    nml_ReturnCode = SQLFreeConnect( nml_HandleToDatabaseConnection );
    if ( nml_ReturnCode != SQL_SUCCESS ) {
        printf( "%s: SQLFreeConnect() failed\n", pszId );
        fun_PrintError( SQL_NULL_HSTMT );
        return SQL_ERROR;
    } else {
        printf( "%s: SQLFreeConnect() succeeded\n", pszId );
        return SQL_SUCCESS;
    } /* endif */
} /* end fun_ReleaseDbcHandle */

SQLRETURN fun_ReleaseStmHandle()
{
    static
        char*pszId = "fun_ReleaseStmHandle()";

    nml_ReturnCode = SQLFreeStmt( nml_HandleToSqlStatement, SQL_CLOSE );
    if ( nml_ReturnCode != SQL_SUCCESS ) {
        printf( "%s: SQLFreeStmt() failed\n", pszId );
        fun_PrintError( nml_HandleToSqlStatement );
        return SQL_ERROR;
    } else {
        printf( "%s: SQLFreeStmt() succeeded\n", pszId );
        return SQL_SUCCESS;
    } /* endif */
} /* end fun_ReleaseStmHandle */

void fun_PrintError( SQLHSTMT nml_HandleToSqlStatement )
{
    static
        char*pszId = "fun_PrintError()";

    SQLCHAR chs_SqlState[ SQL_SQLSTATE_SIZE ];
    SQLINTEGER nmi_NativeErrorCode;
    SQLCHAR chs_ErrorMessageText[ SQL_MAX_MESSAGE_LENGTH + 1 ];
    SQLSMALLINT nmi_NumberOfBytes;

    nml_ReturnCode = SQLError( nml_HandleToEnvironment,
                               nml_HandleToDatabaseConnection,
                               nml_HandleToSqlStatement,
                               chs_SqlState,
                               &nmi_NativeErrorCode,
                               chs_ErrorMessageText,
                               sizeof( chs_ErrorMessageText ),
                               &nmi_NumberOfBytes );

    if ( nml_ReturnCode != SQL_SUCCESS ) {

```

```

        printf( "%s: SQLError() failed\n", pszId );
        return;
    } /* endif */

    printf( "%s: SqlState - %s\n", pszId, chs_SqlState );
    printf( "%s: SqlCode - %d\n", pszId, nmi_NativeErrorCode );
    printf( "%s: Error Message:\n", pszId );
    printf( "%s: %s\n", pszId, chs_ErrorMessageText );
} /* end fun_PrintError */

```

## Data encoding

Most operating systems, such as AIX and Linux, use ASCII character encoding. Most IBM i functions use EBCDIC character encoding.

You can specify a coded character set identifier (CCSID) value for some IBM i object types to identify a specific encoding for character data in the object.

PASE for i byte stream files have a CCSID attribute that is used by most system interfaces outside PASE for i to convert text data read from or written to the file as needed. IBM i does not do CCSID conversion for data read from or written to stream files (consistent with AIX), but it does set the CCSID attribute of any byte stream file created by an PASE for i program to the current PASE for i CCSID value so other system functions can correctly handle ASCII text in the file.

If you use AIX APIs that are shipped in the PASE for i shared libraries, PASE for i handles most of the data conversion for you. PASE for i programs can use `iconv` functions provided in shared library `libiconv.a` for any character data conversions that are not handled automatically by PASE for i run time. For example, an PASE for i application generally needs to convert character strings to EBCDIC before calling an IBM i API function (using either `_ILECALLX` or `_PGMCALL`).

### Related concepts

#### File systems

PASE for i programs can access any file or resource that is accessible through the integrated file system, including objects in the QSYS.LIB and QOPT file systems.

## File systems

PASE for i programs can access any file or resource that is accessible through the integrated file system, including objects in the QSYS.LIB and QOPT file systems.

## Buffered input and output

Input and output to and from external devices is buffered on the IBM i operating system. It is handled by input and output processors that deal with blocks of data. Conversely, operating systems, such as AIX and Linux, typically operate with character-by-character (unbuffered) input and output. On the IBM i operating system, only certain input and output signals (for example, the Enter key, function keys, and system request) send an interrupt to the system.

## Data conversion support

PASE for i programs pass ASCII (or UTF-8) path names to the `open()` function to open byte stream files. The names are automatically converted to the encoding scheme used by the IBM i operating system, but any data read or written from the open file is not converted.

## Use of file descriptors

The PASE for i run time normally uses ILE C run time support for files `stdin`, `stdout`, and `stderr`, which provide consistent behavior for PASE for i and ILE programs.

PASE for i and ILE C use the same streams for standard input and output (`stdin`, `stdout`, and `stderr`). PASE for i programs always access standard input and output using file descriptors 0, 1, and 2. ILE C, however, does not always use integrated file descriptors for `stdin`, `stdout`, and `stderr`, so PASE for i provides a mapping between PASE for i file descriptors and descriptors in the integrated file system. Because of this

mapping, PASE for i programs and ILE C programs can use different descriptor numbers to access the same open file.

You can use the PASE for i extension on the `fcntl()` function, `F_MAP_XPFFD`, to assign an PASE for i descriptor to an ILE number. This is useful if your PASE for i application needs to do file operations for an ILE descriptor that was not created by PASE for i.

An IBM i system-unique extension to the `fstatx()` function, `STX_XPFFD_PASE`, allows an PASE for i program to determine the integrated file system descriptor number for an PASE for i file descriptor. Special values (negative numbers) are returned for any PASE for i descriptor attached to ILE C runtime support for files `stdin`, `stdout`, and `stderr`.

If the ILE environment variable `QIBM_USE_DESCRIPTOR_STDIO` is set to Y or I when the `Qp2RunPase()` API is called, PASE for i synchronizes file descriptors 0, 1, and 2 with the integrated file system so that both PASE for i and ILE C programs use the same descriptor numbers for files `stdin`, `stdout`, and `stderr`. When operating in this mode, if either PASE for i code or ILE C code closes or reopens file descriptor 0, 1, or 2, the change affects `stdin`, `stdout`, and `stderr` processing for both environments.

PASE for i run time generally does no character encoding conversion for data read or written through PASE for i file descriptors (including sockets), except that ASCII-to-EBCDIC conversion is done (between the PASE for i CCSID and job default CCSID) for data read from ILE C `stdin` or written to ILE C `stdout` and `stderr`.

Two environment variables control the automatic translation of `stdin`, `stdout`, and `stderr`:

- The variable that generally applies is `QIBM_USE_DESCRIPTOR_STDIO`. When set to Y, the ILE runtime uses file descriptor 0, 1, or 2 for these files.
- The PASE for i system-specific environment variable is `QIBM_PASE_DESCRIPTOR_STDIO`. It has values of B for binary and T for text.

ASCII-to-EBCDIC conversion for PASE for i `stdin`, `stdout`, and `stderr` is disabled if the ILE environment variable `QIBM_USE_DESCRIPTOR_STDIO` is set to Y and `QIBM_PASE_DESCRIPTOR_STDIO` is set to B (allowing binary data to be read from `stdin` and written to `stdout` or `stderr`). The default for `QIBM_PASE_DESCRIPTOR_STDIO` is T for text. This value causes translation of EBCDIC to ASCII.

### **Related concepts**

#### Data encoding

Most operating systems, such as AIX and Linux, use ASCII character encoding. Most IBM i functions use EBCDIC character encoding.

### **Related information**

#### Integrated file system

## **Globalization**

Because the PASE for i run time is based on the AIX run time, PASE for i programs can use the same rich set of programming interfaces for locales, character string manipulation, date and time services, message catalogs, and character encoding conversions supported on AIX.

PASE for i supports the interfaces in AIX run time for managing the locale that an application uses and for performing locale-sensitive functions (such as `ctype()` and `strcoll()`), including support for both single-byte and multibyte character encoding.

PASE for i includes a subset of AIX locales, which provide support for a large number of countries and languages using industry-standard encoding (code sets ISO8859-x), code set IBM-1250, and code set UTF-8. PASE for i provides support for the Euro in three different ways: IBM-1252 locales and ISO 8859-15 locales (both of which use single-byte encodings), and UTF-8 locales.

**Note:** Locale support for PASE for i is independent of either form of locale support used by ILE C programs (object types `*CLD` and `*LOCALE`). In addition to internal structural differences, none of the existing shipped locales for ILE C programs supports ASCII.

## Creating new locales

PASE for i does not ship a utility to create new locales. However, you can create locales for use in PASE for i on an AIX system with the `localedef` utility.

## Changing locales

When an PASE for i application changes locales, generally it also should change the PASE for i CCSID (using the `_SETCCSID()` runtime function) to match the encoding for the new locale. This ensures that any character data interface arguments are correctly interpreted by PASE for i run time (and possibly converted when calling an EBCDIC system service). You can use the `cstoccsid()` runtime function to determine what CCSID corresponds to a code set name.

The PASE for i run time sets the CCSID tag on any file created by an PASE for i program to the current PASE for i CCSID value (supplied either when the program is started or using the most recent `_SETCCSID()` value).

You should use UTF-8 locales for PASE for i applications that support Japanese, Korean, Traditional Chinese, and Simplified Chinese. The IBM i operating system includes other locales for these languages, but the system does not support setting the PASE for i CCSID to match the encoding for IBM-eucXX code sets. Using UTF-8 support might require converting file data that might be stored in other encoding schemes (such as Shift-JIS) when the application runs on other platforms.

## Where PASE for i conversion objects and locales are stored

Conversion objects and locales for PASE for i are packaged with IBM i language feature codes. When you install PASE for i, only those locales that are associated with installed IBM i language features are created.

All PASE for i locales use ASCII or UTF-8 character encoding; therefore, all PASE for i run time works in ASCII (or UTF-8).

### Related tasks

[Installing IBM PASE for i](#)

PASE for i is an optionally installable component of the operating system. You need to install PASE for i to use it or to run some software that requires PASE for i support.

### Related information

[IBM i globalization](#)

[IBM PASE for i locales](#)

[\\_SETCCSID\(\)--Set IBM PASE for i CCSID](#)

## Message services

PASE for i signals and ILE signals are independent, so it is not possible to directly call a handler for one signal type by raising the other type of signal.

You can use the PASE for i `Qp2SignalPase()` API to post corresponding PASE for i signals for any ILE signal that you receive. The `QP2SHELL()` program and the PASE for i `fork()` function always set up handlers to map every ILE signal to a corresponding PASE for i signal.

The system automatically converts any IBM i exception message sent to the program message queue of a call running the `Qp2RunPase()`, `Qp2CallPase()`, or `Qp2CallPase2()` API to a corresponding PASE for i signal. An PASE for i application can therefore handle any IBM i exception by handling the PASE for i signal that the system converts it to.

PASE for i provides the following runtime functions that give you direct control over IBM i message handling:

- `QMHSNDM`
- `QMHSNDM1`
- `QMHSNDPM`

- QMHSNDPM1
- QMHSNDPM2
- QMHRCVM
- QMHRCVM1
- QMHRCVPM
- QMHRCVPM1
- QMHRCVPM2

## IBM i message support

IBM i provides message support in a variety of contexts:

### Job logs

Your job log contains any messages issued by the IBM i operating system or your application while the job is running or being compiled. To look at a job log, type DSPJOBLOG on a command line. When the Display Job Log display screen appears, press F10 (Include detailed messages from the Command Entry display), followed by Shift + F6. The Display All Messages display appears and shows the most recent messages. To view the details of any particular message, move the cursor to the message and press F1 (Help).

### Work with active jobs (WRKACTJOB) command

The Work with Active Jobs (WRKACTJOB) command is useful for examining jobs and job stacks on the IBM i operating system.

### Related information

[Qp2SignalPase\(\)--Post an IBM PASE for i Signal](#)

[Runtime functions for use by IBM PASE for i programs](#)

[Work with active jobs \(WRKACTJOB\) command](#)

[Work management](#)

[IBM PASE for i signal handling](#)

## Printing output from IBM PASE for i applications

You can use the QShell **Rfile** utility to read and write output from PASE for i shells.

The following example writes the contents of stream file mydoc.ps to spooled printer device file QPRINT as unconverted ASCII data, and then uses the CL **LPR** command to send the spooled file to another system:

```
before='ovrprtft qprint devtype(*userascii) spool(*yes)'\
after="lpr file(qprint) system(usrchprt01) prtq('rchdps') transform(*no)"
cat -c mydoc.ps | Rfile -wbQ -c "$before" -C "$after" qprint
```

### Related information

[Rfile - Read or write record files](#)

## Pseudo-terminal (PTY)

PASE for i supports both AT&T and Berkeley Software Distributions (BSD) style devices. From a programming perspective, these devices work in PASE for i in the same way that they work on AIX.

PASE for i allows a maximum of 1024 instances for AT&T style devices, and a maximum of 592 BSD style devices. When the system is started, the first 32 instances of each device type are created automatically.

## Configuring PTY devices in PASE for i

On AIX, an administrator uses **smit** to configure the number of available devices of each type. In PASE for i, these devices are configured in the following way:

- For AT&T-style devices, PASE for i supports autoconfiguration. If the first 32 instances are in use and an application tries to open another instance, the CHRSTF device is created in the integrated file system automatically, up to the limit of 1024 devices.
- For BSD-style devices, you must create the CHRSTF devices manually, using the PASE for i mknod utility. To do this, you need to know the major numbers for the BSD subordinate and BSD primary devices as well as the naming convention. The following example shell script shows how to create additional BSD pseudo-terminal (PTY) devices. It creates them in groups of 16.

**Note:** By using the code examples, you agree to the terms of the [Code license and disclaimer information](#).

```
#!/QOpenSys/usr/bin/ksh

prefix="pqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ"
bsd_tty_major=32949
bsd_pty_major=32948

if [ $# -lt 1 ]
then
    echo "usage: $(basename $0) ptyN "
    exit 10
fi

function mkdev {
    if [ ! -e $1 ]
    then
        mknod $1 c $2 $3
        chown QSYS $1
        chmod 0666 $1
    fi
}

while [ "$1" ]
do
    N=${1##pty}
    if [ "$N" = "$1" -o "$N" = "" -o $N -lt 0 -o $N -gt 36 ]
    then
        echo "skipping: \"$1\": not valid, must be in the form ptyN where: 0 <= N <= 36"
        shift
        continue
    fi

    minor=$((N * 16))
    pre=$(expr "$prefix" : ".\{$N\}(.\\)")

    echo "creating /dev/[pt]ty${pre}0 - /dev/[pt]ty${pre}f"
    for i in 0 1 2 3 4 5 6 7 8 9 a b c d e f
    do
        echo ".\c"
        mkdev /dev/pty${pre}${i} $bsd_pty_major $minor
        echo ".\c"
        mkdev /dev/tty${pre}${i} $bsd_tty_major $minor
        minor=$((minor + 1))
    done
    echo ""

    shift
done
```

For more information about PTY devices, see the [AIX Resources Web page](#).

## Security

From a security point of view, PASE for i programs are subject to the same security restrictions as any other program on the IBM i operating system.

To run an PASE for i program on the IBM i operating system, you must have authority to the AIX binary files in the integrated file system. You must also have the proper level of authority to each of the resources that your program accesses, or the program will receive an error when you attempt to access those resources.

The following information is particularly important when you run PASE for i programs.

## User profiles and authority management

System authorization management is based on user profiles that are also objects. All objects created on the system are owned by a specific user. Each operation or access to an object is verified by the system to ensure the user's authority. The owner or appropriately authorized user profiles can delegate various types of authorities to operate on an object to other user profiles. Authority checking is provided uniformly to all types of objects.

The object authorization mechanism provides various levels of control. A user's authority can be limited to exactly what is needed. Files stored in the QOpenSys file system are authorized in the same manner as UNIX files. The following table shows the relationship between UNIX permissions and the security values used on IBM i database files. On the IBM i operating system, \*OBJOPR is use object authority; \*EXCLUDE is no authority. \*READ, \*ADD, \*UPD, \*DLT, and \*EXECUTE are data authorities. You need \*EXECUTE authority (and sometimes \*READ authority) to a file to run it as an PASE for i program.

| UNIX permission | *OBJOPR | *READ | *ADD | *UPD | *DLT | *EXECUTE |
|-----------------|---------|-------|------|------|------|----------|
| r(read)         | X       | X     |      |      |      |          |
| w(write)        | X       |       | X    | X    | X    |          |
| x(execute)      | X       |       |      |      |      | X        |
| No authority    |         |       |      |      |      |          |

### User profiles in PASE for i

On the IBM i operating system, authentication information is stored in individual profiles rather than in files such as `/etc/passwd`. Users and groups have profiles. All of these profiles share one name space, and each profile must have a unique monospace name. If you pass a lowercase name to the `getpwnam()` or `getgrnam()` API, the system converts the name strings to the expected case.

If you call `getpwuid()` or `getgrgid()` to get the profile name returned, it will be in lowercase, unless you set the PASE for i environment variable `PASE_USRGRP_LOWERCASE=N`, which returns the result in uppercase.

Every user has a user identification (UID). Every group has a group identification (GID). These are defined according to the Portable Operation System Interface X (POSIX) 1003.1 standard. The two numeric spaces are separate, so you can have a user with a UID of 104 and a group with a GID of 104 that are distinct from each other.

The IBM i operating system has a user profile for the security officer, QSECOFR, that has a UID of 0. No other profile can have the UID of 0. QSECOFR is the most privileged profile on the system and, in that sense, acts as the root user. However, the IBM i operating system also provides a set of specific privileges that can be assigned to individual users by system administrators. For example, one of these privileges, \*ALLOBJ, overrides the discretionary access control for file access, which is a typical use of root privileges on operating systems, such as AIX and Linux.

In a ported application that uses root access, it is probably a better security practice to create a specific user profile for the *application user* that can be given \*ALLOBJ authority. Therefore, you can avoid the use of QSECOFR, which has much more privilege than is needed by the single application. Unlike operating systems, such as AIX or Linux, the IBM i operating system does not require group membership for users. The GID of 0 for a user profile on the IBM i operating system means *no group assigned* rather than referring to a group with more privileges.

IBM i security relies on integrated security built into the system. All accesses to objects must pass a security check. The security check is done with respect to the user profile for which the process runs at the time of the access.

PASE for i relies on giving each process a separate address space to maintain integrity and security. If a resource is not available in your PASE for i address space, you cannot access it. File system security prevents someone from loading a resource into their address space without proper authorization. After it

is in the address space, the resource is available to the process regardless of the identity under which the process is running.

An PASE for i program uses system calls to request system functions. System calls for an PASE for i program are handled by the IBM i operating system. This interface gives PASE for i programs only indirect (and safe) access to system internals.

#### **Related information**

[Security](#)

### **Work management**

The IBM i operating system handles PASE for i programs in the same way it handles any other job on the system.

#### **Related information**

[Work management](#)

## **Debugging your IBM PASE for i programs**

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The PASE for i runtime environment provides library support for the `syslog()` runtime function, and a `syslogd` binary file for more sophisticated message routing. In addition, you can use existing facilities in the IBM i operating system, such as job logs for diagnostic messages and severe messages that are sent to the system operator message queue QSYSOPR.

Depending on the application, your strategy for debugging an PASE for i application can take different paths:

1. If the application does not require any IBM i integration (for instance, with Db2 for i or with ILE functions), first debug the application on AIX.
2. Use a combination of PASE for i dbx and IBM i debug capabilities (for example, job logs) to debug the application on the IBM i operating system.

Applications that you have coded to use database or ILE functions cannot be fully tested on AIX, but you can debug the remaining parts of the application on AIX to assure their proper structure and design.

### **Using dbx in PASE for i**

PASE for i supports the AIX dbx debugger utility. The utility lets you debug related processes, such as parent and child, at the source code level, if they were compiled as such. You can use the Network File System (NFS) to make the AIX source visible to the debugger that runs in PASE for i.

PASE for i support for `xterm` and `aixterm` lets you use dbx to debug both the parent and child processes. dbx launches another `xterm` window with dbx attached to the second process.

For details on dbx, see the IBM AIX operating system: Library Web site. You can also type `help` on the dbx command line.

### **Using IBM i debugging tools**

You can use the following tools on IBM i to debug your PASE for i applications:

- The IBM i Debugger provides specific support for PASE for i application debugging.
- The ILE C source debugger is an effective tool for determining problems with your code.

#### **Related information**

[System i Debugger](#)

[IBM AIX documentation](#)

## Optimizing performance

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To achieve the best performance, store the binary files of your application in the local stream file system.

It is much slower to start PASE for i programs if your binary files (such as base program and libraries) are outside of the local stream file system because file mapping cannot be done.

If you run an application in PASE for i that performs a large number of `fork()` operations, it will not run as fast as it runs on AIX. This is because each PASE for i `fork()` operation starts a new IBM i job, which can have a significant impact on performance.

### Related information

[Performance](#)

## IBM PASE for i shells and utilities

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PASE for i includes three shells (Korn, Bourne, and C shell) and provides many utilities that run as PASE for i programs. PASE for i shells and utilities provide an extensible scripting environment that includes a large number of industry-standard and defacto-standard commands.

The PASE for i default shell (`/QOpenSys/usr/bin/sh`) is the Korn shell.

To access PASE for i shells and utilities, you can call the Run an i5/OS Terminal Session (QP2TERM) program. The program presents an interactive display with a command line where you can enter PASE for i commands. To run any PASE for i program, including a shell or utility, you can call the Run any PASE for i program (QP2SHELL) API.

Many PASE for i utilities have the same name (with similar options and behavior) as QShell utilities in directory `/usr/bin`, so PASE for i utilities are provided in directory `/QOpenSys/usr/bin` or `/QOpenSys/usr/sbin`. When you run an PASE for i shell, the PASE for i PATH environment variable should generally include directories `/QOpenSys/usr/bin`, `/QOpenSys/usr/bin/X11`, and `/QOpenSys/usr/sbin`. See [Run any PASE for i program \(QP2SHELL\) API](#) for information about setting initial values for PASE for i environment variables.

### Related concepts

[What's new for IBM i 7.3](#)

Read about new or significantly changed information for the PASE for i topic collection.

[IBM PASE for i concepts](#)

PASE for i is an integrated runtime environment for AIX applications running on the IBM i operating system.

### Related tasks

[Running an IBM PASE for i program with QP2TERM\(\)](#)

You use this IBM i program to run an PASE for i program in an interactive shell environment.

### Related reference

[Compiling your AIX source](#)

You can install one of the AIX compiler products that support installation on IBM i to compile your programs in the PASE for i environment.

### Related information

[Run an IBM PASE for i Terminal Session](#)

## IBM PASE for i commands

Most PASE for i commands support the same options and provide the same behavior as AIX commands. But PASE for i commands differ from AIX commands in some ways.

The following list describes the difference between PASE for i commands and AIX commands:

- Many PASE for i commands for display operations and for UNIX jobs control work only in a teletypewriter (TTY) session, such as a session started by the **aixterm** or **xterm** command. These

functions do not work on 5250 workstation devices (including the display presented by the QP2TERM program).

- PASE for i generally does not support interfaces that are provided on AIX for system management. For example, PASE for i does not support the AIX System Management Interface Tool (SMIT) or functions that require an SMIT database.
- The IBM i operating system is fundamentally an EBCDIC system. PASE for i shells and utilities run in ASCII and generally do not perform automatic conversion of stream data. You might need to use tools (for example, the `iconv()` function) to convert between ASCII and EBCDIC.

Unlike the QShell interpreter and utilities, most PASE for i shells and utilities do not perform automatic Coded Character Set Identifier (CCSID) conversion of stream file data. However, the PASE for i utilities system and any PASE for i utility that runs a QShell command are exceptions. This is because they provide CCSID conversion support for data that the CL command or the QShell command reads from standard input or writes to standard output or standard error.

PASE for i utilities that run QShell Java utilities (for example, the Java command) set the Java `file.encoding` property to match the PASE for i CCSID so that stream data read and written by the Java program is converted from and to the PASE for i CCSID. To force a specific `file.encoding` value, set the PASE for i environment variable `PASE_JAVA_ENCODING` before running the utility.

- For many system resources, the IBM i operating system uses names that are not case sensitive. However, these system resources have names that are case sensitive in AIX; for example, user and group names and object names in the root file system. Some PASE for i shell and utility functions require matching case for resources that have names that are not case sensitive in IBM i, and others might return names in uppercase that are normally lowercase on AIX. For example, file name expansion in PASE for i shells is case sensitive, so you must specify uppercase to match generic names in the /QSYS.LIB file system.

```
rather than  ls /qsys.lib/qgpl.lib/GEN*.PGM
            ls /qsys.lib/qgpl.lib/gen*.pgm
```

- To provide case-sensitivity and avoid name collisions with directories and files used for ILE support, most PASE for i directories and files (including shells and utilities) are stored in the /QOpenSys file system. In particular, PASE for i shells and utilities are stored in /QOpenSys/usr/bin and /QOpenSys/usr/sbin (rather than /usr/bin and /usr/sbin on AIX).

In addition to the following PASE for i commands, each PASE for i shell supports a number of built-in commands (such as **cd**, **exec**, and **if**). See the [AIX Resources Web page](#) for information about the built-in commands supported by each PASE for i shell and for detailed information about most of the following PASE for i commands.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

| <b>A</b>                   |                                                                                       |
|----------------------------|---------------------------------------------------------------------------------------|
| <b>admin</b>               | Create and control Source Code Control System (SCCS) files.                           |
| <b>aixterm</b>             | Initialize an Enhanced X Window System terminal emulator.                             |
| <b>alias</b>               | Define or display aliases.                                                            |
| <b><u>appletviewer</u></b> | Run the QShell <b>appletviewer</b> command to run Java applets without a Web browser. |
| <b>apply</b>               | Apply a command to a set of parameters.                                               |
| <b>apt</b>                 | Run the QShell <b>apt</b> command, the Java annotation processing tool.               |

|                      |                                                                                                   |
|----------------------|---------------------------------------------------------------------------------------------------|
| <b>ar</b>            | Maintain the indexed libraries used by the linkage editor.                                        |
| <b>as</b>            | Run the assembler.                                                                                |
| <b><u>attr</u></b>   | Run the QShell <b>attr</b> command to display or change integrated file system object attributes. |
| <b>awk</b>           | Find lines in files matching patterns and then perform specified actions on them.                 |
| <b>B</b>             |                                                                                                   |
| <b>banner</b>        | Write ASCII character strings in large letters to standard output.                                |
| <b>basename</b>      | Return the base filename of a string parameter.                                                   |
| <b>bc</b>            | Provide an interpreter for arbitrary-precision arithmetic language.                               |
| <b>bdiff</b>         | Use the <b>diff</b> command to find differences in very large files.                              |
| <b>bfs</b>           | Scan files.                                                                                       |
| <b>bg</b>            | Run a job in the background.                                                                      |
| <b>bsh</b>           | Call the Bourne shell.                                                                            |
| <b>C</b>             |                                                                                                   |
| <b>cat</b>           | Concatenate or display files.                                                                     |
| <b>cd</b>            | Change the current directory.                                                                     |
| <b>cdc</b>           | Change the comments in a SCCS delta.                                                              |
| <b>chgrp</b>         | Change the group ownership of a file or directory.                                                |
| <b>chmod</b>         | Change permission modes.                                                                          |
| <b>chown</b>         | Change the user associated with a file.                                                           |
| <b>chroot</b>        | Change the root directory of a command.                                                           |
| <b>cksum</b>         | Display the checksum and byte count of a file.                                                    |
| <b>clear</b>         | Clear the terminal screen.                                                                        |
| <b><u>clrtmp</u></b> | Run the QShell <b>clrtmp</b> command to clear directory / tmp.                                    |
| <b>cmp</b>           | Compare two files.                                                                                |
| <b>colrm</b>         | Extract columns from a file.                                                                      |
| <b>comb</b>          | Combine SCCS deltas.                                                                              |
| <b>comm</b>          | Select or reject lines common to two sorted files.                                                |
| <b>command</b>       | Run a simple command.                                                                             |
| <b>compress</b>      | Compress data.                                                                                    |
| <b>cp</b>            | Copy files.                                                                                       |
| <b>cpio</b>          | Copy files into and out of archive storage and directories.                                       |

|                        |                                                                                        |
|------------------------|----------------------------------------------------------------------------------------|
| <b>csch</b>            | Call the C shell.                                                                      |
| <b>csplit</b>          | Split files by context.                                                                |
| <b>cut</b>             | Write out selected bytes, characters, or fields from each line of a file.              |
| <b>D</b>               |                                                                                        |
| <b>date</b>            | Display or set the date or time.                                                       |
| <b>dbx</b>             | Provide an environment to debug and run PASE for i programs.                           |
| <b>dc</b>              | Provide an interactive desk calculator for arbitrary-precision integer arithmetic.     |
| <b>dd</b>              | Convert and copy a file.                                                               |
| <b>df</b>              | Reports information about space on file systems.                                       |
| <b>diff</b>            | Compare text files.                                                                    |
| <b>diff3</b>           | Compare three files.                                                                   |
| <b>dircmp</b>          | Compare two directories and the contents of their common files.                        |
| <b>dirname</b>         | Write to standard output all but the last part of a specified path.                    |
| <b>dspcat</b>          | Display all or part of a message catalog.                                              |
| <b>dspmsg</b>          | Display a selected message from a message catalog.                                     |
| <b>du</b>              | Summarize disk usage.                                                                  |
| <b>dump</b>            | Dump selected parts of an object file.                                                 |
| <b>E</b>               |                                                                                        |
| <b>echo</b>            | Write character strings to standard output.                                            |
| <b>ed</b>              | Edit text by line.                                                                     |
| <b>edit</b>            | Provide a simple line editor for the new user.                                         |
| <b>egrep</b>           | Search a file for a pattern.                                                           |
| <b>env</b>             | Display the current environment or set the environment for the execution of a command. |
| <b>ex</b>              | Edit lines interactively with a screen display.                                        |
| <b>execerror</b>       | Write error messages to standard error.                                                |
| <b>expand</b>          | Write to standard output with tabs changed to spaces.                                  |
| <b>expr</b>            | Evaluate arguments as expressions.                                                     |
| <b><u>extcheck</u></b> | Run the QShell <b>extcheck</b> command to detect Java archive conflicts.               |
| <b>F</b>               |                                                                                        |
| <b>false</b>           | Return a nonzero exit value (false).                                                   |
| <b>fc</b>              | Process the command history list.                                                      |
| <b>fg</b>              | Run jobs in the foreground.                                                            |

|                         |                                                                                                  |
|-------------------------|--------------------------------------------------------------------------------------------------|
| <b>fgrep</b>            | Generate the figure list in a format supported by the build process.                             |
| <b>file</b>             | Determine file type.                                                                             |
| <b>find</b>             | Find files with a matching expression.                                                           |
| <b>fold</b>             | Fold long lines for finite-width output device.                                                  |
| <b>G</b>                |                                                                                                  |
| <b>gencat</b>           | Create and modify a message catalog.                                                             |
| <b>get</b>              | Create a specified version of a SCCS file.                                                       |
| <b>getconf</b>          | Write system configuration variable values to standard output.                                   |
| <b><u>getjobid</u></b>  | Run the QShell <b>getjobid</b> command to determine the IBM i job name for a process identifier. |
| <b>getopt</b>           | Parse command line flags and parameters.                                                         |
| <b>getopts</b>          | Process command-line arguments and check for valid options.                                      |
| <b>grep</b>             | Search a file for a pattern.                                                                     |
| <b>H</b>                |                                                                                                  |
| <b>hash</b>             | Remember or report command path names.                                                           |
| <b>head</b>             | Display the first few lines or bytes of a file or files.                                         |
| <b>hostname</b>         | Set or display the name of the current host system.                                              |
| <b>I</b>                |                                                                                                  |
| <b>iconv</b>            | Convert the encoding of characters from one code page encoding scheme to another.                |
| <b>id</b>               | Display the system identifications of a specified user.                                          |
| <b>idlj</b>             | Run the QShell <b>idlj</b> command to run the IDL-to-Java compiler.                              |
| <b>indent</b>           | Reformat a C language program.                                                                   |
| <b>install</b>          | Install a command.                                                                               |
| <b><u>ipcrm</u></b>     | Run the QShell <b>ipcrm</b> command to remove interprocess communications objects.               |
| <b><u>ipcs</u></b>      | Run the QShell <b>ipcs</b> command to display interprocess communications objects.               |
| <b>J</b>                |                                                                                                  |
| <b><u>jar</u></b>       | Run the QShell <b>jar</b> command to archive Java files.                                         |
| <b><u>jarsigner</u></b> | Run the QShell <b>jarsigner</b> command to sign or verify the signature of a Java archive.       |
| <b><u>java</u></b>      | Run the QShell <b>java</b> command to run the Java interpreter.                                  |
| <b><u>javac</u></b>     | Run the QShell <b>javac</b> command to compile a Java program.                                   |

|                       |                                                                                                            |
|-----------------------|------------------------------------------------------------------------------------------------------------|
| <b><u>javadoc</u></b> | Run the QShell <b>javadoc</b> command to generate Java documentation.                                      |
| <b><u>javah</u></b>   | Run the QShell <b>javah</b> command, to generate C header or stub files for Java classes.                  |
| <b><u>javap</u></b>   | Run the QShell <b>javap</b> command to disassemble a compiled Java program.                                |
| <b>jobs</b>           | Display status of jobs in the current session.                                                             |
| <b>join</b>           | Join the data fields of two files.                                                                         |
| <b>K</b>              |                                                                                                            |
| <b><u>keytool</u></b> | Run the QShell <b>keytool</b> command to manage keys and certificates for Java.                            |
| <b>kill</b>           | Send a signal to running processes.                                                                        |
| <b>ksh</b>            | Call the Korn shell.                                                                                       |
| <b>ksh93</b>          | Call the enhanced Korn shell.                                                                              |
| <b>L</b>              |                                                                                                            |
| <b>ld</b>             | Link object files.                                                                                         |
| <b>ldedit</b>         | Modify an XCOFF executable file header.                                                                    |
| <b>lex</b>            | Generate a C or C++ language program that matches patterns for simple lexical analysis of an input stream. |
| <b>line</b>           | Read one line from the standard input.                                                                     |
| <b>ln</b>             | Link files.                                                                                                |
| <b>locale</b>         | Write information about current locale or all public locales.                                              |
| <b>logger</b>         | Make entries in the system log.                                                                            |
| <b>logname</b>        | Display login name.                                                                                        |
| <b>look</b>           | Find lines in a sorted file.                                                                               |
| <b>lorder</b>         | Find the best order for member files in an object library.                                                 |
| <b>ls</b>             | Display the contents of a directory.                                                                       |
| <b>M</b>              |                                                                                                            |
| <b>m4</b>             | Preprocess files and expand macro definitions.                                                             |
| <b>make</b>           | Maintain, update, and regenerate groups of programs.                                                       |
| <b>makekey</b>        | Generate an encryption key.                                                                                |
| <b>mkcatdefs</b>      | Preprocess a message source file.                                                                          |
| <b>mkdir</b>          | Create one or more new directories.                                                                        |
| <b>mkfifo</b>         | Make first-in-first-out (FIFO) special files.                                                              |
| <b>mkfontdir</b>      | Create a <b>fonts.dir</b> file from a directory of font files.                                             |
| <b>mknod</b>          | Create a special file.                                                                                     |
| <b>more</b>           | Display the contents of files one screen at a time.                                                        |

|                            |                                                                                                                       |
|----------------------------|-----------------------------------------------------------------------------------------------------------------------|
| <b>mv</b>                  | Move files.                                                                                                           |
| <b>mwm</b>                 | Run the AIXwindows Window Manager (MWM).                                                                              |
| <b>N</b>                   |                                                                                                                       |
| <b><u>native2ascii</u></b> | Run the QShell <b>native2ascii</b> command to convert characters encoded in the PASE for i CCSID to Unicode encoding. |
| <b>nawk</b>                | Call the new version of <b>awk</b> .                                                                                  |
| <b>newform</b>             | Change the format of a text file.                                                                                     |
| <b>nice</b>                | Run a command at a lower or higher priority.                                                                          |
| <b>nl</b>                  | Number lines in a file.                                                                                               |
| <b>nm</b>                  | Display the symbol table of an object file.                                                                           |
| <b>nohup</b>               | Run a command without hangups.                                                                                        |
| <b>O</b>                   |                                                                                                                       |
| <b>od</b>                  | Display files in a specified format.                                                                                  |
| <b>orbd</b>                | Run the QShell <b>orbd</b> command to run the Java Object Request Broker Daemon.                                      |
| <b>P</b>                   |                                                                                                                       |
| <b>pack</b>                | Compress files.                                                                                                       |
| <b>pack200</b>             | Run the QShell <b>pack200</b> command, the Java archive packing tool.                                                 |
| <b>pagesize</b>            | Display the system page size.                                                                                         |
| <b>paste</b>               | Merge the lines of several files or subsequent lines in one file.                                                     |
| <b>patch</b>               | Apply changes to files.                                                                                               |
| <b>pax</b>                 | Extract, write, and list members of archive files; copy files and directory hierarchies.                              |
| <b>pcat</b>                | Unpack files and write them to standard output.                                                                       |
| <b>pg</b>                  | Format files to the display.                                                                                          |
| <b><u>policytool</u></b>   | Run the QShell <b>policytool</b> command to create and manage Java policy files.                                      |
| <b>pr</b>                  | Write a file to standard output.                                                                                      |
| <b>printenv</b>            | Display the values of environment variables.                                                                          |
| <b>printf</b>              | Write formatted output.                                                                                               |
| <b>prs</b>                 | Display a Source Code Control System (SCCS) file.                                                                     |
| <b>ps</b>                  | Show current status of processes.                                                                                     |
| <b>psh</b>                 | Call the POSIX (Korn) shell.                                                                                          |
| <b>pwd</b>                 | Display the path name of the working directory.                                                                       |
| <b>Q</b>                   |                                                                                                                       |
| <b>qsh</b>                 | Run a QShell command.                                                                                                 |

|                           |                                                                                               |
|---------------------------|-----------------------------------------------------------------------------------------------|
| <b>qsh_inout</b>          | Run a QShell command.                                                                         |
| <b>qsh_out</b>            | Run a QShell command.                                                                         |
| <b>R</b>                  |                                                                                               |
| <b>ranlib</b>             | Convert archive libraries to random libraries.                                                |
| <b>read</b>               | Read one line from standard input.                                                            |
| <b>red</b>                | Edit text by line.                                                                            |
| <b>regcmp</b>             | Compile patterns into C language char declarations.                                           |
| <b>reset</b>              | Initialize a terminal.                                                                        |
| <b>resize</b>             | Set the TERMCAP environment variable and terminal settings to the current window size.        |
| <b>rev</b>                | Reverse characters in each line of a file.                                                    |
| <b><u>Rfile</u></b>       | Run the QShell <b>Rfile</b> command to read or write IBM i record files.                      |
| <b>rgb</b>                | Create the database used by the X Window System server for colors.                            |
| <b>rm</b>                 | Remove (unlink) files or directories.                                                         |
| <b>rmDEL</b>              | Remove a delta from a SCCS file.                                                              |
| <b>rmdir</b>              | Remove a directory.                                                                           |
| <b><u>rmic</u></b>        | Run the QShell <b>rmic</b> command to compile Java RMI stubs.                                 |
| <b><u>rmid</u></b>        | Run the QShell <b>rmid</b> command to run the Java RMI activation system.                     |
| <b><u>rmiregistry</u></b> | Run the QShell <b>rmiregistry</b> command to start a Java remote object registry.             |
| <b>rtl_enable</b>         | Relink shared objects to enable the runtime linker to use them.                               |
| <b>runcat</b>             | Pipe output data from the <b>mkcatdefs</b> command to the <b>gencat</b> command.              |
| <b>S</b>                  |                                                                                               |
| <b>sact</b>               | Display current SCCS file-editing status.                                                     |
| <b><u>serialver</u></b>   | Run the QShell <b>serialver</b> command to return the version number for Java classes.        |
| <b>sccs</b>               | Administration program for SCCS commands.                                                     |
| <b>sccsdiff</b>           | Compare two versions of an SCCS file.                                                         |
| <b>sdiff</b>              | Compare two files and display the differences in a side-by-side format.                       |
| <b>sed</b>                | Provide a stream editor.                                                                      |
| <b>servertool</b>         | Run the QShell <b>servertool</b> command to run the Java IDL Server Tool.                     |
| <b><u>setccsid</u></b>    | Run the QShell <b>setccsid</b> command to set the CCSID for an integrated file system object. |

|                         |                                                                                                                |
|-------------------------|----------------------------------------------------------------------------------------------------------------|
| <b>setmaps</b>          | Set terminal maps or code set maps.                                                                            |
| <b>sh</b>               | Call the default (Korn) shell.                                                                                 |
| <b>size</b>             | Display the section sizes of the Extended Common Object File Format (XCOFF) object files.                      |
| <b>sleep</b>            | Suspend execution for an interval.                                                                             |
| <b>slibclean</b>        | Remove any currently unused modules in kernel and library memory.                                              |
| <b>snapcore</b>         | Gather information for a core file.                                                                            |
| <b>sort</b>             | Sort files, merge files that are already sorted, and check files to determine if they have been sorted.        |
| <b>split</b>            | Split a file into pieces.                                                                                      |
| <b>strings</b>          | Find the printable strings in an object or binary file.                                                        |
| <b>strip</b>            | Reduce the size of an XCOFF object file by removing information used by the binder and symbolic debug program. |
| <b>stty</b>             | Set, reset, and report workstation operating parameters.                                                       |
| <b>sum</b>              | Display the checksum and block count of a file.                                                                |
| <b>syslogd</b>          | Log system messages.                                                                                           |
| <b><u>system</u></b>    | Run a CL command.                                                                                              |
| <b><u>sysval</u></b>    | Run the QShell <b>sysval</b> command to display an IBM i system value or network attribute.                    |
| <b>T</b>                |                                                                                                                |
| <b>tab</b>              | Change spaces into tabs.                                                                                       |
| <b>tabs</b>             | Set tab stops on a terminal.                                                                                   |
| <b>tail</b>             | Write a file to standard output, beginning at a specified point.                                               |
| <b>tar</b>              | Manipulate archives.                                                                                           |
| <b>tee</b>              | Display the output of a program and copy it into a file.                                                       |
| <b>test</b>             | Evaluate conditional expressions.                                                                              |
| <b>tic</b>              | Translate the terminfo description files from source to compiled format.                                       |
| <b>time</b>             | Print the time of the execution of a command.                                                                  |
| <b><u>tnameserv</u></b> | Run the QShell <b>tnameserv</b> command to provide access to the Java naming service.                          |
| <b>touch</b>            | Update the access and modification times of a file.                                                            |
| <b>tput</b>             | Query the terminfo database for terminal-dependent information.                                                |
| <b>tr</b>               | Translate characters.                                                                                          |
| <b>trace</b>            | Record selected system events.                                                                                 |

|                   |                                                                                      |
|-------------------|--------------------------------------------------------------------------------------|
| <b>trbsd</b>      | Translate characters (BSD version).                                                  |
| <b>trcoff</b>     | Stop the collection of trace data.                                                   |
| <b>trcon</b>      | Start the collection of trace data.                                                  |
| <b>trcstop</b>    | Stop the trace function.                                                             |
| <b>true</b>       | Return an exit value of zero (true).                                                 |
| <b>tset</b>       | Initialize a terminal.                                                               |
| <b>tsort</b>      | Sort an unordered list of ordered pairs (a topological sort).                        |
| <b>tty</b>        | Write to standard output the full path name of your terminal.                        |
| <b>type</b>       | Write a description of the command type.                                             |
| <b>U</b>          |                                                                                      |
| <b>ulimit</b>     | Set or report user resource limits.                                                  |
| <b>umask</b>      | Display or set the file mode creation mask.                                          |
| <b>unalias</b>    | Remove alias definitions.                                                            |
| <b>uname</b>      | Display the name of the current operating system.                                    |
| <b>uncompress</b> | Restore compressed files.                                                            |
| <b>unexpand</b>   | Write to standard output with tabs restored.                                         |
| <b>unget</b>      | Cancel a previous SCCS <b>get</b> command.                                           |
| <b>unifdef</b>    | Remove ifdef lines from a file.                                                      |
| <b>uniq</b>       | Delete repeated lines in a file.                                                     |
| <b>unpack</b>     | Expand files.                                                                        |
| <b>unpack200</b>  | Run the QShell <b>unpack200</b> command, the Java archive unpacking tool.            |
| <b>untab</b>      | Change tabs into spaces.                                                             |
| <b>V</b>          |                                                                                      |
| <b>val</b>        | Validate SCCS files.                                                                 |
| <b>vc</b>         | Substitute assigned values for identification keywords.                              |
| <b>vedit</b>      | Edit files with a full-screen display.                                               |
| <b>vi</b>         | Edit files with a full-screen display.                                               |
| <b>view</b>       | Start the vi editor in read-only mode.                                               |
| <b>W</b>          |                                                                                      |
| <b>wait</b>       | Wait until the termination of a process ID.                                          |
| <b>wc</b>         | Count the number of lines, words, and bytes in a file.                               |
| <b>what</b>       | Display identifying information in files.                                            |
| <b>which</b>      | Locate a program file, including aliases and paths (the csh (C shell) command only). |
| <b>X</b>          |                                                                                      |

|                 |                                                                                                    |
|-----------------|----------------------------------------------------------------------------------------------------|
| <b>X</b>        | Run the X server. PASE for i only supports virtual frame buffer processing.                        |
| <b>xargs</b>    | Construct a parameter list and run a command.                                                      |
| <b>xauth</b>    | Edit and display the authorization information used in connecting to the X server.                 |
| <b>xhost</b>    | Control who accesses Enhanced X Window System on the current primary system.                       |
| <b>xlsfonts</b> | Display the font list for X Window System.                                                         |
| <b>xmodmap</b>  | Modify keymaps in the X Server.                                                                    |
| <b>xset</b>     | Set options for your X Window System environment.                                                  |
| <b>xterm</b>    | Provide a terminal emulator for the X Window System.                                               |
| <b>xwd</b>      | Dump the image of an Enhanced X Window System window.                                              |
| <b>xwud</b>     | Retrieve and display the dumped image of an Enhanced X Window System window.                       |
| <b>Y</b>        |                                                                                                    |
| <b>yacc</b>     | Generate an LALR(1) parsing program from input consisting of a context-free grammar specification. |
| <b>yes</b>      | Produce output of an affirmative response repetitively.                                            |
| <b>Z</b>        |                                                                                                    |
| <b>zcat</b>     | Expand a compressed file to standard output.                                                       |

#### Related information

[Utilities for developing Java programs](#)

## IBM PASE for i system utility

The PASE for i **system** utility runs a CL command. By default, any spooled output produced by the command is written to standard output; any messages sent by the command are written to standard output or standard error (depending on whether the CL command sends an exception message).

To avoid unpredictable results, set the ILE environment variable `QIBM_USE_DESCRIPTOR_STDIO` to Y or I so that PASE for i run time and ILE C run time use descriptor standard I/O. This variable is set to Y or I by default in the IBM i jobs that the QP2TERM program uses to run PASE for i shells and utilities.

### Syntax

```
system [-beEhiIkKnOpqsv] CL-command [ CL-parameters ... ]
```

### Options

#### -b

Force binary mode for standard streams used by the CL command.

When this option is omitted, the **system** command converts any data that the CL command reads from standard input from the PASE for i CCSID to the job default CCSID. The **system** command converts data written to standard output or standard error from the job default CCSID to the PASE for i CCSID. This option avoids CCSID conversion for all standard streams except those associated with option -E, -I, or -O.

**-e**

Copy PASE for i environment variables to ILE environment variables before running the CL command.

When this option is omitted, no ILE environment variables are set, and the ILE environment might have missing variables or might have different variable values from the PASE for i environment.

For most variables, the copy has the same name as the original, but the system adds the prefix `PASE_` to the name of the ILE copy of some environment variables. By default, the system adds the prefix when copying PASE for i environment variables `SHELL`, `PATH`, `NLSPATH`, and `LANG`. To control what variables the name prefix is added to, store a colon-delimited list of variable names in the PASE for i environment variable `PASE_ENVIRON_CONFLICT`.

Any PASE for i environment variable names with the prefix `ILE_` are copied to the ILE environment twice. The first copy uses the same variable name, and the second copy uses the name without the prefix. For example, if the PASE for i environment contains a variable named `ILE_PATH`, the value of this variable is used to set both the `ILE_PATH` and `PATH` variables in the ILE environment.

**-E**

Force CCSID conversion for the standard error stream used by the CL command.

When this option is specified, the **system** command converts any data that the CL command writes to standard error from the job default CCSID to the PASE for i CCSID. This option overrides option `-b` for the standard error stream.

**-h**

Write a brief description of allowable syntax for the **system** command to standard output.

**-i**

Run the CL command in the same process (IBM i job) where the **system** utility runs.

When option `-i` is omitted, the CL command is run in a separate process that is created using the ILE spawn API. This separate process is not multithread-capable unless you set the ILE environment variable `QIBM_MULTI_THREADED` to Y. Many CL commands are not supported in a multithreaded job.

**-I**

Force CCSID conversion for the standard input stream used by the CL command.

When this option is specified, the **system** command converts any data that the CL command reads from standard input from the PASE for i CCSID to the job default CCSID. This option overrides option `-b` for the standard input stream. CCSID conversion should only be used for standard input if the CL command reads standard input. This is because the processing done by the **system** command attempts to read and convert all standard input data regardless of whether the CL command uses the data, so it might leave the standard input stream positioned beyond what the CL command read.

**-k**

Keep all spooled files generated by the CL command.

When this option is omitted, spooled output files are deleted after their contents are written as text lines to standard output. Option `-i` has no effect when option `-s` is used.

**-K**

Force a job log for the IBM i job where the CL command runs.

If this option is omitted, a job log can only be produced if an unexpected error occurs.

**-n**

Do not include IBM i message identifiers in any text line that is written to standard output or standard error for a message sent by the CL command.

When this option is omitted, the format of any text lines written for IBM i predefined messages is `XXX1234: message text`, where `XXX1234` is the IBM i message identifier. `-n` suppresses the message identifier, so only `message text` is written to the stream. Option `-n` has no effect when option `-q` is used.

**-O**

Force CCSID conversion for the standard output stream used by the CL command.

When this option is specified, the **system** command converts any data that the CL command writes to standard output from the job default CCSID to the PASE for i CCSID. This option overrides option -b for the standard output stream.

**-p**

This option is ignored.

The PASE for i **system** utility always handles only messages sent to the program that runs the CL command (the way the QShell **system** utility works with option -p).

**-q**

Do not write any text lines to standard output or standard error for IBM i messages sent by the CL command.

If this option is omitted, messages sent by the CL command are received, converted from the job default CCSID to the PASE for i CCSID, and written as text lines to standard output or standard error, depending on whether the CL command sends an exception message.

**-s**

Do not process spooled output files produced by the CL command.

When this option is omitted, spooled output generated by the CL command is converted from the job default CCSID to the PASE for i CCSID and written to standard output. Then, the spooled output files are deleted.

**-v**

Write the complete CL command string to standard output before running the CL command.

## Operands

*CL-command* is concatenated with any *CL-parameters* operands with a single space between them to form the CL command string. You need to enclose CL command and parameter values in quotation marks to prevent the PASE for i shell from expanding special characters (such as parentheses and asterisks).

If a CL command parameter value requires quotation marks (such as a text parameter with lowercase characters or embedded blanks), you must specify those quotation marks inside a quoted string. This is because PASE for i shells remove the outer quotation marks from any argument that is passed to the PASE for i **system** utility.

## Exit status

If any exception message is sent by the CL command analyzer or by the command processing program, the **system** utility returns an exit status of 255. Error messages always appear in the job log of the IBM i job that runs the command, and might also be sent to standard output or standard error unless option -q is specified.

If CL command processing does not send an exception message, the **system** utility returns the exit status set by whatever program the CL command calls, or returns zero if that program does not set an exit status.

## Examples

The following example shows several ways to run the **CRTDTAARA** CL command with the same parameter values. Options -bOE force CCSID conversion for standard output and standard error (but not standard input). The \*char parameter value must be quoted to prevent the PASE for i shell from expanding it as a set of file names. The TEXT parameter requires two sets of enclosing quotation marks because it contains lowercase and embedded blanks.

```
or      system -bOE "crtdataara mydata *char text('Output queue text')"  
or      system -bOE crtdataara mydata "*char text('Output queue text')"  
or      system -BOE crtdataara mydata '*char' "text('Output queue text')"
```

The following example shows how the **system** utility runs the **CALL** CL command to call a program that accepts two parameters. Option **-i** avoids the overhead of creating an additional process to run the CL command. Because no other options are specified, CCSID conversion is done for standard input, standard output, and standard error. The called program sees the first parameter as converted to uppercase (ARG1) and the second parameter as unchanged (arg2) because of the CL rules.

```
system -i "call mypgm (arg1 'arg2')"
```

### Related concepts

[IBM PASE for i qsh, qsh\\_inout, and qsh\\_out commands](#)

The PASE for i **qsh**, **qsh\_inout**, and **qsh\_out** commands run a QShell command. These commands use the PASE for i **system** command to copy PASE for i environment variables to the ILE environment and then call the QShell command program through a link in directory `/usr/bin`.

## IBM PASE for i qsh, qsh\_inout, and qsh\_out commands

The PASE for i **qsh**, **qsh\_inout**, and **qsh\_out** commands run a QShell command. These commands use the PASE for i **system** command to copy PASE for i environment variables to the ILE environment and then call the QShell command program through a link in directory `/usr/bin`.

The PASE for i **qsh**, **qsh\_inout**, and **qsh\_out** commands all provide the syntax and behavior of the QShell **qsh** command, with additional support for encoding conversion of standard input and output between ASCII and EBCDIC. The PASE for i **system** command provides the encoding conversion support. Any other command name that links to PASE for i **qsh**, **qsh\_inout**, or **qsh\_out** (in directory `/QOpenSys/usr/bin`) provides the same syntax and behavior as the QShell command in directory `/usr/bin` with the same base name as the link.

The **qsh** and **qsh\_inout** commands perform encoding conversion between ASCII and EBCDIC for standard input, standard output, and standard error. The **qsh\_out** command performs the encoding conversion only for standard output and standard error.

To avoid unpredictable results, set the ILE environment variable `QIBM_USE_DESCRIPTOR_STDIO` to Y or I so that PASE for i run time and ILE C run time use descriptor standard input and output. This variable is set to Y or I by default in the IBM i jobs that the QP2TERM program uses to run PASE for i shells and utilities.

### Syntax

```
qsh [command-options]
qsh_inout [command-options]
qsh_out [command-options]
```

### Examples

When the QShell command does not read from standard input, you need to use the **qsh\_out** command (instead of the **qsh** or **qsh\_inout** command) to avoid unintended repositioning of the input stream. The following example uses the **qsh\_out** command to avoid repositioning the stream that is processed by the **read** command, and simply echoes the contents of the file `myinput` to standard output.

```
while read ; do
  qsh_out -c "echo $REPLY"
done < myinput
```

The following example uses the QShell **cat** command to convert text in an IBM i source database file to the (ASCII) PASE for i CCSID and store the result in a stream file named `ascii_sqlcli.h`. This uses the QShell utility support for inserting line-end characters, which are not added if the PASE for i **cat** command is used, into the stream.

```
qsh_out -c 'cat /qsys.lib/qsysinc.lib/h.file/sqlcli.mbr' > ascii_sqlcli.h
```

The system provides an PASE for i **getjobid** command that uses the symbolic link /QOpenSys/usr/bin/getjobid -> qsh\_out to run the QShell **getjobid** command. The following example shows two ways to run the QShell utility to determine the name of the IBM i job that is running the PASE for i shell. The first method is more efficient because it avoids running the QShell interpreter. The PASE for i shell expands the variable \$\$ to the process identifier of the shell. The QShell **getjobid** command writes a line to standard output.

```
getjobid $$  
qsh_out -c "/usr/bin/getjobid $$"
```

#### Related reference

[IBM PASE for i system utility](#)

The PASE for i **system** utility runs a CL command. By default, any spooled output produced by the command is written to standard output; any messages sent by the command are written to standard output or standard error (depending on whether the CL command sends an exception message).

#### Related information

[qsh - QShell Command Language Interpreter](#)

## Examples: IBM PASE for i

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These examples have been provided in the PASE for i information.

**Note:** By using the code examples, you agree to the terms of the [Code license and disclaimer information](#).

#### Running PASE for i programs and procedures from ILE programs

- [Running an PASE for i program from an ILE program](#)
- [Calling an PASE for i procedure from an ILE program](#)

#### Calling PASE for i programs from PASE for i programs

- [Calling ILE procedures from an PASE for i program](#)
- [Calling PASE for i programs from PASE for i](#)
- [Running CL commands from PASE for i](#)

#### Using Db2 for i functions in PASE for i programs

- [Calling Db2 for i CLI functions in an PASE for i program](#)

## Related information for IBM PASE for i

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IBM Redbooks publications, Web sites, and other information center topic collections contain information that relates to the PASE for i topic collection. You can view or print any of the PDF files.

#### IBM Redbooks

Bringing PHP to Your iSeries Server  (512 KB): The step-by-step implementation discussed in this publication involves the CGI version of the Hypertext Preprocessor (PHP) running in PASE for i.

#### Web sites

- [IBM AIX Documentation](https://www.ibm.com/docs/aix)  (https://www.ibm.com/docs/aix)

This Web site provides information about the AIX operating system.

## Other information

- [PASE for i APIs](#)

See this topic for details about the following general categories of PASE for i APIs:

- Callable program APIs
- ILE procedure APIs
- Runtime functions for use by PASE for i programs

You must call a system API to run an PASE for i program. The system provides both callable program APIs and ILE procedure APIs to run PASE for i programs. The callable program APIs can be easier to use, but do not offer all the controls available with the ILE procedure APIs.

- [PASE for i runtime libraries](#)

PASE for i run time supports a large subset of the interfaces provided by AIX run time. Most runtime interfaces supported by PASE for i provide the same options and behavior as AIX. The PASE for i runtime libraries are installed (as symbolic links) in /usr/lib.

### Related reference

[PDF file for IBM PASE for i](#)

You can view and print a PDF file of the information for PASE for i.

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## Programming interface information

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