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Internationalization of the File Transfer Protocol
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Status of this Memo

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in <draft-bradner-key-words-03.txt> [KEY WORDS].

Abstract

The File Transfer Protocol, as defined in RFC 959 [RFC959] and RFC 1123 Section 4 [RFC1123], is one of the oldest and widely used protocols on the Internet. The protocol's primary character set, 7 bit ASCII, has served the protocol well through the early growth years of the Internet. However, as the Internet becomes more global, there is a need to support character sets beyond 7 bit ASCII.

This document addresses the internationalization (I18n) of FTP, which includes supporting the multiple character sets found throughout the Internet community. This is achieved by extending the FTP specification and giving recommendations for proper internationalization support.

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1 Introduction

As the Internet grows throughout the world the requirement to support character sets outside of the ASCII [ASCII] / Latin-1 [ISO-8859] character set becomes ever more urgent. For FTP, because of the large installed base, it is paramount that this be done without breaking existing clients and servers. This document addresses this need. In doing so it defines a solution which will still allow the installed base to interoperate with new international clients and servers.

This document enhances the capabilities of the File Transfer Protocol by removing the 7-bit restrictions on pathnames used in client commands and server responses, recommending the use of a Universal Character Set (UCS) ISO/IEC 10646 [ISO-10646], and recommending a UCS transformation format (UTF) UTF-8 [UTF-8].

The recommendations made in this document are consistent with the recommendations expressed by the 29 Feb - 1 Mar 1996 IAB Character Set Workshop as expressed in <draft-weider-iab-char-wrkshop-00.txt> [WORKSHOP].

2 Internationalization

The File Transfer Protocol was developed in a period when the predominate character sets were 7 bit ASCII and 8 bit EBCDIC. Today these character sets cannot support the wide range of characters needed by multinational systems. Given that there are a number of character sets in current use that provide more characters than 7-bit ASCII, it makes sense to decide on a convenient way to represent the union of those possibilities. To work globally either requires support of a number of character sets and to be able to convert between them, or the use of a single preferred character set. To assure global interoperability this document RECOMMENDS the latter approach and defines a single character set, in addition to NVT ASCII and EBCDIC, which is understandable by all systems. For FTP this character set SHALL be ISO/IEC 10646:1993. For support of global compatibility it is STRONGLY RECOMMENDED that clients and servers use UTF-8 encoding when exchanging pathnames. Clients and servers are, however, under no obligation to perform any conversion on the contents of a file for operations such as STOR or RETR.

The character set used to store files SHALL remain a local decision and MAY depend on the capability of local operating systems. Prior to the exchange of pathnames they should be converted into a ISO/IEC 10646 format and UTF-8 encoded. This approach, while allowing international exchange of pathnames, will still allow backward compatibility with older systems because the code set positions for ASCII characters are identical to the one byte sequence in UTF-8.

Sections 2.1 and 2.2 give a brief description of the international character set and transfer encoding recommended by this document.

A more thorough description of UTF-8, ISO/IEC 10646, and UNICODE [UNICODE], beyond that given in this document, can be found in RFC 2044 [RFC2044].

2.1 International Character Set

The character set defined for international support of FTP SHALL be the Universal Character Set as defined in ISO 10646:1993 as amended. This standard incorporates the character sets of many existing international, national, and corporate standards. ISO/IEC 10646 defines two alternate forms of encoding, UCS-4 and UCS-2. UCS-4 is a four byte (31 bit) encoding containing 2**31 code positions divided into 128 groups of 256 planes. Each plane consists of 256 rows of 256 cells. UCS-2 is a 2 byte (16 bit) character set consisting of plane zero or the Basic Multilingual Plane (BMP). Currently, no codesets have been defined outside of the 2 byte BMP.

The Unicode standard version 2.0 [UNICODE] is consistent with the UCS-2 subset of ISO/IEC 10646. The Unicode standard version 2.0 includes the repertoire of IS 10646 characters, amendments 1-7 of IS 10646, and editorial and technical corrigenda.

2.2 Transfer Encoding

UCS Transformation Format 8 (UTF-8), also known as UTF-2 or UTF-FSS, SHALL be used as a transfer encoding to transmit the international character set. UTF-8 is a file safe encoding which avoids the use of byte values which have special significance during the parsing of pathname character strings. UTF-8 is an 8 bit encoding of the characters in the UCS. Some of UTF-8's benefits are that it is compatible with 7 bit ASCII, so it doesn't affect programs that give special meanings to various ASCII characters; it is immune to synchronization errors; its encoding rules allow for easy identification; and it has enough space to support large character sets.

UTF-8 encoding represents each UCS character as a sequence of 1 to 6 bytes in length. For all sequences of one byte the most significant bit is ZERO. For all sequences of more than one byte the number of ONE bits in the first byte, starting from the most significant bit position, indicates the number of bytes in the UTF-8 sequence followed by a ZERO bit. For example, the first byte of a 3 byte UTF-8 sequence would have 1110 as its most significant bits. Each additional bytes (continuing bytes) in the UTF-8 sequence, contain a ONE bit followed by a ZERO bit as their most significant bits. The remaining free bit positions in the continuing bytes are used to identify characters in the UCS. The relationship between UCS and UTF-8 is demonstrated in the following table:

UCS-4 range(hex)	UTF-8 byte sequence(binary)
00000000 - 0000007F	0xxxxxxx
00000080 - 000007FF	110xxxxx 10xxxxxx
00000800 - 0000FFFF	1110xxxx 10xxxxxx 10xxxxxx
00010000 - 001FFFFF	11110xxx 10xxxxxx 10xxxxxx 10xxxxxx
00200000 - 03FFFFFF	111110xx 10xxxxxx 10xxxxxx 10xxxxxx 10xxxxxx
04000000 - 7FFFFFFF	1111110x 10xxxxxx 10xxxxxx 10xxxxxx 10xxxxxx 10xxxxxx

A beneficial property of UTF-8 is that its single byte sequence is consistent with the ASCII character set. This feature will allow a transition where old ASCII-only clients can still interoperate with new servers which support the UTF-8 encoding.

Another feature is that the encoding rules make it very unlikely that a character sequence from a different character set will be mistaken for a UTF-8 encoded character sequence. Clients and servers can use a simple routine to determine if the character set being exchanged is valid UTF-8. Section B.1 shows a code example of this check.

3 Conformance

3.1 General

- The 7-bit restriction for pathnames exchanged is dropped.

- Many operating system allow the use of spaces <SP>, carriage return <CR>, and line feed <LF> characters as part of the pathname. The exchange of pathnames with these special command characters will cause the pathnames to be parsed improperly. This is because ftp commands associated with pathnames have the form:

  ```
            COMMAND <SP> <pathname> <CRLF>.
  ```

  To allow the exchange of pathnames containing these characters, the definition of pathname is changed from

  ```
    <pathname> ::=3D <string>
  to
    <pathname> ::=3D <ext-string>
    <ext-string> ::=3D <ext-char> | <ext-char><ext-string>
    <ext-char> ::=3D any 8 bit sequence except 0x00.
  ```

  To avoid mistaking these characters within pathnames as special command characters the following rules will apply:

  There MUST be only one <SP> between a ftp command and the pathname. Implementations MUST assume <SP> characters following the initial <SP> as part of the pathname. For

  example the pathname in STOR <SP><SP><SP>foo.bar<CRLF> is <SP><SP>foo.bar .

  Current implementations which may allow multiple <SP> characters as separators between the command and pathname MUST assure that they comply with this single <SP> convention.

  When a <CR> character is encountered as part of a pathname it MUST be padded with a <NUL> character prior to sending the command. On receipt of a pathname containing a <CR><NUL> sequence the <NUL> character MUST be stripped away. This approach is described in RFC 854 [RFC854] on pages 11 and 12. For example, to store a pathname foo<CR><LF>boo.bar the pathname would become foo<CR><NUL><LF>boo.bar prior to sending the command STOR <SP>foo<CR><NUL><LF>boo.bar<CRLF> .

Upon receipt of the altered pathname the <NUL> character following the <CR> would be stripped away to form the original pathname.

- Conforming internationalized clients and servers MUST support UTF-8 for the transfer and receipt of pathnames. Clients and servers MAY in addition give the user a choice to specify interpretation of pathnames in another encoding. Note that configuring clients and servers to use other character sets / encoding other than UTF-8 is outside of the scope of this document. While it is recognized that in certain operational scenarios this may be desirable, this is left as a quality of implementation and operational issue.

- Pathnames are sequences of bytes. The encoding of names that are valid UTF-8 sequences is assumed to be UTF-8. The character set of other names is undefined. Clients and servers, unless otherwise configured to support a specific native character set, MUST check for a valid UTF-8 byte sequence to determine if the pathname being presented is UTF-8.

- To avoid data loss, clients and servers SHOULD use the UTF-8 encoded pathnames when unable to convert them to a usable code set.

- There may be cases when the code set / encoding presented to the server or client cannot be determined. In such cases the raw bytes SHOULD be used.

3.2 International Servers

- Mirror servers may want to exactly reflect the site that they are mirroring. In such cases servers MAY store and present the exact pathname bytes that it received from the main server.

3.3 International Clients

- Clients which do not require display of pathnames are under no obligation to do so. Non-display clients do not need to conform to requirements associated with display.

- Clients which are presented UTF-8 pathnames by the server SHOULD parse UTF-8 correctly, and attempt to display the pathname within the limitation of the resources available.

- Character semantics of other names shall remain undefined. If a client detects that a server is non UTF-8, it SHOULD change its display appropriately. How a client implementation handles non UTF-8 is a quality of implementation issue. It MAY try to assume some other encoding, give the user a chance to try to assume something, or save encoding assumptions for a server from one FTP session to another.

- Glyph rendering is outside the scope of this document. How a client presents characters it cannot display is a quality of implementation issue. This document RECOMMENDS that octets corresponding to non-displayable characters SHOULD be presented in URL %HH format defined in RFC 1738 [RFC1738]. They MAY, however, display them as question marks, with their UCS hexadecimal value, or in any other suitable fashion.

- Many existing clients interpret 8-bit pathnames as being in the local character set. They MAY continue to do so for pathnames that are not valid UTF-8.

4 Security

This document addresses the support of character sets beyond 1 byte. Conformance to this document should not induce a security threat.

5 Acknowledgments

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6 Glossary

BIDI	abbreviation for Bi-directional, a reference to mixed right-to-left or left-to-right text.
Character Set / Charset	a collection of characters used to represent textual information in which each character has a numeric value
Code Set	(see character set).
Glyph	a character image represented on a display device.
I18N	"I eighteen N", the first and last letters of the word "internationalization" and the eighteen letters in between.
UCS-2	the ISO/IEC 10646 two octet Universal Character Set form.
UCS-4	the ISO/IEC 10646 four octet Universal Character Set form.
UTF-8	the UCS Transformation Format represented in 8 bits.
UTF-16	the USC-2 encoding equivalent with UNICODE.

7 Bibliography

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[ISO-8859]

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Appendix A - Implementation Considerations

- Implementers should be aware that ISO 10646 is amended from time to time; 4 amendments have been adopted since the initial 1993 publication, none of which significantly affects this specification. A fifth amendment, now under consideration, will introduce incompatible changes to the standard: 6556 Korean Hangul syllables allocated between code positions 3400 and 4DFF (hexadecimal) will be moved to new positions (and 4516 new syllables added), thus making references to the old positions invalid. Since the Unicode consortium has already adopted the corresponding amendment in Unicode 2.0, adoption of DAM 5 is considered likely and implementers should probably consider the old code positions as already invalid. Despite this one-time change, the relevant standard bodies have committed themselves not to change any allocated code position in the future. To encode Korean Hangul irrespective of these changes, the conjoining Hangul Jamo in the range 1110-11F9 can be used.

- Implementers should ensure that their code accounts for potential problems, such as using a NULL character to terminate a string or no longer being able to steal the high order bit for internal use, when supporting the extended character set.

- Implementers should be aware that there is a chance that pathnames which are non UTF-8 may be parsed as valid UTF-8. The probability is low for some encoding or statistically zero to zero for others. A recent non-scientific analysis found that EUC encoded words had a 2.7% false reading; SJIS had a 0.0005% false reading; other encoding such as ASCII or KOI-8 have a 0% false reading. This probability is highest for short pathnames and decreases as pathname size increases. Implementers may want to look for signs that pathnames which parsed as UTF-8 are not valid UTF-8, such as the existence of multiple local character sets in short pathnames. Hopefully, as more implementations conform to UTF-8 transfer encoding there will be a smaller need to guess at the encoding.

- Client developers should be aware that it will be possible for pathnames to contain mixed characters (e.g. /Latin1DirectoryName/HebrewFileName). They should be prepared to handle the Bi-directional (BIDI) display of these character sets (i.e. right to left display for the directory and left to right display for the filename). While bi-directional display is outside the scope of this document and more complicated than the above example, an algorithm for bi-directional display can be found in the UNICODE 2.0 [UNICODE] standard. Also note that pathnames can have different byte ordering yet be logically and display-wise equivalent due to the insertion of BIDI control characters at different points during composition. Also note that

mixed character sets may also present problems with font swapping.

- A server that copies pathnames transparently from a local filesystem may continue to do so. It is then up to the local file creators to use UTF-8 pathnames.

- Servers can supports charset labeling of files and/or directories, such that different file names may have different charsets. The server should attempt to convert all file names to UTF-8, but if it can't then it should leave that name in its raw form.

- Server's OS that do not mandate the character set, but the administrator can configures it in the FTP server. The server should be configured to use a particular mapping table. (Maybe external, but the server might have some common choices built-in.) This also allows the flexibility of defining different charsets for different directories.

- If the server's OS does not mandate the character set and it is not configured. The server should simply use the raw bytes in the file name. They might be ASCII or UTF-8.

- Server is a mirror, and wants to look just like the site it is
  mirroring. It should save the exact file name bytes that it
  received from the main server.

Appendix B - Sample Code and Examples

B.1 Valid UTF-8 check

The following routine checks if a byte sequence is valid UTF-8.

```
int utf8_valid(const unsigned char *buf, unsigned int len)
{
  const unsigned char *endbuf =3D buf + len;
  int trailing =3D 0;    // trailing (continuation) bytes to follow

  while (buf !=3D endbuf)
  {
     unsigned char c =3D *buf++;
     if (trailing)
       if      ((c&0xC0) =3D=3D 0x80)  trailing--;
```

```
          else                        return 0;
        else
          if      ((c&0x80) =3D=3D 0x00)  continue;
          else if ((c&0xE0) =3D=3D 0xC0)  trailing =3D 1;
          else if ((c&0xF0) =3D=3D 0xE0)  trailing =3D 2;
          else if ((c&0xF8) =3D=3D 0xF0)  trailing =3D 3;
          else if ((c&0xFC) =3D=3D 0xF8)  trailing =3D 4;
          else if ((c&0xFE) =3D=3D 0xFC)  trailing =3D 5;
          else                        return 0;
     }
     return trailing =3D=3D 0;
   }
```

B.2 Conversions

The code examples in this section closely reflect the algorithm in ISO 10646 and may not present the most efficient solution for converting to / from UTF-8 encoding. If efficiency is an issue, implementers should use the appropriate bitwise operators.

Additional code examples and numerous mapping tables can be found at the Unicode site, HTTP://www.unicode.org or FTP://unicode.org.

Note that the conversion examples below assume that the local character set supported in the operating system is something other than UCS2/UTF-16. There are some operating systems which already support UCS2/UTF-16 (notably Plan 9 and Windows NT). In this case no conversion will be necessary from the local character set to the UCS.

B.2.1 Conversion from local character set to UTF-8

Conversion from the local filesystem character set to UTF-8 will normally involve a two step process. First convert the local character set to the UCS; then convert the UCS to UTF-8.

The first step in the process can be performed by maintaining a mapping table which includes the local character set code and the corresponding UCS code. For instance the ISO/IEC 8859-8 [ISO-8859] code for the Hebrew letter "VAV" is 0xE4. The corresponding 4 byte ISO/IEC 10646 code is 0x000005D5.

The next step is to convert the UCS character code to the UTF-8 encoding. The following routine can be used to determine and encode the correct number of bytes based on the UCS-4 character code:

```
unsigned int ucs4_to_utf8 (unsigned long *ucs4_buf, unsigned int
                           ucs4_len, unsigned char *utf8_buf)

{
 const unsigned long *ucs4_endbuf =3D ucs4_buf + ucs4_len;
 unsigned int utf8_len =3D 0;            // return value for UTF8 size
 unsigned char *t_utf8_buf =3D utf8_buf; // Temporary pointer
                                       // to load UTF8 values

 while (ucs4_buf !=3D ucs4_endbuf)
 {
   if ( *ucs4_buf <=3D 0x7F)    // ASCII chars no conversion needed
   {
    *t_utf8_buf++ =3D (unsigned char) *ucs4_buf;
    utf8_len++;
    ucs4_buf++;
   }
   else
    if ( *ucs4_buf <=3D 0x07FF )  // In the 2 byte utf-8 range
    {
     *t_utf8_buf++=3D (unsigned char) (0xC0 + (*ucs4_buf/0x40));
     *t_utf8_buf++=3D (unsigned char) (0x80 + (*ucs4_buf%0x40));
     utf8_len+=3D2;
     ucs4_buf++;
    }
    else
     if ( *ucs4_buf <=3D 0xFFFF ) /* In the 3 byte utf-8 range. The
                                  values 0x0000FFFE, 0x0000FFFF
                                  and 0x0000D800 - 0x0000DFFF do
                                  not occur in UCS-4 */
     {
      *t_utf8_buf++=3D (unsigned char) (0xE0 +  (*ucs4_buf/0x1000));
      *t_utf8_buf++=3D (unsigned char) (0x80 +
                     ((*ucs4_buf/0x40)%0x40));
      *t_utf8_buf++=3D (unsigned char) (0x80 + (*ucs4_buf%0x40));
      utf8_len+=3D3;
      ucs4_buf++;

     }
     else
      if ( *ucs4_buf <=3D 0x1FFFFF ) //In the 4 byte utf-8 range
      {
          *t_utf8_buf++=3D (unsigned char) (0xF0 +  (*ucs4_buf/0x040000))=
;
          *t_utf8_buf++=3D (unsigned char) (0x80 +
                         ((*ucs4_buf/0x10000)%0x40));
          *t_utf8_buf++=3D (unsigned char) (0x80 +
                         ((*ucs4_buf/0x40)%0x40));
          *t_utf8_buf++=3D (unsigned char) (0x80 + (*ucs4_buf%0x40));
          utf8_len+=3D4;
          ucs4_buf++;

        }
        else
          if ( *ucs4_buf <=3D 0x03FFFFFF )//In the 5 byte utf-8 range
          {
           *t_utf8_buf++=3D (unsigned char) (0xF8 +
                          (*ucs4_buf/0x01000000));
           *t_utf8_buf++=3D (unsigned char) (0x80 +
                          ((*ucs4_buf/0x040000)%0x40));
           *t_utf8_buf++=3D (unsigned char) (0x80 +
                          ((*ucs4_buf/0x1000)%0x40));
           *t_utf8_buf++=3D (unsigned char) (0x80 +
                          ((*ucs4_buf/0x40)%0x40));
           *t_utf8_buf++=3D (unsigned char) (0x80 +
                          (*ucs4_buf%0x40));
           utf8_len+=3D5;
           ucs4_buf++;
          }
          else
          if ( *ucs4_buf <=3D 0x7FFFFFFF )//In the 6 byte utf-8 range
           {
            *t_utf8_buf++=3D (unsigned char)
                           (0xF8 +(*ucs4_buf/0x40000000));
            *t_utf8_buf++=3D (unsigned char) (0x80 +
                           ((*ucs4_buf/0x01000000)%0x40));
            *t_utf8_buf++=3D (unsigned char) (0x80 +
                           ((*ucs4_buf/0x040000)%0x40));
            *t_utf8_buf++=3D (unsigned char) (0x80 +
                           ((*ucs4_buf/0x1000)%0x40));
            *t_utf8_buf++=3D (unsigned char) (0x80 +
                           ((*ucs4_buf/0x40)%0x40));
            *t_utf8_buf++=3D (unsigned char) (0x80 +
                           (*ucs4_buf%0x40));
            utf8_len+=3D6;
            ucs4_buf++;

           }
   }
   return (utf8_len);
  }
```

B.2.2 Conversion from UTF-8 to local character set

When moving from UTF-8 encoding to the local character set the reverse procedure is used. First the UTF-8 encoding is transformed into the UCS-4 character set. The UCS-4 is then converted to the local character set from a mapping table (i.e. the opposite of the table used to form the UCS-4 character code).

To convert from UTF-8 to UCS-4 the free bits (those that do not define UTF-8 sequence size or signify continuation bytes) in a UTF-8 sequence are concatenated as a bit string. The bits are then distributed into a four byte sequence starting from the least significant bits. Those bits not assigned a bit in the four byte sequence are padded with ZERO bits. The following routine converts the UTF-8 encoding to UCS-4 character codes:

```
int utf8_to_ucs4 (unsigned long *ucs4_buf, unsigned int utf8_len,
               unsigned char *utf8_buf)
{

const unsigned char *utf8_endbuf =3D utf8_buf + utf8_len;
unsigned int ucs_len=3D0;


 while (utf8_buf !=3D utf8_endbuf)
 {

   if ((*utf8_buf & 0x80) =3D=3D 0x00)  /*ASCII chars no conversion
                                  needed */
   {
    *ucs4_buf++ =3D (unsigned long) *utf8_buf;
    utf8_buf++;
    ucs_len++;
   }
   else
    if ((*utf8_buf & 0xE0)=3D=3D 0xC0) //In the 2 byte utf-8 range
    {
     *ucs4_buf++ =3D (unsigned long) (((*utf8_buf - 0xC0) * 0x40)
                    + ( *(utf8_buf+1) - 0x80));
     utf8_buf +=3D 2;
```

```
      ucs_len++;
     }
     else
      if ( (*utf8_buf & 0xF0) =3D=3D 0xE0 ) /*In the 3 byte utf-8
                                            range */
      {
      *ucs4_buf++ =3D (unsigned long) (((*utf8_buf - 0xE0) * 0x1000)
                      + (( *(utf8_buf+1) -  0x80) * 0x40)
                      + ( *(utf8_buf+2) - 0x80));
       utf8_buf+=3D3;
       ucs_len++;
      }
```

```
      else
       if ((*utf8_buf & 0xF8) =3D=3D 0xF0) /* In the 4 byte utf-8
                                            range */
       {
         *ucs4_buf++ =3D (unsigned long)
                           (((*utf8_buf - 0xF0) * 0x040000)
                         + (( *(utf8_buf+1) -  0x80) * 0x1000)
                         + (( *(utf8_buf+2) -  0x80) * 0x40)
                         + ( *(utf8_buf+3) - 0x80));
         utf8_buf+=3D4;
         ucs_len++;
       }
       else
         if ((*utf8_buf & 0xFC) =3D=3D 0xF8) /* In the 5 byte utf-8
                                              range */
         {
          *ucs4_buf++ =3D (unsigned long)
                           (((*utf8_buf - 0xF8) * 0x01000000)
                         + ((*(utf8_buf+1) - 0x80) * 0x040000)
                         + (( *(utf8_buf+2) -  0x80) * 0x1000)
                         + (( *(utf8_buf+3) -  0x80) * 0x40)
                         + ( *(utf8_buf+4) - 0x80));
          utf8_buf+=3D5;
          ucs_len++;
         }
         else
          if ((*utf8_buf & 0xFE) =3D=3D 0xFC) /* In the 6 byte utf-8
                                               range */
          {

           *ucs4_buf++ =3D (unsigned long)
                            (((*utf8_buf - 0xFC) * 0x40000000)
                          + ((*(utf8_buf+1) - 0x80) * 0x010000000)
                          + ((*(utf8_buf+2) - 0x80) * 0x040000)
                          + (( *(utf8_buf+3) -  0x80) * 0x1000)
                          + (( *(utf8_buf+4) -  0x80) * 0x40)
                          + ( *(utf8_buf+5) - 0x80));
           utf8_buf+=3D6;
           ucs_len++;
          }

  }
 return (ucs_len);
 }
```

B.2.3   ISO/IEC 8859-8 Example

This example demonstrates mapping ISO/IEC 8859-8 character set to UTF-8 and back to ISO/IEC 8859-8. As noted earlier, the Hebrew letter "VAV" is convertd from the ISO/IEC 8859-8 character code 0xE4 to the corresponding 4 byte ISO/IEC 10646 code of 0x000005D5 by a simple lookup of a conversion/mapping file.

The UCS-4 character code is transformed into UTF-8 using the ucs4_to_utf8 routine described earlier by:

1. Because the UCS-4 character is between 0x80 and 0x07FF it will map to a 2 byte UTF-8 sequence.
2. The first byte is defined by (0xC0 + (0x000005D5 / 0x40)) =3D 0xD7.
3. The second byte is defined by (0x80 + (0x000005D5 % 0x40)) =3D 0x95.

The UTF-8 encoding is transferred back to UCS-4 by using the utf8_to_ucs4 routine described earlier by:

1. Because the first byte of the sequence, when the '&' operator with a value of 0xE0 is applied, will produce 0xC0 (0xD7 & 0xE0 =3D 0xC0) the UTF-8 is a 2 byte sequence.
2. The four byte UCS-4 character code is produced by (((0xD7 - 0xC0) * 0x40) + (0x95 -0x80)) =3D 0x000005D5.

Finally, the UCS-4 character code is converted to ISO/IEC 8859-8 character code (using the mapping table which matches ISO/IEC 8859-8 to UCS-4) to produce the original 0xE4 code for the Hebrew letter "VAV".

B.2.4 Vendor Codepage Example

This example demonstrates the mapping of a codepage to UTF-8 and back to a vendor codepage. Mapping between vendor codepages can be done in a very similar manner as described above. For instance both the PC and Mac codepages reflect the character set from the Thai standard TIS 620-2533. The character code on both platforms for the Thai letter "SO SO" is 0xAB. This character can then be mapped into the UCS-4 by way of a conversion/mapping file to produce the UCS-4 code of 0x0E0B.

The UCS-4 character code is transformed into UTF-8 using the ucs4_to_utf8 routine described earlier by:

1. Because the UCS-4 character is between 0x0800 and 0xFFFF it will map to a 3 byte UTF-8 sequence.
2. The first byte is defined by (0xE0 + (0x00000E0B / 0x1000) =3D 0xE0.
3. The second byte is defined by (0x80 + ((0x00000E0B / 0x40) % 0x40))) =3D 0xB8.
4. The third byte is defined by (0x80 + (0x00000E0B % 0x40)) =3D 0x8B.

The UTF-8 encoding is transferred back to UCS-4 by using the utf8_to_ucs4 routine described earlier by:

1. Because the first byte of the sequence, when the '&' operator with a value of 0xF0 is applied, will produce 0xE0 (0xE0 & 0xF0 =3D 0xE0) the UTF-8 is a 3 byte sequence.
2. The four byte UCS-4 character code is produced by (((0xE0 - 0xE0) * 0x1000) + ((0xB8 - 0x80) * 0x40) + (0x8B -0x80) =3D 0x0000E0B.

Finally, the UCS-4 character code is converted to either the PC or MAC codepage character code (using the mapping table which matches codepage to UCS-4) to produce the original 0xAB code for the Thai letter "SO SO".

B.3 Pseudo Code for a high-quality translating server

```
if utf8_valid(fn)
   {
   attempt to convert fn to the local charset, producing localfn
   if (conversion fails temporarily) return error
   if (conversion succeeds)
     {
     attempt to open localfn
     if (open fails temporarily) return error
     if (open succeeds) return success
     }
   }
attempt to open fn
if (open fails temporarily) return error
if (open succeeds) return success
return permanent error
```