# Python and Unicode

Unicode Support in Python

Marc-André Lemburg

EGENIX.COM Software GmbH
Germany

# Python & Unicode: Overview

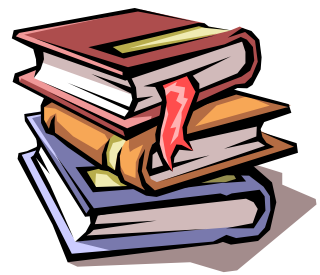
1. Introduction to Unicode
2. Python‘s Path to Unicode
3. Using Unicode in Python
4. The Future

# Python & Unicode: Part 1

1. Introduction to Unicode
2. Python‘s Path to Unicode
3. Using Unicode in Python
4. The Future

# Introduction to Unicode: **The Problem**

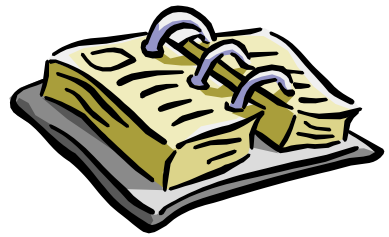
- Storing scripts: human readable text data
  - Localization (l10n) and Internationalization (i18n) of software and GUIs
  - Basis for national language and script support
  - Common ground for textual information exchange



# Introduction to Unicode: First Approximations

- Mappings of bytes to characters: Code Pages (CP)
  - Problem: Attaching the encoding information to the data
    - No support in the OS for maintaining per data buffer encoding information
    - Each application/protocol has to implement its own way of dealing with encodings
  - Problem: Scripts with many characters
    - e.g. Asian scripts use shift information to address all characters using 8 bits
  - Problem: Not available for ancient scripts
    - e.g. Old Italic
  - Problem: Incompatible mappings for the same script
    - e.g. Latin-1 and Windows CP-152x

# Introduction to Unicode: The Unicode Consortium Solution



- One encoding for all scripts of the world
- ASCII compatibility (even Latin-1)
- Includes character meta data
  - Case mapping information
  - Numeric conversion
  - Character category information
- Accounts for scripts using different orientations
- Enables sorting and normalization support

Also see the Unicode Consortium web-site at http://www.unicode.org/

# Introduction to Unicode: **Other Solutions**

- ISO 10646:
  The ISO way of defining a Universal Character Set
  - Code point compatible to Unicode
  - Some minor differences in interpretation
  - "Closed Source":
    standard documents are only available on a pay-per-page basis
  - Independent organization

# Introduction to Unicode: What is a Character ?

- Unicode Terminology


– Graphemes:


This is what users regard as a character.

– Code Points:


This is an Unicode encoding of the string.

– Code Units:


This is what the implementation stores (UTF-8).

# Introduction to Unicode: **Statistics**

- Unicode 3.0
  - released: September 1999
  - $17 * 2^{16} - 1 = 1114111 = 0x10FFFF$ code points (17 planes)
  - 49 194 assigned code points
  - No assigned code points outside plane 0, the Basic Multilingual Plane (BMP) which fits into 16 bits
- Unicode 3.1
  - released: May 2001
  - $17 * 2^{16} - 1 = 1114111 = 0x10FFFF$ code points (17 planes)
  - 94 140 assigned code points
  - Assigned code points in plane 1, no longer fits into 16 bits

# Introduction to Unicode: **Connecting to the Real World**

- Conversions between Unicode and Code Pages (CP)
  - Mapping tables are available at the Unicode web-site
  - Examples:
    - Latin-1 (Western Europe)
    - CP-1250 (Windows Western Europe)
    - KOI8-R (Cyrillic)
- Conversions between Unicode and other encodings
  - Special encoders/decoders (codecs) are required for each encoding
  - Examples:
    - Shift JIS, EUC-JP (Japanese)
    - Big5, EUC-TW (Chinese)

# Introduction to Unicode: **Encoding Issues (Part 1)**

- Round-trip safety
  - Unicode .. Encoding .. Unicode
    - UTF-7 (7-bit encoding, for e.g. email)
    - UTF-8 (8-bit encoding, 1-4 bytes per code point)
    - UTF-16 (16-bit encoding, endianness is an issue)
    - UTF-32 (32-bit encoding, memory / disk space intense)
    - These are loss-less encodings !
  - Encoding .. Unicode .. Encoding
    - Most code pages (IBM, Microsoft, etc.)
    - Asian encodings: Chinese, Japanese, Korean, Vietnamese (CJKV)
    - Not necessarily loss-less !

# Introduction to Unicode: **Encoding Issues (Part 2)**

- Identifying Encodings
  - Byte Order Marks (BOMs)
    - Originally: Marker for little vs. big endian for UTF-16/32
    - Microsoft: uses BOMs as Unicode file magic
  - Auto-Detection:
    - often requires knowledge about the encoded data
    - BOMs + file headers usually go a long way (e.g. for XML-data)
    - Protocols can have encoding meta information (e.g. HTTP Content-Type)

# Introduction to Unicode: Internal Storage Formats (Part 1)

- Unicode Transfer Format 8 (UTF-8):
  - 8-bit variable length encoding: 1-4 bytes per code point
  - Problem: indexing and slicing
- Universal Character Set 2 (UCS-2):
  - 16-bit fixed length encoding: 2 bytes per code point
  - Problem: not all code points are representable
- Unicode Transfer Format 16 (UTF-16):
  - 16-bit variable length encoding: 1-2 words per code point
  - Problem: indexing and slicing

# Introduction to Unicode: Internal Storage Formats (Part 2)

- Universal Character Set 4 (UCS-4):
  - 32-bit fixed length encoding: 4 bytes per code point
  - Requires ISO 10646 standards conformity
  - Problem: memory consumption
- Unicode Transfer Format 32 (UTF-32):
  - 32-bit fixed length encoding: 4 bytes per code point
  - Requires Unicode standards conformity
  - Problem: memory consumption

For a discussion about UTF-16 vs. UTF-32 see e.g.
http://mail.nl.linux.org/linux-utf8/2000-08/msg00025.html

# Introduction to Unicode: **Unicode Implementations**

- Java, Windows NT/2000
  - Basis: Unicode 2.x
  - 16-bit code units (UCS-2 / UTF-16)
  - Problem: Unicode 3.1 introduces characters which require two code units per code point (UTF-16)
- GNU libc 2.x
  - Basis: ISO 10646
  - 32-bit code units (UCS-4)
- Python 1.6 and later
  - Basis: Unicode 3.0
  - Versions 1.6 – 2.1: 16-bit code units (UCS-2)
  - Version 2.2: 32-bit code units as configuration option (UTF-32)

# Introduction to Unicode: **Comparing Unicode Strings**

- Problem: There are multiple ways to encode a characters

  Example: **é = e + ´**

- Solution: Normalization

  – Recode Unicode strings to help finding a common ground for comparisons (Unicode Annex #15)

  – Different forms are available:

    - FORM D: "Canonical Decomposition"
    - FORM C: "Canonical Decomposition, followed by Canonical Composition"
    - Other forms for normalization

# Introduction to Unicode: **Sorting Unicode Strings**

- Problem: Sorting order is locale/application specific

  Example:

  German phone book sorting order: A ... AE ... Ä ... AB ... B ...

- Solution: Collation Support

  – Recode Unicode strings into Collation Elements using a collation table (see Unicode Annex #10)

  – The Collation Elements can then be compared on an lexicographic basis as is done with ASCII

# Introduction to Unicode: **Conclusion**

- Unicode ...
  - solves real world problems
  - reduces the time / money effort it takes to internationalize software
  - simplifies managing text data
  - is a mature and stable standard
  - is open enough for everyone to adapt

# Python & Unicode: Part 2

1. Introduction to Unicode
2. Python‘s Path to Unicode
3. Using Unicode in Python
4. The Future

# Python's Path to Unicode: Motivation

- Why Unicode ?
  - All modern programming languages will have to support Unicode (sooner or later)
  - See the "Introduction to Unicode"
- Possible paths to Unicode support:
  1. Switch to Unicode as basic string type

     problem: compatibility
  2. Provide a separate Unicode type and integrate it with the existing string type

     problem: integration

  >>> Guido van Rossum chose Path 2.

# Python's Path to Unicode: **History**

Background: In 1999 Hewlett-Packard worked on a project called "e-speak" which was partly written in Python; for the i18n support they needed a Unicode type, so they joined the Python Consortium and contracted CNRI to have it implemented.

October 1999: Guido van Rossum subcontracted Fredrik Lundh to write an Unicode aware regular expression engine (SRE) and Marc-André Lemburg for the Unicode integration (deadline March 1st)

November 1999: First version of the Unicode integration proposal

March 2000: CVS checkin of the Unicode implementation and the SRE engine

September 2000: CNRI releases Python 1.6 with Unicode support

# Python's Path to Unicode: **Goals of the Implementation**

- Integration:
  Existing 8-bit strings and Unicode should integrate well with the ultimate goal to use them interchangeably

- Ease of use:
  Unicode should be just as easy to use as 8-bit strings

- Conversions:
  An extensible codec (encoder / decoder) library should enable built-in conversions between Unicode and other encodings

- Backward compatibility:
  Should be maintained if at all possible

# Python's Path to Unicode: When Strings meet Unicode

- Unicode is "more" than an 8-bit string:
  - coercion is always towards Unicode
- Problem: 8-bit strings don't carry any encoding information
  - When coercing 8-bit strings to Unicode Python must make an encoding assumption: the default encoding
  - Default encoding is a startup run-time parameter
- Question:
  Which default encoding to choose as default ?

# Python's Path to Unicode: **Default Encoding: UTF-8 ...**

- First approach:
  - Use UTF-8 as default encoding
- Problems:
  - Variable length encoding (1-4 bytes per code point)
  - Indexing can easily fail
  - len(s) not always == number of code points
  - Slicing can break the encoding
  - Common encodings like Latin-1 don't map well to UTF-8, e.g. all accented characters require two bytes

# Python's Path to Unicode: ... or let the locale decide ...

- Second approach:
  - Determine the encoding by querying the current locale
- Problems:
  - Python code is not portable:
    String literal in source code will receive different interpretations depending on the platform
  - Mixing Python code from different origins (locales) will likely fail at run-time
  - Some locales have more than one encoding in common use (e.g. Russia)

# Python's Path to Unicode: ... or let the BDFL decide !

- Final decision by Guido van Rossum:
  - Python's default for the default encoding is ASCII
- Problems:
  - Coercion errors are very common for all non-ASCII applications which mix 8-bit strings and Unicode
- Advantages:
  - Helps identify the problem areas in programs
  - Encourages: Explicit is better than implicit !
  - Works well for ASCII-users

# Python's Path to Unicode: **Features of the Implementation**

- Integration:
  Auto-coercion of 8-bit strings to Unicode based on the default encoding (usually ASCII)

- Internals:
  Uses UCS-2 for internal storage, based on Unicode 3.0

- Unicode Properties:
  Provide access to the Unicode property database via string methods

- Conversions:
  Provides codecs for most common (Western) encodings; codecs for Eastern encodings are available separately

# Python & Unicode: Part 3

1. Introduction to Unicode
2. Python‘s Path to Unicode
3. Using Unicode in Python
4. The Future

# Using Unicode in Python: **Overview**

- Creating Unicode objects in Python
- Converting Unicode to other encodings
- Working with files
- Writing a codec (encoder/decoder)

# Using Unicode in Python: **Creating Unicode objects**

- Unicode literals:
  - u"Hello World !" (note the small u)
- Unicode from 8-bit strings:
  - unicode("Hello World !", "latin-1")
- Unicode from files:
  - import codecs
  - f = codecs.open("myfile.txt", encoding="latin-1")
  - data = f.read()

# Using Unicode in Python: **Encoding Unicode**

- Using the Unicode method .encode(data [,encoding]):
  - u"ndré Le".encode("utf-8") (note the small u)

    = = "ndr\xc3\xa9 Le"
  - u"ndré Le".encode("latin-1")

    = = "ndr\xe9 Le"
  - u"ndré Le".encode() (default encoding)

    UnicodeError: ASCII encoding error: ordinal not in range(128)

# Using Unicode in Python: **Working with Files**

- The codecs module provides Unicode aware wrappers around file objects:
  - import codecs

  Read the data as UTF-8 and convert it to Unicode on-the-fly:
  - file = codecs.open("myfile.txt", encoding="utf-8")
  - data = file.read()

  Process the Unicode data (here: using Unicode methods):
  - data = data.upper()

  Write back the Unicode as UTF-16
  - file = codecs.open("myfile.txt", "wb", encoding="utf-16")
  - file.write(data)

# Using Unicode in Python: **Writing Codecs**

- A Latin-1 to UTF-8 recoder written as codec (latin1_to_utf8.py):

```
import codecs

# Encoding / decoding functions
def encode(latin1_data):
    return unicode(latin1_data, 'latin-1').encode('utf-8'), len(latin1_data)
def decode(utf8data):
    return unicode(utf8data, 'utf-8').encode('latin-1'), len(utf8data)


# StreamCodecs
class Codec(codecs.Codec):
   def encode(self, latin1_data): return encode(latin1_data)
   def decode(self, utf8data): return decode(utf8data)
class StreamWriter(Codec,codecs.StreamWriter):
   pass
class StreamReader(Codec,codecs.StreamReader):
   pass

# Codec registry entry point
def getregentry():
   return (encode, decode, StreamReader, StreamWriter)
```

# Python & Unicode: Part 4

1. Introduction to Unicode
2. Python‘s Path to Unicode
3. Using Unicode in Python
4. The Future

# The Future: Unicode Support in Python 2.2 and later

- Internals:
  Switch to UTF-32 to fully support Unicode 3.1and later
- Unicode Algorithms:
  Implement the Unicode collation algorithm, the compression algorithm and the normalization algorithms
- Unicode Helpers:
  Add helpers which allow indexing Unicode objects based on characters, code points, words and lines
- Conversions:
  Add fast codecs for Eastern encodings to the Python core (but as separate download)

# Questions...

Thank you for your time.

# Contact

eGenix.com Software, Skills and Services GmbH
Marc-André Lemburg
Postfach 1201
D-40737 Langenfeld
Germany

eMail: mal@egenix.com
Phone: +49 211 9304112
Fax: +49 211 3005250
Web: http://www.egenix.com/