An Introduction to Unicode

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What's Unicode?

- 21-bit coded character set
- Includes property data, rules and algorithms
- Aims to cover all human writing systems currently in use
- Also covers some obsolete systems for scholarly use

ISO-10646

- A standard list of characters that is the same as the Unicode list of characters
- Looks more official as a reference
- The Unicode Standard is more than the list
- Just refer to Unicode
- Specs that are available on the Web win

Why Unicode?

- Multiple encodings are trouble
- Legacy repertoires often too narrow
- Mutually exclusive repertoires are bad
  - Why should the user have to pick either German or Russian support?
- Display layer late binding prevents smart processing based on character semantics

Resistance is Futile

- Immense momentum towards Unicode
  - XML, HTML 4…
  - Java, C#, Python, Perl 5.8, JavaScript…
  - Mac OS X, Windows 2000, Gnome 2…
- Apple, Microsoft, IBM, Sun, Gnome Foundation, W3C, IETF all pulling to the same direction!

You Will be Assimilated

- Better to conform now than to fight and conform later
- Your boss wants XML; XML wants Unicode
- Need €? ISO-8859-15 is just fire fighting!

Free Your Mind

- People have a lot of prior assumptions that are not true of Unicode
  - Some of them were true with more primitive text encodings and fonts
- It helps not to assume these things
- For example, there's no *single* "Unicode encoding" for interchange

Misconceptions

- Unicode character = 16 bits
- Character = glyph
- Code point = glyph index
- Selection unit = glyph
- Key press = character
- Caret moves character by character

More Misconceptions

- I am European / American / Japanese.
  I don’t need to know about Unicode.
- Displaying Chinese is the hardest problem
- Once you’ve tackled CJK, you’re done
- Unicode is just “wide ISO-8859-1”—the same way ISO-8859-1 is “wide ASCII”
- Klingon is in Unicode

Glyph

- An atomic shape in a font
- Different glyphs: a *a* **a** A *A* **A**
- One glyph: ä ﬁ
- Two glyphs: ą fi
- Glyph sharing between Latin, Greek and Cyrillic possible (leads to Latin dominance)

Grapheme

- Fuzzy concept
- A graphical unit as perceived by a user
- May consist of multiple glyphs
- Eg. base character plus diacritics

Abstract Character

- A is A regardless of font
  - A A A A A A A A A A A A A A A A A
- Greek A and Cyrillic A are distinct
- Upper and lower case are distinct

Control Characters

- Ambiguous controls from ASCII
  - Line feed, carriage return, etc.
- New ones
  - Ligature modifiers, less ambiguous paragraph separators, etc.

Combining Characters

- How many characters: ä?
  - One: LATIN SMALL LETTER A WITH DIAERESIS
  - Two: LATIN SMALL LETTER A + COMBINING DIAERESIS
- Precomposed vs. decomposed
  - Canonical equivalence
  - Normalization forms

Presentation Forms

- fi: LATIN SMALL LETTER F + LATIN SMALL LETTER I
- ﬁ: LATIN SMALL LIGATURE FI
- Presentation forms as characters for compatibility with legacy encodings
  - Compatibility equivalence
  - Normalization forms

Normalization Forms

	Precomposed	Decomposed
Compatibility chars intact	NFC	NFD
Compatibility decomposition	NFKC	NFKD

Normalization Forms

↔

↓

NFC	NFD
NFKC	NFKD

Unicode as “Wide ASCII”

- Requires precomposed form
- Workable with
  - Latin, Greek, Cyrillic, Armenian, Georgian
  - Chinese, Japanese, modern Korean
  - Ogham, Runic, …

What’s Latin?

- Not just A–Z with a mix of diacritics
- IPA
- IPA-based characters in African writing
  - The poorest people have the strangest characters
  - Font availability problems

Latin Complications

- Sorting with local conventions
- Searching
  - Case-insensitive?
  - Diacritic-insensitive?
- Turkısh i

Sorting

- How to sort ä?
  - Finnish, Swedish:
    letter on own right; sort after z and å
  - English, French:
    a with diacritic; sort after a
  - German phonebook:
    alternative of ae; sort between ae and af

Case Mapping

- German ß
- Turkısh i
- Croatian digraphs
- Greek also: Final sigma

Diacritic Appearance

- Caron and cedilla may look different
- Naïve combinations in Gill Sans: ģ ķ ď ť
- Helvetica: ģ ķ ď ť
- Some fonts have alternative glyphs
- Core fonts biased towards bigger markets

Han Unification

- CJK ideographs share a Chinese origin
- If encoded thrice, even common ideographs wouldn’t fit in the BMP
- An ideograph that appears across CJK is considered one character (unified)
- Controversial: Imposed by Westeners

GB18030

- Instead of endorsing Unicode, China made a new standard on its own…
- …And outlawed the sale of non-conforming software products!
- The sane conformance strategy: Unicode internally, Unicode extended to cover GB18030, converters for IO, huge font (even if ugly) provided with the OS

Beyond “Wide ASCII”

- One-to-one character to glyph mapping and left to right glyph placement on the baseline not enough for all writing systems
- Right to left, ligatures, positional forms, combining marks, reordering…

Different Cultural Expectations

- Latin
  - History of adapting writing to technology
  - Dumbed-down typography tolerated
- Arabic
  - Calligraphic appearance retained in print
  - Contextual shaping expected up front

Progressive Latin Featuritis

`ALL UPPER CASE MONOSPACE`

`English with lower case`

`Éüröpéän çhäräçtérs`

Variable-width glyphs

“Quotes”—even dashes

Type with kerning pairs

Specific automatic ligatures

A̦b̋it̯̮rạ̗̐̏rỵ̻ diacritics

Full support for arbitrary shaping

Bidi

- Bidirectional layout needed for Hebrew, Arabic, etc.
- Characters stored and typed in logical order
- Characters have inherent directionality: LTR (eg. a), RTL (eg. א) or neutral (eg. ?)
- Need to know dominant direction

Positional Forms

- Required for Arabic
- Abstract character stored – glyph varies
- Isolated ف, final ـف, medial ـفـ, initial فـ
- Can be used as an effect with Latin: *aa*

Grapheme Boundaries

	E̊x̜̆am̜̆p̆l̜e̊	यूनिकोड क्या है
Caret stops	E̊x̜̆am̜̆p̆l̜e̊	यूनिकोड क्या है
Backspaces	7	15
Characters	15	15

Hangul

- Alphabet–syllabary duality
- A syllable block (한) consists of alphabetic letters called jamo (ㅎ ㅏ ㄴ)
- When treated as an alphabet, layout software needs to group letters as blocks
- Precomposed syllable characters for modern Korean only

Fonts

- Type 1 format inadequate
- TrueType more extensible
  - Extended TrueType (.ttf)
  - OpenType (.otf)
  - Apple Advanced Typography (.dfont)

Extended TrueType

- Like old TrueType but with a larger repertoire and Unicode mapping
- May contain additional tables for OpenType "smart font" features

OpenType

- Extended TrueType with Type 1 geometry
- Provides a migration path for foundries with a heavy investment in Type 1 fonts
- Backed by Adobe and Microsoft

Apple Advanced Typography

- Resurrected GX
- More advanced shaping than in OpenType
- Features overlap with OpenType
- Only supported by Apple
- Advanced features not supported by Adobe’s cross-platform font engine

Printing

- PostScript and PDF have an old-style notion of a font
  - A font is basically an array of hinted glyphs (with advances)
- Need to build magic into a printing library that lets apps use new-style fonts and complex text layout

Printing, continued

- Auto-generate embedded fonts with up to 256 glyphs in each
  - Type 1 or 42 depending on glyph data
- Position glyphs individually
- Recovering intelligible text gets ugly
  - PDF *may* contain reverse mappings

Unicode Encoding Forms and Schemes

- More than one way to store sequences of code points
- Unicode Encoding Form: Representation as in-memory *code units* (32, 16 or 8 bits)
- Unicode Encoding Scheme: Representation as bytes for interchange
  - Encoding Form + byte order

UTF-32

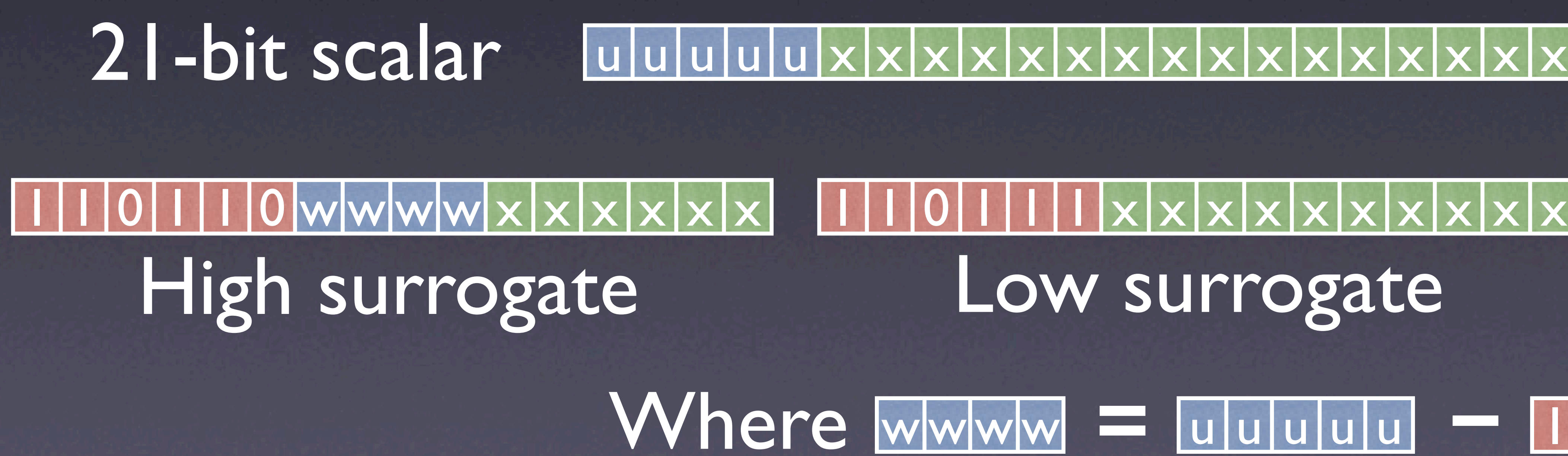
- 32-bit code units
- One code unit per code point
- Straight-forward
- Wastes space
- Byte order issues with serialization
- Don’t use for interchange

UTF-16

- 16-bit code units
- Extension to the original UCS-2 encoding
- BMP characters take one code unit
- Astral characters take two code units (surrogate pair)

Surrogates

- Chars above U+FFFF don’t fit in 16 bits
- Represented in UTF-16 as a *surrogate pair* consisting of two 16-bit code units



Byte Order Mark (BOM)

- U+FEFF written at the start of a data stream
- U+FFFE guaranteed to be unassigned
- If a UTF-16 data stream starts with 0xFFFE, swap bytes
- Also considered an encoding signature or magic number for UTF-16

UTF-8 – One Encoding to Rule Them All

- 8-bit code units
- A character is encoded as 1…4 bytes
- Invented by Ken Thompson
  (Yes, *that* Ken Thompson)
- "Is UTF-8 a racist kludge or a stroke of genius?" – Tim Bray

UTF-8 Byte Sequences

0xxxxxxx

110xxxxx 10xxxxxx

1110xxxx 10xxxxxx 10xxxxxx

11110xxx 10xxxxxx 10xxxxxx 10xxxxxx

Racist Kludge?

- Compared to UTF-16…
  - English text shrinks by 50%
  - Asian text expands by 50%
- The status of ASCII is a historical reality
- Not a real technical problem: Use gzip!
- One ideograph vs. many alphabetic letters

Stroke of Genius?

- ASCII is ASCII (one byte per character)
  - Including control characters!
- Other characters don't overlap with ASCII
- No byte order issues
- Byte-wise lex sort = code point lex sort
- Implemented using bitwise operations – no multiplication, division or look-up tables

Benefits of ASCII Identity of UTF-8

- \0 termination
- Unix file system compatibility
- Retrofitting text terminals with Unicode
- Works over SMTP without Base64
- Byte-oriented parsing of grammars where non-ASCII occurs only in string literals

UTF-8 Disadvantages

- No O(1) random access by character index
  - Not such a big deal
  - Doesn't work with UTF-16, either, in the presence on astral characters
- Harder to look inside a string than with UTF-16
- Space requirement for Asian text

Other Unicode Encoding Schemes

- UTF-7
  - RFC 2152; obsolete email encoding
- CESU-8
  - Formalization of broken UTF-8
- Punycode
  - RFC 3492; only for IDNs

Compressed Representations

- SCSU
  - Not deterministic
- BOCU-1
  - MIME text/* compatible
  - Byte-wise lex sort = code point lex sort
  - Deterministic

Dealing with Encodings

- Unicode is designed to be round-trip compatible with legacy encodings
  - Legacy encodings can easily be converted to Unicode

Encodings on Input

- Convert input into your internal Unicode encoding form at the first opportunity
- When dealing with XML, let the XML processor do this for you

Encodings on Output: XML

- XML processors are required to support two encodings: UTF-8 and UTF-16
  - Using any other encoding takes more work and is unsafe
- Use explicit XML declaration with UTF-8
- Use xml:lang for CJK disambiguation
- Don’t use text/xml; use application/xml

Encodings on Output: HTML

- Use UTF-8
- The only serious browser in recent memory that does not support UTF-8 is Opera 5
- Even Netscape 4 and Lynx support UTF-8

Encodings on Output: text/plain Mail

- The lazy way: Use UTF-8
  - Tell pine users to install the iconv patch
- The compatible way: Adaptive encoding
  - Try ASCII, ISO-8859-1, Windows-1252…
  - UTF-8 as last resort
- Always declare the encoding properly

Normalization and IO

- Unless otherwise required by protocol, use NFC for output
- To be safe, normalize input data to your required form yourself

C

- \0-terminated UTF-8 strings
  - Preferred by Gnome libraries
  - Smuggling Unicode through legacy code
- 0x0000-terminated UTF-16 strings
  - Preferred by APIs from Apple, Microsoft and IBM

UTF-16 in C

- wchar_t not portable
  - Can be 1, 2 (MS) or 4 (GNU) bytes wide
- Everyone has a typedef for UTF-16
  - UniChar, UChar, gunichar2, PRUnichar, …

String Tools for C

- ICU from IBM
- glib
- CoreFoundation

C APIs for Imaging

- ATSUI (Mac OS X)
- Pango aka. Παν語 (Gnome)
- Uniscribe (Windows)

C APIs for Imaging, continued

- Handle hit testing / selection / caret movement on behalf of the app
- At their best when driven with paragraph-sized chunks
- Problematic with apps that expect to do almost everything themselves

C++

- No universally accepted Unicode string class library (as usual with C++…)
- C-style UTF-8 or UTF-16 strings needed as common ground between libraries

Java

- Originally assumes character = 16 bits (“Wide ASCII” mindset in API design)
- Treat Strings and char[]s as UTF-16
- Normalization and other cool tools available in ICU4J by IBM
- Never trust the platform default encoding! Know what encoding you are using for IO!

C#

- Strings are indexed by UTF-16 code units as in Java

JavaScript

- Strings are indexed by UTF-16 code units as in Java

Objective-C (on OS X)

- NSStrings are indexed by UTF-16 code units as in Java
- NSString provides methods for normalization
- Comparison considers canonical equivalence

Python

- Byte strings and Unicode strings since Python 2.0
- UTF-16 or UTF-32 depending on how the interpreter was compiled! (Cf. PEP 261)
  - UTF-16: Jython, Apple
  - UTF-32: Debian

Perl

- Byte and Unicode strings since Perl 5.6
- Avoid versions earlier than Perl 5.8
- Strings are indexed by UTF-32 code units
- Normalization in Unicode::Normalize
- Character class & name data

AppleScript

- Legacy MacRoman strings (string)
- UTF-16 strings (Unicode text)
  - Badly documented and supported
  - Script Editor can’t display astral chars
- “International Text” means locale-specific legacy Mac encodings

PHP4

- No notion of a Unicode string
  - Strings are byte strings (can hold UTF-8)
- No supporting library functions by default, either
  - Optional iconv and mb_ functions

Don’t Trust the Documentation

- “Unicode character” in API docs often means a UTF-16 code unit
- Even when docs say “UCS-2”, UTF-16 may be supported
- When docs say “UTF-8”, the implementation may use CESU-8
- Always test with astral chars yourself!

References

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