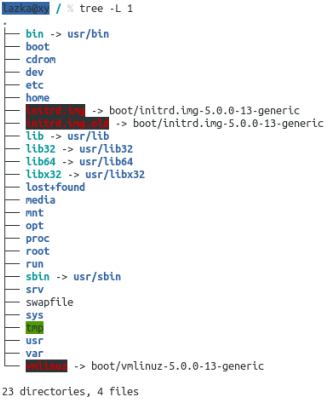
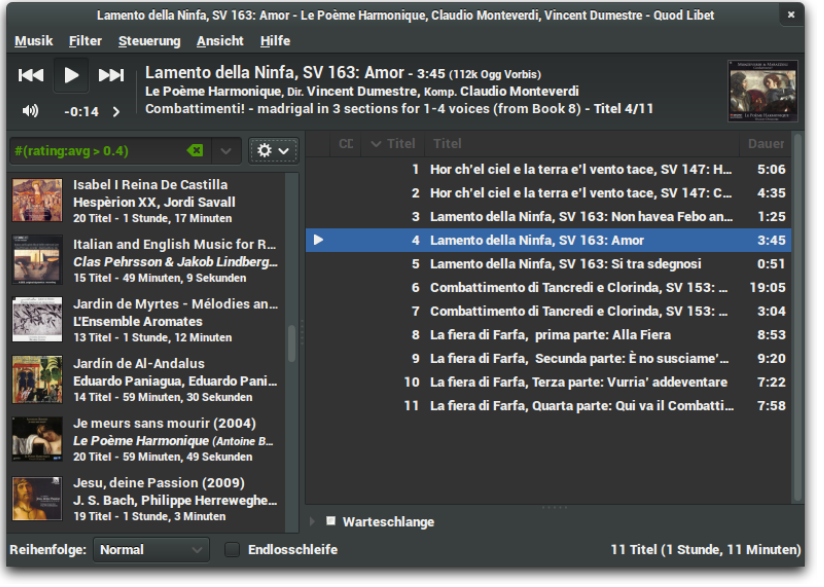
The Missing Filesystem Path Type

Christoph Reiter @ PyGRAZ 2019-11-05




Lamento della Ninfa, SV 163: Amor - Le Poème Harmonique, Claudio Monteverdi, Vincent Dumestre - Quod Libet
Musik Filter Steuerung Ansicht Hilfe
Lamento della Ninfa, SV 163: Amor - 3:45 (112k Ogg Vorbis)
Le Poème Harmonique, Dir. Vincent Dumestre, Komp. Claudio Monteverdi
Combattimenti! - madrigal in 3 sections for 1-4 voices (from Book 8) - Titel 4/11
-0:14
#(rating:avg > 0.4)
Isabel I Reina De Castilla
Hespèrion XX, Jordi Savall
20 Titel - 1 Stunde, 17 Minuten
Italian and English Music for R...
Clas Pehrsson & Jakob Lindberg...
15 Titel - 49 Minuten, 9 Sekunden
Jardin de Myrtes - Mélodies an...
L'Ensemble Aromates
13 Titel - 1 Stunde, 12 Minuten
Jardín de Al-Andalus
Eduardo Paniagua, Eduardo Pani...
14 Titel - 59 Minuten, 30 Sekunden
Je meurs sans mourir (2004)
Le Poème Harmonique (Antoine B...
20 Titel - 59 Minuten, 49 Sekunden
Jesu, deine Passion (2009)
J. S. Bach, Philippe Herreweghe...
19 Titel - 1 Stunde, 3 Minuten
CD Titel Titel Dauer
1 Hor ch'el ciel e la terra e'l vento tace, SV 147: H... 5:06
2 Hor ch'el ciel e la terra e'l vento tace, SV 147: C... 4:35
3 Lamento della Ninfa, SV 163: Non havea Febo an... 1:25
4 Lamento della Ninfa, SV 163: Amor 3:45
5 Lamento della Ninfa, SV 163: Si tra sdegnosi 0:51
6 Combattimento di Tancredi e Clorinda, SV 153: ... 19:05
7 Combattimento di Tancredi e Clorinda, SV 153: ... 3:04
8 La fiera di Farfa, prima parte: Alla Fiera 8:53
9 La fiera di Farfa, Secunda parte: È no susciame'... 9:20
10 La fiera di Farfa, Terza parte: Vurria' addeventare 7:22
11 La fiera di Farfa, Quarta parte: Qui va il Combatti... 7:58
Warteschlange
Reihenfolge: Normal
Endlosschleife
11 Titel (1 Stunde, 11 Minuten)


3v2
WinRAR
KaZoo
File Operations Setup
Operation type: Copy Move Rename
Presets
Example
Load Save Delete
Destination folder: Z:\Music
File name pattern: [%discnumber%.][%tracknumber%.][%artist% -]%title%
Move entire source folder content
Remove empty source folders
Show output files when done
Preview
Operation Source Destination
Move 01 Only Shallow.mp3 Z:\Music\01. My Bloody Valentine - Only Shallow.mp3
Move 02 Loomer.mp3 Z:\Music\02. My Bloody Valentine - Loomer.mp3
Move 03 Touched.mp3 Z:\Music\03. My Bloody Valentine - Touched.mp3
Move 04 To Here Knows When.mp3 Z:\Music\04. My Bloody Valentine - To Here Knows When.mp3
Move 05 When You Sleep.mp3 Z:\Music\05. My Bloody Valentine - When You Sleep.mp3
Move 06 I Only Said.mp3 Z:\Music\06. My Bloody Valentine - I Only Said.mp3
Move 07 Come In Alone.mp3 Z:\Music\07. My Bloody Valentine - Come In Alone.mp3
Move 08 Sometimes.mp3 Z:\Music\08. My Bloody Valentine - Sometimes.mp3
Move 09 Blown A Wish.mp3 Z:\Music\09. My Bloody Valentine - Blown A Wish.mp3
Move 10 What You Want.mp3 Z:\Music\10. My Bloody Valentine - What You Want.mp3
Move 11 Soon.mp3 Z:\Music\11. My Bloody Valentine - Soon.mp3
Run Close

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ã€Œæ–‡å—åŒ–ã 'ã€ ã ¨ã „ã †è¨€è'‰ã ¯ã€ ã‚³ãƒ³ãƒ"ãƒ¥ãƒ¼ã‚¿ç'°å¢ƒã §åŽŸå‰‡ã ¨ã —ã ¦ãƒžãƒ«ãƒ ãƒ ã‚¤ãƒˆæ–‡å—ã'ä½¿ç"¨ã —ã ªã „æ¬§ç±³ç‰ã ®ãƒ©ãƒ†ãƒ³ã‚¢ãƒ«ãƒ•ã‚¡ãƒ™ãƒƒãƒˆä½¿ç"¨è€…ã «ã Šã „ã ¦ã ¯è©²å½"ã ™ã‚‹ç"¨èªžã Œå˜åœ¨ã — ã ªã ‹ã £ã Ÿã "ã ¨ã ‹ã‚‰ã€ æ—¥æœ¬èªž ã ® â€œ**Mojibake**â€ ã ¨ã „ã †è¨€è'‰ã Œã ã ®ã ¾ã ¾é€šç"¨ã ™ã‚‹ã‚ˆã †ã «ã ªã £ã Ÿã€‚â†'#Mojibake

ç›®æ¬¡ [é žè¡¨ç¤º]

```
python3 -c "import sys; print(sys.argv[1])" *.txt
Traceback (most recent call last):
File "<string>", line 1, in <module>
UnicodeEncodeError: 'utf-8' codec can't encode characters in position 0-1: surrogates not allowed
```

```
python3 -c "import os;  os.mkdir('\xf6')"
Traceback (most recent call last):
File "<string>", line 1, in <module>
UnicodeEncodeError: 'ascii' codec can't encode character '\xf6' in position 0: ordinal not in range(128)
```

stdlib: str / bytes / unicode / pathlib

https://docs.python.org/3/library: os.path, pathlib, os.environ, sys.argv, os.getcwd, getcwdb, tempfile, open(), io, os.environb

```
>>> os.listdir(u"/sys")
['kernel', 'power', 'class', 'devices', 'dev', 'hypervisor', 'fs']
>>> os.listdir(b"/sys")
[b'kernel', b'power', b'class', b'devices', b'dev', b'hypervisor', b'fs']
>>> os.listdir(pathlib.Path("/sys"))
['kernel', 'power', 'class', 'devices', 'dev', 'hypervisor', 'fs']
>>> tempfile.mkstemp("foo", "bar")
(3, '/tmp/barg6vl4_ykfoo')
>>> tempfile.mkstemp("foo", b"bar") # also os.path.join(b"", "")
TypeError: Can't mix bytes and non-bytes in path components.
```

- In general: The type that gets passed in also gets passed out
- pathlib is converted to `str` first, so `str` is returned
- Functions taking multiple paths need one shared type (since Python 3)

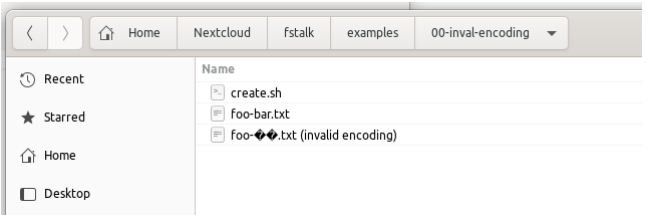
Filesystem Encoding on Linux

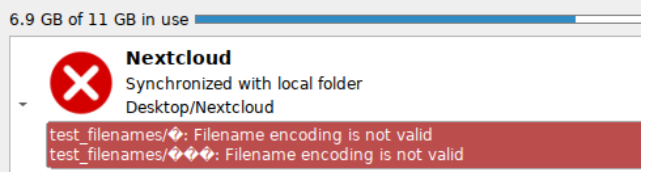
```
>>> import os
>>> os.listdir(".")
['foo-bar.txt', 'foo-\udcff\udcfe.txt', 'create.sh']
>>> os.listdir(".")[0].encode("utf-8")
b'foo-bar.txt'
>>> os.listdir(".")[1].encode("utf-8")
Traceback (most recent call last):
File "<stdin>", line 1, in <module>
UnicodeEncodeError: 'utf-8' codec can't encode characters in position 4-5: surrogates not allowed
>>> os.listdir(".")[1].encode("utf-8", "surrogateescape")
b'foo-\xff\xfe.txt'
>>>
```

-> **surrogates ?**

-> **surrogateescape ?**

How do Programs handle these?





Surrogates

https://www.ling.upenn.edu/courses/Spring_2003/ling538/UnicodeRanges.html

- D800-DBFF: High Surrogate Area
- DC00-DFFF: Low Surrogate Area

https://en.wikipedia.org/wiki/Universal_Coded_Character_Set#History

- In the beginning Unicode fit into 16 bit (UCS-2 encoding), turned out to be not enough
- Unicode was extended to fit into 32 bit, UCS-2 was upgraded to UTF-16
- The (unallocated) surrogate areas are re-used to encode code points outside of UCS-2, by using them in pairs, so called surrogate-pairs.

Utf-16 Emoji Example

```
>>> u = "■"  # <- supposed to be a smiley emoji ":)"
>>> len(u), hex(ord(u))
(1, '0x1f60a')
>>> 0x1f60a
128522  # doesn't fit 16bit
>>> 2**16
65536
>>> hex(0x1f60a - 0x10000)  # remove offset
'0xf60a'
>>> high = 0xf60a >> 10
>>> low = 0xf60a & 0b1111111111
>>> hex(high)
'0x3d'
>>> hex(low)
'0x20a'
>>> (hex(0xD800 + high), hex(0xDC00 + low)) # split bits and offset into surrogate block
('0xd83d', '0xde0a')
>>> u
'■'
>>> [hex(c) for c in u.encode("utf-16-be")]
['0xd8', '0x3d', '0xde', '0xa']  # same values as above
# decoding a long surrogate will lead to errors
>>> u.encode("utf-16-be")[:2].decode("utf-16-be")
UnicodeDecodeError: 'utf-16-be' codec can't decode bytes in position 0-1: unexpected end of data
>>> u.encode("utf-16-be")[2:].decode("utf-16-be")
UnicodeDecodeError: 'utf-16-be' codec can't decode bytes in position 0-1: illegal encoding
```

UTF-16 and Surrogates

- UTF-16 not strictly a superset of UCS-2 because previously valid strings with code points in the surrogate range no longer valid. C APIs couldn't just reject data they previously accepted.
- APIs worked with 16bit values and couldn't be changed anymore (wchar_t on Windows)
- Examples: JS strings in browsers, Java etc.

Python 2/3 Differences

In Python 2 surrogates where handled like every other codepoint in the utf-x codec family.

```
>>> # Python 2
>>> u"\udcee".encode("utf-16-le").decode("utf-16-le")
# ???
>>> u"\udcee".encode("utf-8").decode("utf-8")
# ???
```

Surrogates can create problems if they end up in utf-8/16 text that gets passed to other programs. e.g. glib based programs will error out.

Python 3 finally doesn't allow them by default `\o/`, except in filesystem paths `:(`

'surrogateescape' Error Handler

https://www.python.org/dev/peps/pep-0383/ (Python 3.1)

> "File names, environment variables, and command line arguments are defined as being character data in POSIX; the C APIs however allow passing arbitrary bytes - whether these conform to a certain encoding or not. This PEP proposes a means of dealing with such irregularities by embedding the bytes in character strings in such a way that allows recreation of the original byte string."
>
> "With this PEP, non-decodable bytes >= 128 will be represented as lone surrogate codes U+DC80..U+DCFF."

1. Python decodes filesystem paths (bytes)
2. In case of errors embeddeds affected bytes in lone surrogates
3. When passing the string back to the OS it extracts them again without losing information

'surrogateescape': The Good and the Bad

- **Bad:** `"some string: " + os.path.basename(path)` could result in an invalid unicode string by accident. No way to tell if the string is potentially invalid and with which codec it was created.

- **Good:** Even if decoding fails, some operations still work: `"invalid-\udcee-name.txt".endswith(".txt")`. In the common case the user can just assume that they are strings.

Codec Error Handlers

Common codec error handlers: 'strict', 'ignore', 'replace'.

```
>>> b"a\xffb".decode("ascii", "strict") # <- default
UnicodeDecodeError: 'ascii' codec can't decode byte 0xff in position 1: ordinal not in range(128)
>>> b"a\xffb".decode("ascii", "replace")
'a■b'  # ■ <- "REPLACEMENT CHARACTER"
>>> b"a\xffb".decode("ascii", "ignore")
'ab'
>>>
```

But there are more: `xmlcharrefreplace`, `backslashreplace`, `namereplace`, `surrogateescape`, `surrogatepass`

https://docs.python.org/3/library/codecs.html#error-handlers

User defined error handlers possible:
https://www.python.org/dev/peps/pep-0293/ (Python 2.3)

> "This PEP aims at extending Python's fixed codec error handling schemes with a more flexible callback based approach."

Custom Error Handlers

We can create our own error handler which receives a UnicodeError and can decide what output to produce based on the input.

```
import codecs

def pygraz(error):
    # UnicodeError -> (replacement, newpos)
    return ("[pygraz]", error.end)

# pygraz custom handler
codecs.register_error("pygraz", pygraz)
>>> print(b"hallo-\xff!".decode("ascii", "pygraz"))
hallo-[pygraz]!
>>> print("hallo-ß!".encode("ascii", "pygraz"))
b'hallo-[pygraz]!'
# surrogateescape
se = codecs.lookup_error("surrogateescape")
>>> se(UnicodeDecodeError('ascii', b"\xee", 0, 1, "broken whatever"))     #
('\udcee', 1)
```

What's the Filesystem Encoding?

We've used UTF-8 for now, but is it always that way?

NO :((but most of the time yes)

- The filesystem encoding is read from `LC_CTYPE` env var of the current locale (see the `locale` command).
- You can see the available locales with `locale -a`
- In Python: `sys.getfilesystemencoding()`

What's the Filesystem Encoding?

```
$ locale
LANG=en_US.UTF-8
LANGUAGE=
LC_CTYPE="en_US.UTF-8"
...
LC_ALL=
$ locale -a
C
C.UTF-8
```

- Once special locale that is always available: `C` or `POSIX` (the same), ASCII encoding
- In newer distros, also `C.UTF-8` **<- use this instead of C!**
- Many docker images default to `C`, can be fixed with `ENV LC_ALL C.UTF-8`

What's the Filesystem Encoding?

Related Python API:

```
>>> import sys, os
>>> sys.getfilesystemencoding()
'utf-8'
>>> os.fsencode("\udcee")
b'\xee'
>>> os.fsdecode(b"\xee")
'\udcee'
>>>
```

Note: `os.fsdecode()` will pass through `str` and not validate them. Returned value not stricly valid.

What's the Filesystem Encoding?

In 99% of cases UTF-8 or POSIX/C because it's the default fallback (SSH, Docker). Ideally it would be UTF-8 always.

New PEPs to the rescue:

- https://www.python.org/dev/peps/pep-0538/ (Python 3.7)

  "Coercing the legacy C locale to a UTF-8 based locale"

  Will set LC_CTYPE to UTF-8 in case the POSIX locale is active
- https://www.python.org/dev/peps/pep-0540/ (Python 3.7)

  "Add a new UTF-8 Mode"

  Will use UTF-8 everywhere in case of the POSIX locale

What's the Filesystem Encoding?

Python 3.6:

```
LANG=C python3 -c "import sys; print(sys.getfilesystemencoding())"
ascii
```

Python 3.7:

```
LANG=C python3 -c "import sys; print(sys.getfilesystemencoding())"
utf-8
```

With this in 99% of cases you will get "utf-8" and most fs encoding problems are gone for Python 3 users `\o/`

Linux Filesystem Paths

`Posix Standard`: https://pubs.opengroup.org/onlinepubs/009695399/basedefs/xbd_chap03.html

- Absolute: `/foo/bar/quux`
- Relative `foo/bar`, `../foo`, `./foo`
- Directory in every directory pointing to the directory itself: `.`
- Directory in every directory pointing to the parent `..`, or itself in case of `/`

- Paths starting with exactly two `/` are implementation defined (Linux doesn't do anything special)
- Multiple slahes are otherwise considered one slash: `/foo//bar` == `/foo/bar`
- Paths ending with trailing slash(es) as if they have an implicit trailing `"."`: `/foo///` == `/foo/.`

Linux Filesystem Paths

- `os.path` and `pathlib` abstract most of this away across platforms.
- `os.path.basename('/foo///')` -> Output?
- `pathlib` is easier in this case
- `os.path` doesn't follow the posix lookup rules, use `os.path.normpath()` first

Linux Filesystem Paths

In some cases you want multiple paths in one string (for example the PATH env var)

Use `os.pathsep`.

How does it work if ":" is contained in one of the paths? Escape it?

Since <colon> is a separator in this context, directory names that might be used in PATH should not include a <colon> character.

https://pubs.opengroup.org/onlinepubs/9699919799/basedefs/V1_chap08.html#tag_08_03

Linux Path Limits

It depends :/ ->
https://en.wikipedia.org/wiki/Comparison_of_file_systems#Limits

- Limitations because of the on-disk-format
- Limitations because of the OS APIs

ext4: 255 bytes for a filename, 4096 bytes for a path

```
>> os.stat("/abcde" + "/f" * 2045)
OSError: [Errno 36] File name too long:...
>>> os.mkdir("a" * 256)
OSError: [Errno 36] File name too long:...
```

Case Insensitive Filesystems?

EXT4 added a case insensitive + normalization lookup in Linux 5.2 (inspired by macos APFS)

See https://lwn.net/Articles/784041/

- Kernel has to be build with `CONFIG_UNICODE` (Arch/Ubuntu do by default)
- `mkfs.ext4 -E encoding=utf8` <- needs to be specified at format time (stores the current unicode version on disk)
- `chattr +F <some-empty-dir>` <- can be enabled for empty directories
- Does case normalization and NFD normalization on lookup
- Similar to when you mount FAT32 or NTFS, except they only do case normalization.
- (In theory case folding depends on the locale... https://www.w3.org/International/wiki/Case_folding)

Demo...

Windows

```
# https://docs.microsoft.com/en-us/windows/win32/fileio/naming-a-file            .
# https://en.wikipedia.org/wiki/Path_(computing)
\ (relative to current working directory root)
or [drive_letter]:\
or \\[server]\[sharename]\
or \\?\[drive_spec]:\
or \\?\[server]\[sharename]\
or \\?\UNC\[server]\[sharename]\
or \\.\[physical_device]\
```

- "\\?\" <- Prefix for "long paths" (get sent straight to the FS)
- "/" is the same as "\", except for paths starting with "\\?\"
- \\[server]\[sharename]\ <- UNC paths (Universal Naming Convention), Network shares etc.
- If a program can't handle UNC paths, mount the network share as a drive.
- Lookup case insensitive

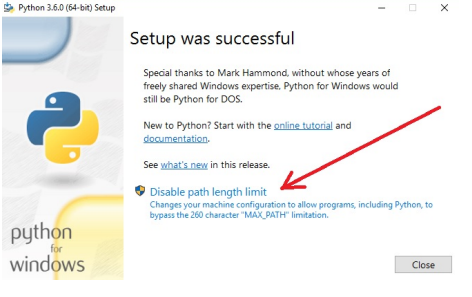
Windows

- Special reserved characters: <>:"/\|?*
- An easy way to get a valid filename is `urllib.parse.quote(path, '/\\')`
- Special reserved filenames: CON, PRN, AUX, NUL, COM1, COM2, COM3, COM4, COM5, COM6, COM7, COM8, COM9, LPT1, LPT2, LPT3, LPT4, LPT5, LPT6, LPT7, LPT8, and LPT9
- Of these "NUL" is useful, similar to `/dev/null` on Unix, see `os.devnull`

Unrelated Trick: Windows does env var expansion in various places like `explorer.exe`: `%USERPROFILE%/Downloads`. Most important directories have a corresponding env var you can use. Also see `os.path.expandvars()` in Python.

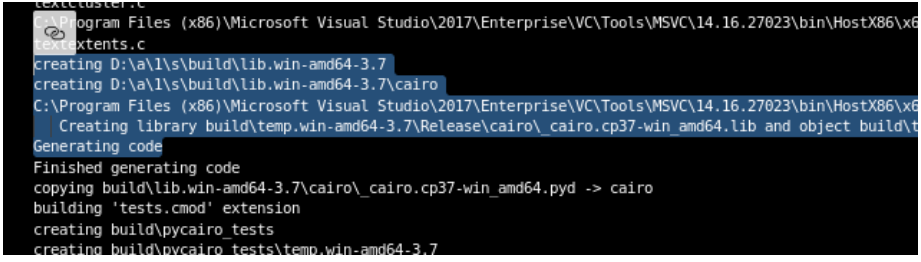
Windows Path Length Limit

- Windows has a very low limit for the path length by default -> 260
- In Windows 10 this limit can be removed for most functions, but needs changes to the system and the app.
- The Python Windows installer suggests adding the registry entry for you:



https://docs.python.org/3/using/windows.html?highlight=max_path#removing-the-max-path-limitation

Windows Path Length Limit



Microsoft being afrait to hit the path limit on Azure Pipelines

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Path length limit problems in meson:
https://github.com/mesonbuild/meson/issues/4226

Windows Path Encoding/API History

- On Windows instead of a locale encoding there is a "Windows Code Page" (also called ANSI Code Page)
- When Unicode came out Windows duplicated all its API and split it into ANSI versions and WIDE (wchar_t) version:
    - CreateDirectoryA: https://docs.microsoft.com/en-us/windows/win32/api/fileapi/nf-fileapi-create
    - CreateDirectoryW: https://docs.microsoft.com/en-us/windows/win32/api/fileapi/nf-fileapi-create
- They initially used UCS-2 but when Unicode got extended they switched to UTF-16
- Because they couldn't error out on surrogates they still allow them -> WTF-16

https://docs.microsoft.com/en-us/windows/win32/intl/unicode-in-the-windows-api

Windows Paths Python History

- When Unicode came out Python got the new `unicode` type and Windows got the WIDE APIs
- Using the `unicode` type with OS functions used the W APIs while using `str/bytes` used the A APIs. -> https://www.python.org/dev/peps/pep-0277/ (Python 2.3) "Unicode file name support for Windows NT"
- *mbcs* is an encoder for the active code page (a "meta encoder")
- Still the same split when Python3 came out: bytes uses A API, str uses W API. Paths can contain surrogates, this time not to smuggle bytes, but to smuggle themselves.

Problem: `bytes` work on Unix for paths, but on Windows they don't support Unicode. The code page is different on different Windows versions to somewhat support the local language.

Switch to UTF-8 on Windows

https://www.python.org/dev/peps/pep-0529/ (Python 3.6)

"Change Windows filesystem encoding to UTF-8"

- *sys.getfilesystemencoding() -> "mbcs" -> "utf-8"*
- Only uses W API now for *bytes* and *str*
- Since Python 3.6 *bytes* can be used on all platforms (easier to port things)
- What about surrogates? -> *"surrogatepass"* error handler

Printing Unicode Paths on Windows

https://www.python.org/dev/peps/pep-0528/ (Python 3.6)

> "Change Windows console encoding to UTF-8"

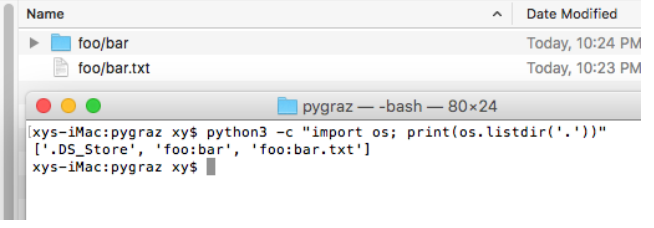
- Python used the ANSI APIs for communicating with the console
- The PEP makes stdout aspecial file object that communicates with console using `ReadConsoleW`/`WriteConsoleW`

This makes it finally possible to print Unicode filenames (and text) on Windows. (Piping to a file still problematic though)

```
>>> os.getcwdu()
u'C:\\Users\\\U00029e3d'
>>> print(os.getcwdu())
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
  File "C:\Python27\lib\encodings\cp850.py", line 12, in encode
    return codecs.charmap_encode(input,errors,encoding_map)
UnicodeEncodeError: 'charmap' codec can't encode characters in position 9-10: ch
aracter maps to <undefined>
>>> _
```

macOS

- Unicode support in the kernel. sys.getfilesystemencoding() == utf-8, always!
- Sadly they use Unicode normalization, which adds another special case to the OS mix.
- (old fun fact) macOS 9 used ":" as a path separator not "/" (Python 2 had a macpath module for this). When creating a file "foo:bar" Finder will show "foo/bar" and vice versa



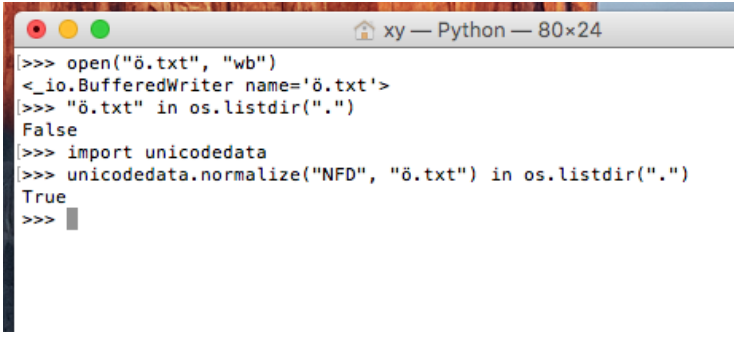
https://stackoverflow.com/a/13298479

Unicode Normalization

```
>>> a = "ö"
>>> norm = unicodedata.normalize("NFD", "ö")                    #
>>> len(norm)
2
>>> norm
'o■'
>>> norm[0]
'o'
>>> norm[1]
'■'
>>> norm2 = unicodedata.normalize("NFC", norm)
>>> len(norm2)
1
>>> norm2
'ö'
>>>
```

https://en.wikipedia.org/wiki/Unicode_equivalence

Unicode Normalization on macOS



- This is on HFS+ (the older file system).
- APFS no longer does any normalization (or only on lookup according to some sources?? I don't have a APFS system right now)

```
unicodedata.normalize("NFD", a) == unicodedata.normalize("NFD", b)
```

pathlib.Path

- https://docs.python.org/3/library/pathlib.html / https://www.python.org/dev/peps/pep-0428/ (Python 3.4)
- Split into two layers, PurePath and Path, allows working with Windows paths on Linux and vice versa
- Normalizes on construction (`Path("/bin/.").name == "bin"`)
- Combines various os/os.path/os.stat APIs into one class. Nicer type annotations and auto completion in IDEs
- Didn't see much usage with 3.4/3.5 as it always needs to be converted to str when you pass it to the OS

pathlib.Path

- Attempt to save it -> https://www.python.org/dev/peps/pep-0519/ (Python 3.6)
- PEP: adds os.PathLike, __fspath__(), os.fspath()
- __fspath__() like __int__(), os.fspath() like int(), but str or bytes and not int. pathlib.Path() implements it.
- Usable with most stdlib functions that take paths, more got added in 3.7/8.
- Usable with your own API if you use os.fspath()!

```
@abc.abstractmethod
 def __fspath__(self) -> Union[str, bytes]:
     ...
```

Serialization

1. Write a path of a recently used file to a config file
2. Transfer a path between process over some IPC mechanism

- Windows Paths: Not strictly Unicode, so no utf-8 possible
- Linux Paths: Can by anything
- macOS Paths: utf-8 work, no complications

---

1. For bytes transport we can use WTF-8 for Windows, bytes on Linux, utf-8 on macOS
2. For text: Convert to file URIs: `pathlib.Path(p).as_uri()` (doesn't support surrogates on Windows)

https://docs.python.org/3/library/pathlib.html#pathlib.PurePath.as_uri

WTF-8

https://simonsapin.github.io/wtf-8/

```
def to_wtf8(text):
    # merge surrogate pairs
    data = text.encode("utf-16-le", "surrogatepass")
    text = data.decode("utf-16-le", "surrogatepass")
    # write utf-8 like Python 2 did, surrogates included
    wtf8 = text.encode("utf-8", "surrogatepass")
    return wtf8
```

Used in rust for storing Windows paths in memory:

https://doc.rust-lang.org/std/ffi/struct.OsString.html

IMHO: What type should I use?

str or **pathlib** (3.6+)

- Works cross platform with all Python 3 versions in use.
- Easier to work with **str**. Mixing **bytes** and **str** can lead to bugs: `os.path.splitext(path)[1] == ".txt"`. Using `-bb` is a good idea when running your tests.
- str works with pathlib.Path
- Easy to combine with ASCII str: `"{}.txt".format(path)`
- With the POSIX locale ignored in 3.7 on 99% of systems all of **str** (minus surrogates) is usable, so if you assume well formed filenames you can just ingore all the error cases.

IMHO: How should I write APIs?

```
import os

def myfunc(path: Union[os.PathLike, bytes, str]):
    path = os.fspath(path)
    path = os.fsdecode(path)
    # path is a str now, so can be turned into Pathlib etc
    ...
    # if you want to match the stdlib fsencode again if it was bytes and
    # raise TypeError if types of multiple parameters don't match
```

IMHO: What should I watch out for?

- Python 3 > Python 2
- Python 3.7 > Python 3 (3.7 ignores the POSIX locale)
- Make sure the locale is set to UTF-8 (in your containers for example)
- When creating a file, *newpath in os.listdir()* might not be true because of Unicode normalization.
- When searching in filenames use Unicode normalization on everything.

- If you want to create Unicode filenames you can make sure the FS encoding is utf-8 and else error out and complain to the user. Like click: https://click.palletsprojects.com/en/5.x/python3/#python-3-surrogate-handling

/T/H/E/../E/N/D

https://senf.readthedocs.io <- The missing type, but Python 3 is fine now... :)