

Unicode and its s: normalisation, Han unification and more →

2017

<https://github.com/gyng/book/tree/master/slides/unicode>

1. Some background
2. Unicode and UTF-*x*
3. Programmer pitfalls

```
> 1 + 1;
```

```
← 2
```

```
> 1 + 1;
```

```
←  SyntaxError: illegal character 
```

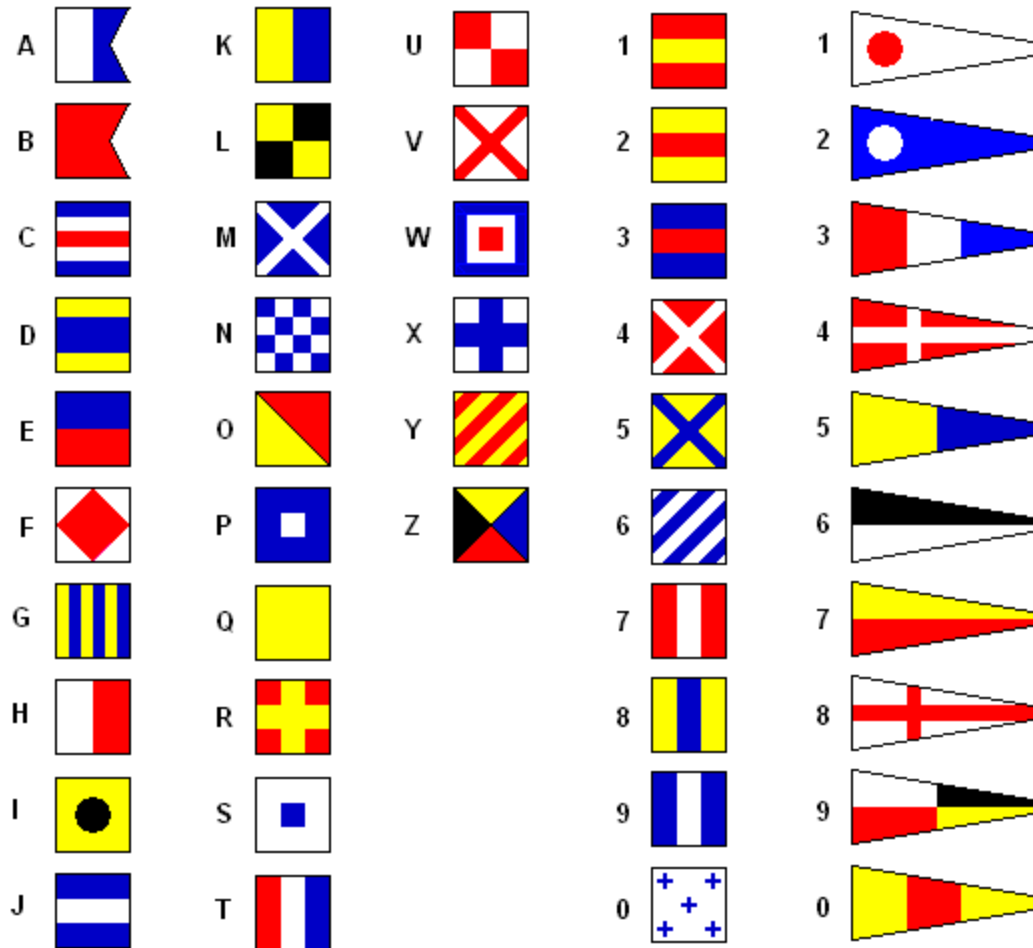
Encodings

not encryption

Braille

[illegible]

"Ancient" encodings



Maritime Signal Flags

Penants

"Ancient" encodings — Morse

M	O	R	S	E		C	O	D	E
--	---	...	...	.	(space)	----	---	...	.

- Three letters: $\{_, ., EOW\}$
- Variable-width letters

併	低	休	仰	仃	亢	予	弟	中	七
〇一八四	〇一六四	〇一四四	〇一二四	〇一〇四	〇〇八四	〇〇六四	〇〇四四	〇〇二四	〇〇〇四
倍	住	伙	仔	仆	交	事	乏	丰	丈
〇一八五	〇一六五	〇一四五	〇一二五	〇一〇五	〇〇八五	〇〇六五	〇〇四五	〇〇二五	〇〇〇五
份	佐	伯	伶	仇	亥		乖	串	三
〇一八六	〇一六六	〇一四六	〇一二六	〇一〇六	〇〇八六	〇〇六六	〇〇四六	〇〇二六	〇〇〇六
使	佑	估	仲	今	亦		乘		上
〇一八七	〇一六七	〇一四七	〇一二七	〇一〇七	〇〇八七	〇〇六七	〇〇四七	〇〇二七	〇〇〇七
侃	佔	佚	伙	介	享	二			下
〇一八八	〇一六八	〇一四八	〇一二八	〇一〇八	〇〇八八	〇〇六八	〇〇四八	〇〇三八	〇〇〇八
來	何	你	低	仍	荒	于		丷	不
〇一八九	〇一六九	〇一四九	〇一二九	〇一〇九	〇〇八九	〇〇六九	〇〇四九	〇〇二九	〇〇〇九
侈	伐	昵	件	仔	亨	云		丸	丐
〇一九〇	〇一七〇	〇一五〇	〇一三〇	〇一一〇	〇〇九〇	〇〇七〇	〇〇五〇	〇〇三〇	〇〇一〇
例	余	伴	件	仕	京	互	乙	凡	丑
〇一九一	〇一七一	〇一五一	〇一三一	〇一一一	〇〇九一	〇〇七一	〇〇五一	〇〇三一	〇〇一一
侍	余	伶	攸	他	亭	五	九	丹	且
〇一九二	〇一七二	〇一五二	〇一三二	〇一一二	〇〇九二	〇〇七二	〇〇五二	〇〇三二	〇〇一二
侏	佛	伸	价	仗	亮	井	乞	主	丕
〇一九三	〇一七三	〇一五三	〇一三三	〇一一三	〇〇九三	〇〇七三	〇〇五三	〇〇三三	〇〇一三
恤	作	伺	任	付	毫	亘	也		世
〇一九四	〇一七四	〇一五四	〇一三四	〇一一四	〇〇九四	〇〇七四	〇〇五四	〇〇三四	〇〇一四
侑	佞	伴	仿	仙	亘	互	乚		丘
〇一九五	〇一七五	〇一五五	〇一三五	〇一一五	〇〇九五	〇〇七五	〇〇五五	〇〇三五	〇〇一五
侔	佟	似	企	全	豐	况	乳	丿	丙
〇一九六	〇一七六	〇一五六	〇一三六	〇一一六	〇〇九六	〇〇七六	〇〇五六	〇〇三六	〇〇一六
侗	佩	伽	仇	仞		些	乾	父	丞
〇一九七	〇一七七	〇一五七	〇一三七	〇一一七	〇〇九七	〇〇七七	〇〇五七	〇〇三七	〇〇一七
侗	侗	侗	伊	任		西	劑	乃	主

“Ancient” encodings — Chinese telegraph code

電 碼

7193 4316

--... .---- ----. ...-- /- ...-- .---- -....

EGL EWS

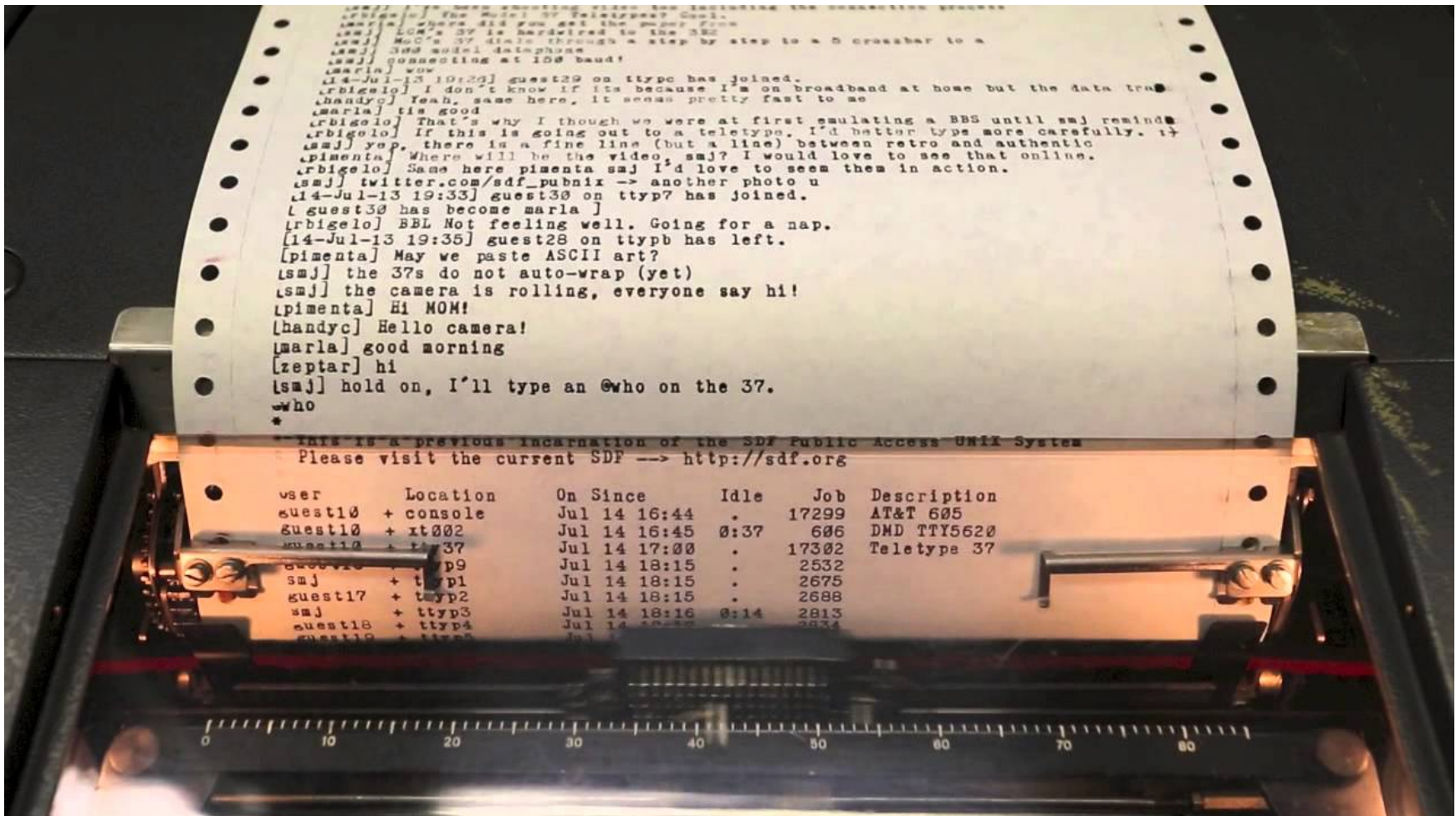
. --. .-.. / . .-- ...

- Same characters, different encodings, different lengths
- The *code point* (電 = 7193) is not the *encoding* (morse)

ASCII

Dec	Hex		Dec	Hex		Dec	Hex		Dec	Hex		Dec	Hex		Dec	Hex	
0	00	NUL	16	10	DLE	32	20		48	30	0	64	40	@	80	50	P
1	01	SOH	17	11	DC1	33	21	!	49	31	1	65	41	A	81	51	Q
2	02	STX	18	12	DC2	34	22	"	50	32	2	66	42	B	82	52	R
3	03	ETX	19	13	DC3	35	23	#	51	33	3	67	43	C	83	53	S
4	04	EOT	20	14	DC4	36	24	\$	52	34	4	68	44	D	84	54	T
5	05	ENQ	21	15	NAK	37	25	%	53	35	5	69	45	E	85	55	U
6	06	ACK	22	16	SYN	38	26	&	54	36	6	70	46	F	86	56	V
7	07	BEL	23	17	ETB	39	27	'	55	37	7	71	47	G	87	57	W
8	08	BS	24	18	CAN	40	28	(	56	38	8	72	48	H	88	58	X
9	09	HT	25	19	EM	41	29	)	57	39	9	73	49	I	89	59	Y
10	0A	LF	26	1A	SUB	42	2A	*	58	3A	:	74	4A	J	90	5A	Z
11	0B	VT	27	1B	ESC	43	2B	+	59	3B	;	75	4B	K	91	5B	[
12	0C	FF	28	1C	FS	44	2C	,	60	3C	<	76	4C	L	92	5C	\
13	0D	CR	29	1D	GS	45	2D	-	61	3D	=	77	4D	M	93	5D]
14	0E	SO	30	1E	RS	46	2E	.	62	3E	>	78	4E	N	94	5E	^
15	0F	SI	31	1F	US	47	2F	/	63	3F	?	79	4F	O	95	5F	_

<http://www.catb.org/esr/faqs/things-every-hacker-once-knew/>



<https://youtu.be/MikoF6KZjm0?t=289>

ASCII

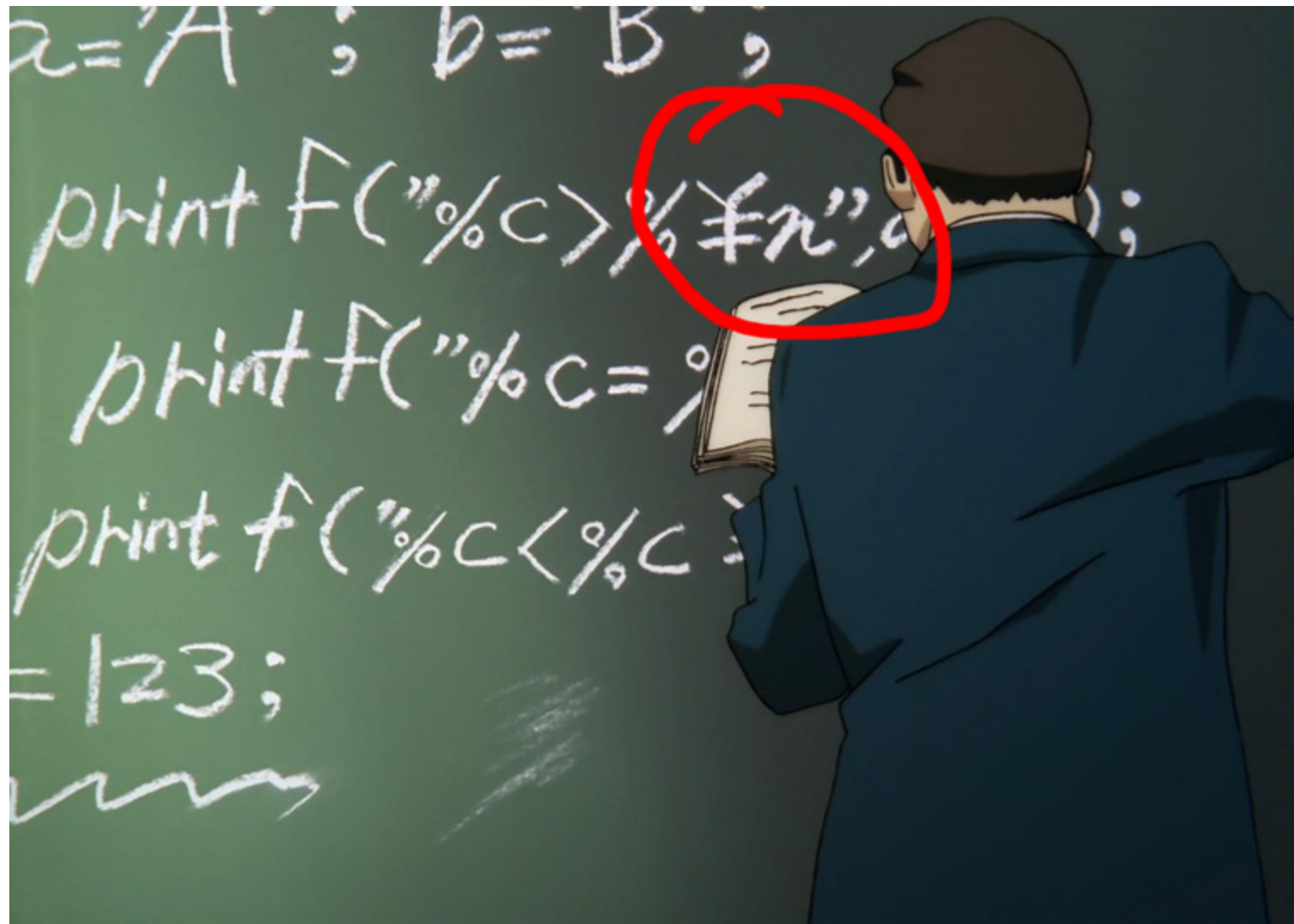
- 1963
- American Standard Code for Information Interchange
- 7-bit (8th bit used for parity)
- $2^7 = 128$ possible values

ASCII

- 0–31 are control characters `NUL` `CR` `LF` `DEL` etc.
- 32–126 are punctuation, numerals and letters
- `_` in binary: `0100000` = 32
- `A` in binary: `1000001` = 65
- `a` in binary: `1100001` = 65 + 32 = 97
- Alternative: IBM's EBCDIC (also 1963)

Modified ASCII

- Extended ASCII (8-bit, has more characters ç ü ☒ ğ æ)
- Modified 7-bit ASCII exist
 - # → £ on UK teletypes
 - \ → ¥ in Japan (Shift-JIS)
 - \ → ₩ in Korea (EUC-KR)



ASCII Highlights

Control characters

- `CR` Moves the print head to the left margin
- `LF` Scrolls down one line
- `DEL` Backspace and delete
- `BEL` Rings the (physical) bell

```
sleep 3 && echo $'\a'
```


Problems with ASCII

- Latin-centric
- Everybody else came up with their own encodings
- Alternative ASCII sets cause problems with interchange
- Mojibake (文字化け): JIS, Shift-JIS, EUC, and Unicode
- No emoji, only emoticons :-)









Dark ages

- ???
- ???
- ???
- ???
- ???
- Xerox Character Code Standard (XCCS), 1980

Early telecommunications	Chinese, Cyrillic · Needle telegraph codes
ISO/IEC 8859	-1 · -2 · -3 · -4 · -5 · -6 · -7 · -8 · -9 · -10 · -11 · -12 · -13 · -14 · -15 · -16
Bibliographic use	ANSEL · ISO 5426 / 5426-2 / 5427 / 5428 / 6438 / 6861 / 6862 / 10585 / 10586 / 10754 / 11822 · MARC-8
National standards	ArmSCII · BraSCII · CNS 11643 · ELOT 927 · GOST 10859 · GB 18030 · HKSCS · ISCII · JIS X 0201 · JIS X 0208 · JIS X 0212 · JIS X 0213 · KOI-7 · KPS 9566 · KS X 1001 · PASCII · SI 960 · TIS-620 · TSCII · VISCI · YUSCII
EUC	CN · JP · KR · TW
ISO/IEC 2022	CN · JP · KR · CCCII
MacOS code pages ("scripts")	Arabic · Celtic · CentEuro · ChineseSimp / EUC-CN · ChineseTrad / Big5 · Croatian · Cyrillic · Devanagari · Dingbats · Esperanto · Farsi · Gaelic · Greek · Gujarati · Gurmukhi · Hebrew · Iceland · Japanese / ShiftJIS · Korean / EUC-KR · Latin-1 · Roman · Romanian · Sámi · Symbol · Thai / TIS-620 · Turkish · Ukrainian
DOS code pages	100 · 111 · 112 · 113 · 151 · 152 · 161 · 162 · 163 · 164 · 165 · 166 · 210 · 220 · 301 · 437 · 449 · 489 · 620 · 667 · 668 · 707 · 708 · 709 · 710 · 711 · 714 · 715 · 720 · 721 · 737 · 768 · 770 · 771 · 772 · 773 · 774 · 775 · 776 · 777 · 778 · 790 · 850 · 851 · 852 · 853 · 854 · 855/872 · 856 · 857 · 858 · 859 · 860 · 861 · 862 · 863 · 864/17248 · 865 · 866/808 · 867 · 868 · 869 · 874/1161/1162 · 876 · 877 · 878 · 881 · 882 · 883 · 884 · 885 · 891 · 895 · 896 · 897 · 898 · 899 · 900 · 903 · 904 · 906 · 907 · 909 · 910 · 911 · 926 · 927 · 928 · 929 · 932 · 934 · 936 · 938 · 941 · 942 · 943 · 944 · 946 · 947 · 948 · 949 · 950/1370 · 951 · 966 · 991 · 1034 · 1039 · 1040 · 1041 · 1042 · 1043 · 1044 · 1046 · 1086 · 1088 · 1092 · 1093 · 1098 · 1108 · 1109 · 1114 · 1115 · 1116 · 1117 · 1118 · 1119 · 1125/848 · 1126 · 1127 · 1131/849 · 1139 · 1167 · 1168 · 1300 · 1351 · 1361 · 1362 · 1363 · 1372 · 1373 · 1374 · 1375 · 1380 · 1381 · 1385 · 1386 · 1391 · 1392 · 1393 · 1394 · Kamenický · Mazovia · CWI-2 · KOI8 · MIK · Iran System
IBM AIX code pages	367 · 371 · 806 · 813 · 819 · 895 · 896 · 912 · 913 · 914 · 915 · 916 · 919 · 920 · 921/901 · 922/902 · 923 · 952 · 953 · 954 · 955 · 956 · 957 · 958 · 959 · 960 · 961 · 963 · 964 · 965 · 970 · 971 · 1004 · 1006 · 1008 · 1009 · 1010 · 1011 · 1012 · 1013 · 1014 · 1015 · 1016 · 1017 · 1018 · 1019 · 1029 · 1036 · 1089 · 1111 · 1124 · 1129/1163 · 1133 · 1350 · 1382 · 1383
IBM Apple Macintosh Emulations	1275 · 1280 · 1281 · 1282 · 1283 · 1284 · 1285 · 1286
IBM Adobe Emulations	1038 · 1276 · 1277
IBM DEC Emulations	1020 · 1021 · 1023 · 1090 · 1100 · 1101 · 1102 · 1103 · 1104 · 1105 · 1106 · 1107 · 1287 · 1288
IBM HP Emulations	1050 · 1051 · 1052 · 1053 · 1054 · 1055 · 1056 · 1057 · 1058
Windows code pages	CER-GS · 874/1162 (TIS-620) · 932/943 (Shift JIS) · 936/1386 (GBK) · 950/1370 (Big5) · 949/1363 (EUC-KR) · 1169 · 1174 · Extended Latin-8 · 1200 (UTF-16LE) · 1201 (UTF-16BE) · 1250 · 1251 · 1252 · 1253 · 1254 · 1255 · 1256 · 1257 · 1258 · 1259 · 1261 · 1270 · 54936 (GB18030)
EBCDIC code pages	1 · 2 · 3 · 4 · 5 · 6 · 7 · 8 · 9 · 10 · 11 · 12 · 13 · 14 · 15 · 16 · 17 · 18 · 19 · 20 · 21 · 22 · 23 · 24 · 25 · 26 · 27 · 28 · 29 · 30 · 31 · 32 · 33 · 34 · 35 · 36 · 37/1140 · 38 · 39 · 40 · 251 · 252 · 254 · 256 · 257 · 258 · 259 · 260 · 264 · 273/1141 · 274 · 275 · 276 · 277/1142 · 278/1143 · 279 · 280/1144 · 281 · 282 · 283 · 284/1145 · 285/1146 · 286 · 287 · 288 · 289 · 290 · 293 · 297/1147 · 298 · 300 · 310 · 320 · 321 · 322 · 330 · 351 · 352 · 353 · 355 · 357 · 358 · 359 · 360 · 361 · 363 · 382 · 383 · 384 · 385 · 386 · 387 · 388 · 389 · 390 · 391 · 392 · 393 · 394 · 395 · 410 · 420/16804 · 421 · 423 · 424/8616/12712 · 425 · 435 · 500/1148 · 803 · 829 · 833 · 834 · 835 · 836 · 837 · 838/838 · 839 · 870/1110/1153 · 871/1149 · 875/4971/9067 · 880 · 881 · 882 · 883 · 884 · 885 · 886 · 887 · 888 · 889 · 890 · 892 · 893 · 905 · 918 · 924 · 930/1390 · 931 · 933/1364 · 935/1388 · 937/1371 · 939/1399 · 1001 · 1002 · 1003 · 1005 · 1007 · 1024 · 1025/1154 · 1026/1155 · 1027 · 1028 · 1030 · 1031 · 1032 · 1033 · 1037 · 1047 · 1068 · 1069 · 1070 · 1071 · 1073 · 1074 · 1075 · 1076 · 1077 · 1078 · 1079 · 1080 · 1081 · 1082 · 1083 · 1084 · 1085 · 1087 · 1091 · 1097 · 1112/1156 · 1113 · 1122/1157 · 1123/1158 · 1130/1164 · 1132 · 1136 · 1137 · 1150 · 1151 · 1152 · 1159 · 1165 · 1166 · 1278 · 1279 · 1303 · 1364 · 1376 · 1377 · JEF · KEIS
Platform specific	Acorn · Adobe Standard · ATASCII · Atari ST · BICS · Casio calculators · CDC · CPC · DEC Radix-50 · DEC MCS/NRCS · DG International · ELWRO-Junior · FIELDATA · GEM · GEOS · GSM 03.38 · HP Roman Extension · HP Roman-8 · HP Roman-9 · HP calculators · LICS · LMBCS · NEC APC · NeXT · PETSCII · Sharp calculators · TI calculators · Ventura International · Ventura Symbol · WISCII · XCCS · ZX80 · ZX81 · ZX Spectrum
Unicode / ISO/IEC 10646	UTF-1 · UTF-7 · UTF-8 · UTF-16 (UTF-16LE/UTF-16BE) / UCS-2 · UTF-32 (UTF-32LE/UTF-32BE) / UCS-4 · UTF-EBCDIC · GB 18030 · BOCU-1 · CESU-8 · SCSU
Miscellaneous code pages	ABICOMP · APL · Cork · HZ · Johab · SEASCII · TACE16 · TRON · UTF-5 · UTF-6 · WTF-8
Related topics	Code page · Control character (C0 C1) · CCSID · Character encodings in HTML · Charset detection · Han unification · Hardware · ISO 6429/IEC 6429/ANSI X3.64 · Mojibake

Unicode

Timeline of Unicode

- 1985, Sapporo, 
- KanjiTalk, localised 
- Shift-JIS is a 
- Bunch of  start working on Unicode specs
- 1988, submitted to ISO 
- 1991, Han Unification accepted 
- 1992,  *Kiss Your ASCII Goodbye* in *PC Magazine*
- 1995,  Java 1.0 launches with Unicode support

<http://www.unicode.org/history/earlyyears.html>



The first Unicode TV interview (1991)

<http://www.unicode.org/history/unicodeMOV.mov>

Julie Allen
Editor



Unicode, Oh Unicode

Unicode: the Movie (2000)

<http://www.unicode.org/history/movie/UniMovie-large.mov>

Unicode features*

- A common representation for all characters
- \simeq Compatible with ASCII for English (A = 65)
- Efficient encoding
- ~~Uniform width encoding~~
- Han unification (CJK languages share glyphs)

Unicode 10.0 (2017 June 20)

Unicode 10.0 adds 8,518 characters, for a total of 136,690 characters

<http://www.unicode.org/versions/Unicode10.0.0/>

56 emoji (2,666 total)

http://www.unicode.org/reports/tr51/tr51-12.html#Emoji_Counts

Bitcoin sign

...and more

Unicode terminology

- Scalar value € U+20AC EURO SIGN
- Range U+0000..U+FFFF
- Sequence É < U+0045 LATIN CAPITAL LETTER E, U+0301 COMBINING ACUTE ACCENT >
- Code points are not encoding
- Unicode is not an encoding, but a standard

Unicode planes

- `U+0000..U+FFFF` is Plane 0, Basic Multilingual Plane (BMP)
- Each plane encodes up to $2^{16} = 65536$ code points
- Commonly used characters
- Language “detection”

UTF-16

- Early UTF-16 was fixed-width (UCS-2)
- 2 or 4 bytes per character
- 2 bytes for characters in BMP
 - Can be more efficient than UTF-8 for CJK (2B vs 3B)
- Surrogate pairs have to be handled for code points outside BMP
 - Byte-order matters

UTF-32

- 32 bits ought to be enough for anybody
- Problem solved?

UTF-32

- **A** now takes up 4 bytes

SCSU

But wait! There's more!

✚ Standard Compression Scheme for Unicode ✚

<http://www.unicode.org/reports/tr6/>

SCSU

♪リンゴ可愛いや可愛いやリンゴ。半世紀も前に流行した「リンゴの歌」がぴったりするかもしれない。米アップルコンピュータ社のパソコン「マック（マッキントッシュ）」を、こよなく愛する人たちのことだ。「アップル信者」なんて言い方である。

= not compressible

18/12 = 1.5

= 3000 - 307F static window 7

12/11 = 1.1

= 3040 - 309F dynamic window 5

45/14 = 4.2

= 30A0 - 30FF dynamic window 6

38/8 = 4.75

= FF00 - FF7F dynamic window 7

2/2 = 1.00

= 2600-267F

1/1 = 1.00

- Do not use it*

UTF-8

- Variable-width
- `1100XXXX 10XXXXXX`
- `1110XXXX 10XXXXXX 10XXXXXX`
- `1111110X 10XXXXXX 10XXXXXX 10XXXXXX 10XXXXXX 10XXXXXX`
- First byte specifies number of continuation bytes

Reserved space

- U+nFFFE , U+nFFFF : reserved space for developers
- Suggested for internal use
 - data processing
 - artificial scripts
 - ancient scripts
- □ U+F8FF (↑ - ㄣ - k)
- Ubuntu has U+E0FF and U+F200

U+E0FF: ☺

U+F200: ubuntu®

Combining characters

- Modify other characters

e + ´ = é

e U+0065 LATIN SMALL LETTER E

´ U+0301 COMBINING ACUTE ACCENT

- Precomposed é

é U+00E9 LATIN SMALL LETTER E WITH ACUTE

- Modifiers come after base character

Unicode normalisation





- Some combined characters are sort of the same
- Equivalence criteria
 - canonical (NF)
 - compatibility (NFK)
- `ffi` `U+FB03 LATIN SMALL LIGATURE FFI` vs `f` `f` `i`
 - not equivalent under canonical (NF)
 - equivalent under NFK compatibility (NFK)
- NF is used to canonicalise combining characters

Unicode normalisation

- NFD *Normalization Form Canonical Decomposition*
- NFC *Normalization Form Canonical Composition*
- NFKD *Normalization Form Compatibility Decomposition*
- NFKC *Normalization Form Compatibility Composition*

Han unification

- Maps common Chinese, Japanese, Korean (CJK) characters into unified set

UNICODE U+66DC LANGUAGE Traditional Chinese	UNICODE U+66DC LANGUAGE Simplified Chinese	UNICODE U+66DC LANGUAGE Japanese	UNICODE U+66DC LANGUAGE Korean
			

- Different countries have different standards

Han unification

- Variants can be significant (names)

ashi

芦

Ashi·da, given name vs Ashi·ya, old place name

芦田さんは芦屋のお嬢様だ

- Educational software
- People get ☹ over the differences

Han unification

CJK Extension F contains mostly rare characters, but also includes a number of personal and placename characters important for government specifications in Japan, in particular.

CJK Extension F was added in Unicode 10.0 (2017)

Han unification

- Lose round-trip conversion compatibility with character sets which have variants
- Can use Unicode variation selectors

U+E0101 VARIATION-SELECTOR-18

>> "刃\ufe04"

← "刃"

>> "刃\uDB40\uDD01"

← "刃"

<http://www.unicode.org/ivd/>

<http://unicode.org/reports/tr37/>

Control sequences and vertical text

- Vertical text
- RTL mark

غير مسجل للدخول نقاش مساهمات إنشاء حساب دخول

مقالة نقاش اقرا عدل التاريخ ابحث في ويكيبيديا

[أغلق]

الحسابات الاجتماعية الرسمية
لويكيبيديا العربية

فيس بوك تويتر إنستغرام إنستغرام

قائمة الحروف العربية المشتقة [عدل]

الأبجديات المشتقة من العربية أنظمة كتابة اتخذت أحرفها من أصول حروف اللغة العربية فتداولتها وتناقلتها. وكان اشتقاق الحروف بطرائق منها:

- الشكل، بالهمز أو النقطة وما إليهما؛
- ربط الحروف ودمجها؛

محتويات [أخف]

1 نظم كتابة

1.1 حروف

1.2 شكلات

الصفحة الرئيسية
الأحداث الجارية
أحدث التغييرات
أحدث التغييرات الأساسية

تصفح

المواضيع
أبجدي
بوابات
مقالة عشوائية

Unicode Bidirectional Algorithm @ <http://unicode.org/reports/tr9/>
Unicode Vertical Text Layout @
<http://www.unicode.org/reports/tr50/>

Ligatures

Unicode maintains that ligaturing is a presentation issue rather than a character definition issue

- But! There are some predefined ligatures

ff U+FB04 LATIN SMALL LIGATURE FFL

A/ U+A738 LATIN CAPITAL LETTER AV

æ U+00E6 LATIN SMALL LETTER AE

- Similar issue with subscript and superscript

Emoji

- 絵 (e ≅ picture) + 文字 (moji ≅ written character)
- Early emoji were created by Japanese telcos
- 2008: Gmail, iPhone
- 2010: Unicode 6
- 禁 空 合 満 有 月 申 割 當 NG OK (可) ㄐ

<http://unicode.org/reports/tr51/>

Can be represented differently



- This is a problem



iOS



Android



Windows



Samsung



LG



HTC



Facebook

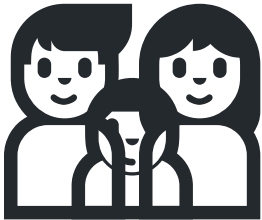


Twitter





Combining emoji

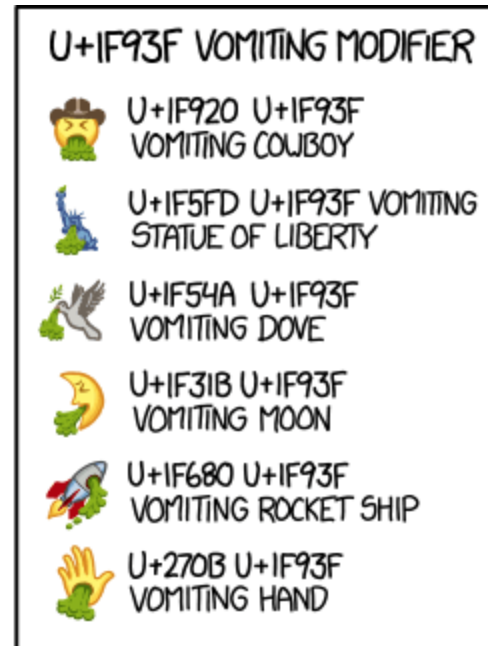


U+1F46A vs combined character

S + G = SG

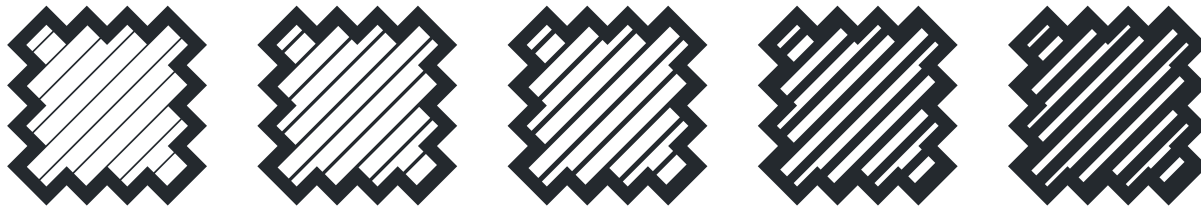
G + S = GS

s < U+1F1F8 REGIONAL INDICATOR SYMBOL LETTER S >
G < U+1F1EC REGIONAL INDICATOR SYMBOL LETTER G >



<https://xkcd.com/1813/>

Variation selectors



<http://unicode.org/faq/vs.html>



EarthWeb commercial, 2001

<http://www.unicode.org/history/EarthwebCommercial.avi>



Necessary

but not necessarily sufficient

programmer knowledge



Recognise garbled text as mojibake

- You might be able to recover the content by changing the character set
- UTF-8 seen using KOI8-R, a Cyrillic character set

п я—п||п—п||п||п||я ||п||я—я■

UTF-8

Библиотека

Use UTF-8 for all source code

- Configure your text editor
- Magic comments for some languages

Ruby \leq 1.9.x

```
# encoding: UTF-8
```

Python 2

```
# -*- coding: utf-8 -*-
```

C \leq C99

```
/* Dear future programmer: Good Luck  */
```

Text processing

- Treat input as bytes
- Treat text as strings (and not byte arrays)
- Use UTF-8 wherever possible
 - unless you know what you are doing
- Decide what to do with invalid bytes
 - discard or substitute?
- Do not self-roll your own text encoding library

Read in text with the right encoding

Especially when parsing HTML or XML

```
# Nokogiri  
doc = Nokogiri.XML(html, nil, 'EUC-JP')
```

```
# BeautifulSoup  
soup = BeautifulSoup(html, fromEncoding='Shift_JIS')
```

Set HTML charset

```
<!doctype html>  
<html>  
  <head>  
    <meta charset="UTF-8">  
  </head>  
</html>
```

Use `lang` in HTML as needed

```
<html lang="en">
  <body>
    <span lang="zh-Hans">刃</span>
    <span lang="zh-Hant">刃</span>
    <span lang="ja">刃</span>
    <span lang="ko">刃</span>
    <span lang="vi">刃</span>
  </body>
</html>
```

U+5203	刃	刃	刃	刃	刃	knife edge

Case conversion

- What is the uppercase form of `i` ?

Case conversion

- What is the uppercase form of `i` ? `I`
- In Turkish?

Case conversion

- What is the uppercase form of `i` ?
- In Turkish?

`ı` → `İ`

`i` → `İ`

Case conversion

- What is the uppercase form of `i` ?

- In Turkish?

`ı` → `İ`

`i` → `İ`

- In Turkish/English mixed text?

Case conversion

- Harder than you think
- What is the uppercase form of

ß U+00DF LATIN SMALL LETTER SHARP S ?

Case conversion

- DE German
- ß upcases to SS

Case conversion

- `ß` upcases to `SS`
- ...or `U+1E9E ß LATIN CAPITAL LETTER SHARP S`

http://unicode.org/faq/casemap_charprop.html

Case conversion

In 2016, the Council for German Orthography proposed the introduction of optional use of ß in its ruleset (i.e. variants STRASSE vs. STRAßE would be accepted as equally valid).[9]
The rule was officially adopted in 2017.[10]

Does your favourite programming language work?

JavaScript (Firefox 53)

```
>> 'ß'.toLocaleUpperCase('de-DE');  
'ß'
```

JavaScript (Chrome 59)

```
>> 'ß'.toLocaleUpperCase('de-DE');  
'SS'
```

Does your favourite programming language work?

² Python 2

```
>>> u'ß'.upper()  
u'\xdf' # ß
```

³ Python 3

```
>>> 'ß'.upper()  
'SS'
```

Does your favourite programming language work?

Ruby 2.3

```
> "\u{00df}".upcase  
=> "ß"
```

Ruby 2.4

```
> "\u{00df}".upcase  
=> "SS"
```

Does your favourite programming language work?

Java

```
public class UppercaseThis {  
    public static void main(String[] args) {  
        System.out.println("\u00df".toUpperCase());  
    }  
}
```

SS

Rust

```
fn main() { println!("{}", "\u00df".to_uppercase()); }
```

SS

Use variation selectors as needed

U+E0101 VARIATION-SELECTOR-18

>> "刃\ufe04"

← "刃"

>> "刃\uDB40\uDD01"

← "刃"

Use a correct font for the language outside HTML

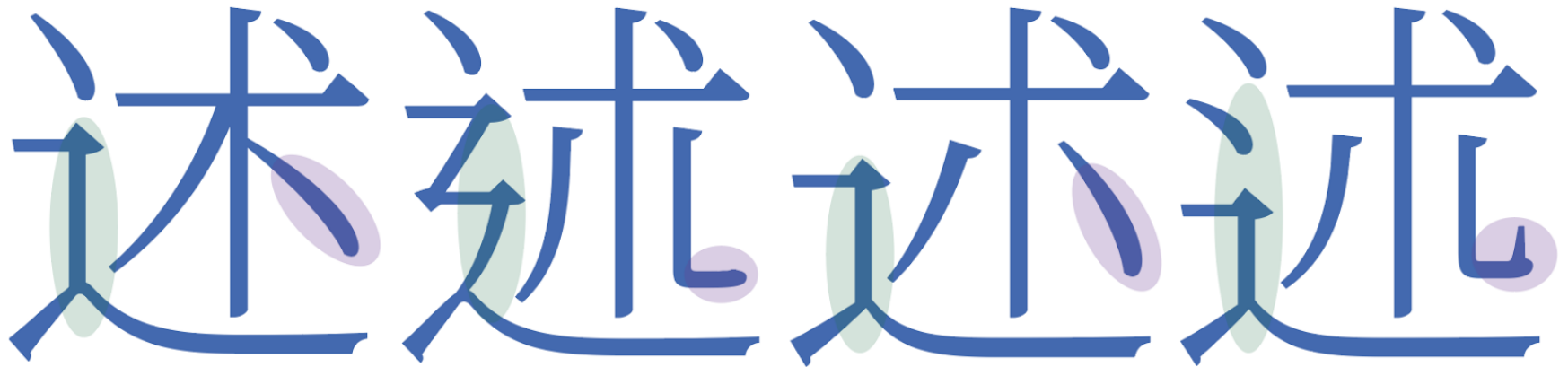
- Google's Noto/Noto CJK has great support
- Similarly, Adobe's Source Han

<https://www.google.com/get/noto/help/cjk/>

<https://source.typekit.com/source-han-serif>

Use a correct font for the language outside HTML

Glyph variations



述 U+8FF0 in S. Chinese, T. Chinese, Japanese and Korean

Noto Serif CJK

Use a correct font for the language outside HTML

Vertical text

セイリッシュ語族は太平洋岸北西部（カナダのブリティッシュコロンビア州、およびアメリカ合衆国のワシントン州、オレゴン州、アイダホ州、モンタナ州）で用いられる言語群である。セイリッシュ語族の分類に関しては、まず Boas & Haeberlin (1927) で 20 種類の言語が「方言」として内陸語派

セイリッシュ語族は太平洋岸北西部（カナダのブリティッシュコロンビア州、およびアメリカ合衆国のワシントン州、オレゴン州、アイダホ州、モンタナ州）で用いられている言語群である。セイリッシュ語族の分類に関しては、まず Boas & Haeberlin (1927) で 20 種類の言語が「方言」として内陸語派

Noto Serif CJK

Unencoded characters

How can I display (CJK/my own) characters not encoded in Unicode?

A large, bold Chinese character '𪛗' (U+2A791) is shown. It is a complex character with multiple strokes. Arrows are overlaid on the character to indicate the correct stroke order for writing it.

UTC-00791

A second instance of the large, bold Chinese character '𪛗' (U+2A791) is shown, identical to the first one, with stroke order arrows overlaid.

UTC-01312

biáng, from *biángbiáng* 面, a noodle dish from Shaanxi, China

Coming to a Unicode version soon?

Unencoded characters

- Use an image
- Use Ideographic Description Sequences

𐤀𐤁𐤂𐤃𐤄𐤅𐤆𐤇𐤈𐤉𐤊𐤋𐤌𐤍𐤎𐤏𐤐 U+2FF0..U+2FFF

𐤀書史 for 𐤀

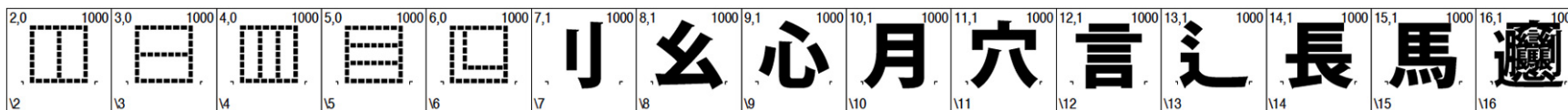
- Use fonts which have the unencoded glyph either
 - as an existing character (Wingdings ! 🙈 🙉 🙊)
 - in Private Use Area
 - as a combined sequence

Unencoded characters

- Source Han and Noto have glyphs for *biáng*!
- Uses Unicode and font features to combine existing glyphs
 - Ideographic Description Characters
 - OpenType's `ccmp` (Glyph Composition/Decomposition)
 - Ligatures `liga`

<https://blogs.adobe.com/CCJKType/2014/03/ids-opentype.html>

Unencoded characters



𠂇 𠂈 𠂉 𠂊 𠂋 𠂌 𠂍 𠂎 𠂏 𠂐 𠂑 𠂒 𠂓 𠂔 𠂕 𠂖 (traditional)
𠂇 𠂈 𠂉 𠂊 𠂋 𠂌 𠂍 𠂎 𠂏 𠂐 𠂑 𠂒 𠂓 𠂔 𠂕 𠂖 (simplified)

If you want to try it out, copy this instead (extra space between first two characters taken out): 𠂇𠂈 𠂉 𠂊 𠂋 𠂌 𠂍 𠂎 𠂏 𠂐 𠂑 𠂒 𠂓 𠂔 𠂕 𠂖

<https://blogs.adobe.com/CCJKType/2017/04/designing-implementing-biang.html>

String sorting

- Sorting strings is hard!

```
>> 'é' > 'f'  
true
```

String sorting

- A-ha! Can we use normalisation for this?

```
>> 'café'.normalize('NFKD')  
'cafe '
```

String sorting

- Sometimes

```
>> '한국어'.normalize('NFKD')  
"ㅎ ㅏ ㄴ ㄱ ㅌ ㄱ ㅍ ㅈ"
```

spaces manually added

[MDN: String.prototype.normalize\(\)](#)

String sorting and equality

- Use a locale-aware comparison

```
>> ['Aa', 'Äa', 'Äb', 'Ab'].sort();  
    ['Aa', 'Ab', 'Äa', 'Äb']
```

```
>> ['Aa', 'Äa', 'Äb', 'Ab']  
>>   .sort(a, b => a.localeCompare(b, 'de'));  
    ['Aa', 'Äa', 'Ab', 'Äb']
```

[MDN: String.prototype.localeCompare\(\)](#)

String searching

- How do I search for `café` by typing `cafe` , or `cafe` `?

String searching

- Not easy!
- Locale-aware comparisons
- Unicode-aware regex
- Read *Unicode Demystified: A Practical Programmer's Guide to the Encoding Standard* by Richard Gillam

String length

Problems arise when your string contains

- combining marks
- surrogate pairs (UTF-16)

String length — combined characters

What's the length of `café` ?

String length — combined characters

```
>> 'café'.length  
5
```

```
>> 'café'.normalize().length  
4
```

```
>> 'ユニコード'.length  
5
```

```
>> 'ユニコード\u3099'.normalize().length  
5
```

Should generally work for combined characters 🍣

String length — surrogate pairs

What's the length of  U+1F4A9 PILE OF POO ?

- UTF-8

F0 9F 92 A9

- Surrogate pairs (UTF-16)

D83D DCA9

Does your favourite programming language work?

JavaScript

```
>> '🐛'.length  
2  
>> [...'🐛'].length  
1
```

Python 2

```
>>> len(u'🐛')  
2
```

Python 3

```
>>> len('🐛')  
1
```

Does your favourite programming language work?

Ruby

```
>> '💩'.length  
1
```

Java

```
System.out.println("💩".length());  
// 2  
  
// use java.text.BreakIterator
```

Rust

```
println!("{}", "💩".len());  
// 4  
  
println!("{}", "💩".chars().count());  
// 1
```

Regex

- What if you want to match `e` and `é`?
- What about all the different whitespace characters?
- What if I want to match one character `/^.$/` but my character is combined? `é` \neq `e` + `'`
- What about matching non-Latin characters?

Regex

- Use Regex right
- Use a good-enough Regex engine
- Make sure `\w` `\d` `\s` are Unicode-aware
- Make sure your Regex engine does [case-folding](#)
- Match by Unicode (Perl)
 - `\N{}` Named or numbered (Unicode) char or sequence
 - `\o{}` Octal escape sequence.



Regex

- In Perl, you can use `\X`
 - `\X` Unicode "extended grapheme cluster". Not in `[]`.
- You can use Regex ranges with code points
- You might be able to match by Regex classes (Perl, Rust)

```
let re = Regex::new(r"\p{Greek}")+").unwrap();
```



Emoji

- Combinations or new emoji might not be supported
 - ☐ U+1F92E FACE VOMITTING (Emoji 5.0, 2017)
 - ☐ ♂ <U+1F937 SHRUG, U+2642 MALE> (Emoji 4.0, 2016)
 -   Ninja Cat riding T-Rex (Windows 10 only)



Emoji

- Let it be

Apple



Google

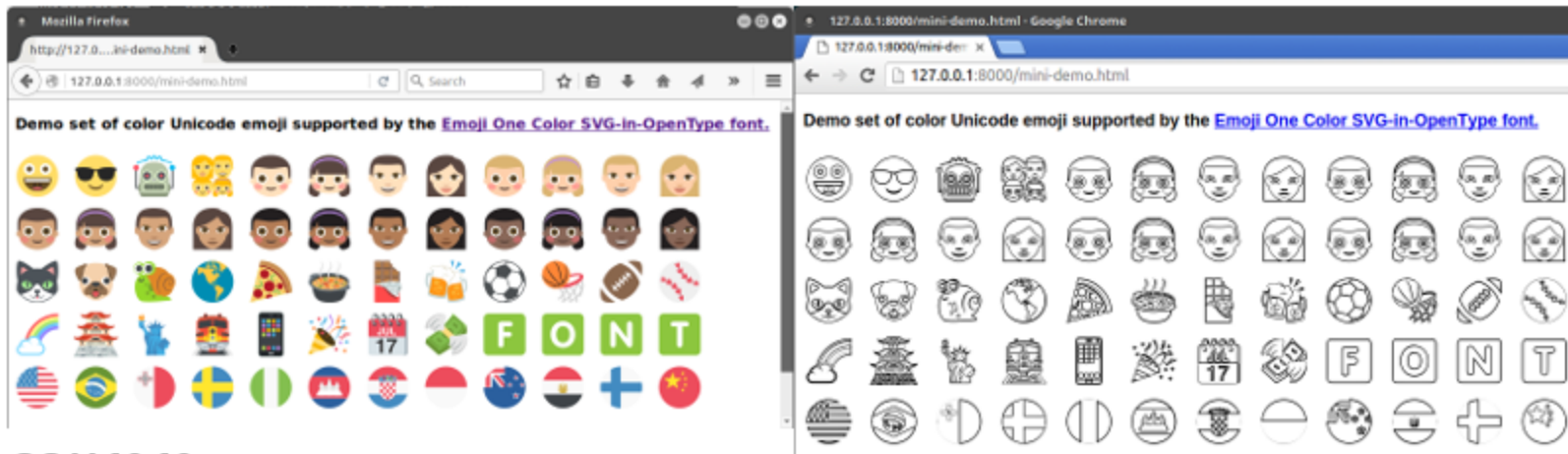


Microsoft

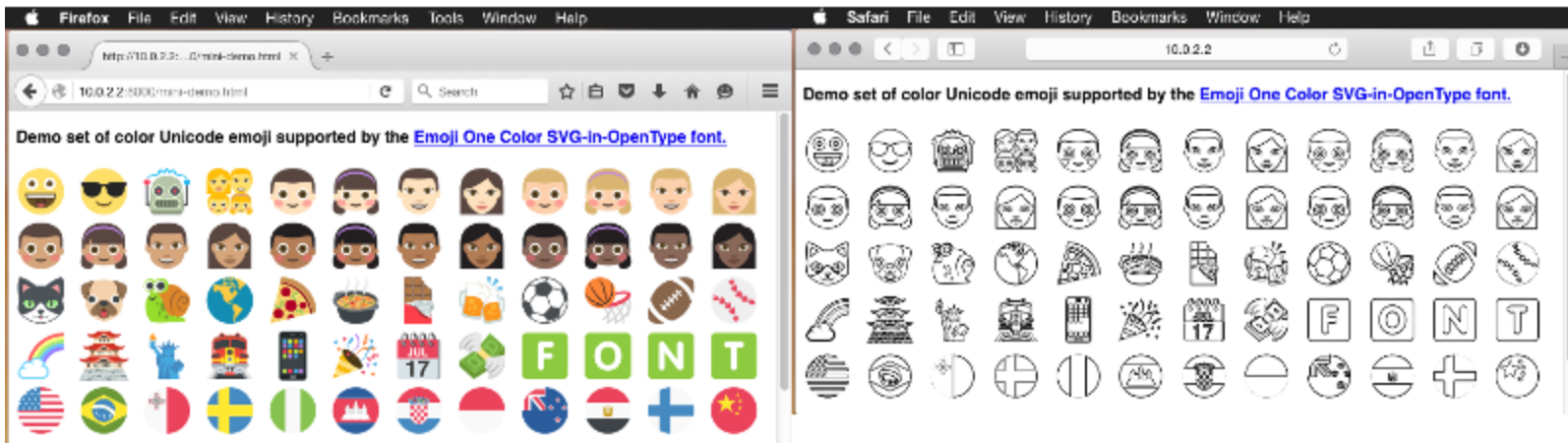


- Replace emoji with images (GitHub, Twitter)
 - <https://github.com/twitter/twemoji>
- Use (coloured) emoji fonts
 - <https://github.com/eosrei/emojione-color-font>
 - <https://github.com/googlei18n/noto-emoji>

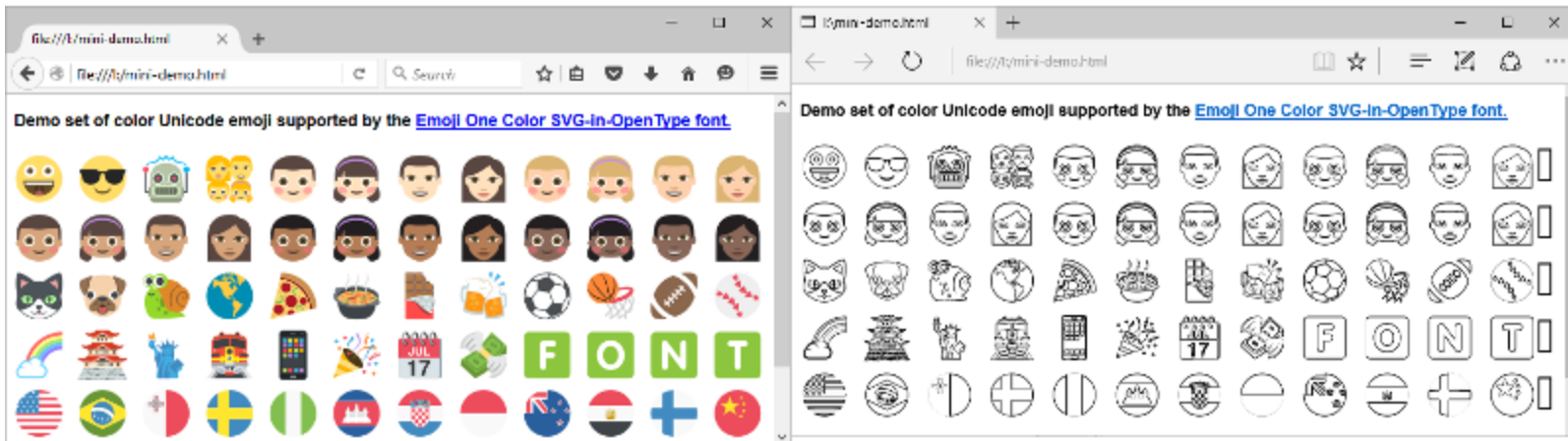
Ubuntu Linux



OS X 10.10



Windows 10



Developing for Unicode

If you ever need to develop Unicode parsing and processing, use the CLDR database:

<http://cldr.unicode.org/>

- * Locale-specific patterns for formatting and parsing: dates, t
- * Translations of names: languages, scripts, countries and regi
- * Language & script information: characters used; plural cases;
- * Country information: language usage, currency information, ca
- * Other: ISO & BCP 47 code support (cross mappings, etc.), keyb

Security

Read *Unicode Security Considerations*
@ <http://www.unicode.org/reports/tr36/>



Restrict passwords and user names to ASCII

- For logistical reasons (customer support)
- Unicode normalisation of passwords can cause problems
- Equivalent characters

e + ´ ≠ é

- Basic authentication can fail in different browsers

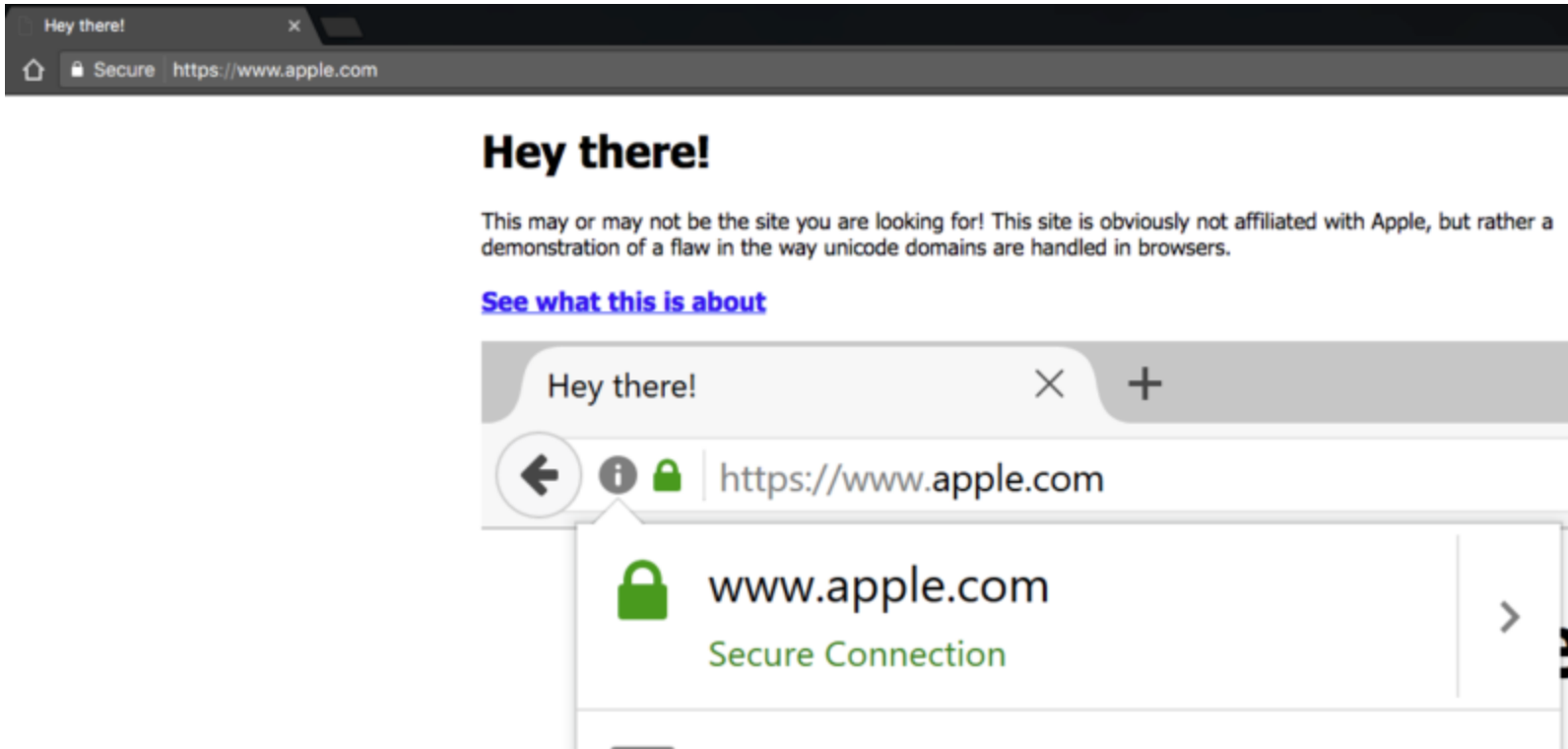
Sanitise text input

- Difficult problem
- “Unicode injection”: RTL, combining characters, wide characters
-  is one (1!) character
U+FD FD ARABIC LIGATURE BISMILLAH AR-RAHMAN AR-RAHEEM
- 
- 25 different whitespace characters

<https://github.com/minimaxir/big-list-of-naughty-strings>

Unicode in URLs

Visit <https://www.xn--80ak6aa92e.com/> in your browser



<https://www.xudongz.com/blog/2017/idn-phishing/>

Unicode in URLs

- Handling legit Unicode in URLs

```
http://Bücher.de  
→ http://xn--bcher-kva.de  
→ http://bücher.de
```

- Punycode, ASCII representation for Unicode domain names (IDN)

<http://www.unicode.org/reports/tr46/>

Free pizza!

Title: Free Pizza Fridays!

From: HR

To: You

Happy Friday!

Visit <https://tech.gov.sg/free.pizza> to claim a FREE 🍕!

FYNAP

- HR

This message could be a scam. [Report] [Ignore]

Unicode in URLs

/ U+29F8 BIG SOLIDUS

Visit <https://tech.gov.sg/free.pizza> to claim a FREE 🍕!

🍕 [sg/free.pizza](#) 🍕

Unicode in URLs

Solution: Use Punycode

Visit `https://tech.gov.xn--sgfree-jx4d.pizza` to claim a
FREE 🍕!

Click [here](#) for one neat trick to ruin bad software!

- MySQL UTF-8

What happens when you insert valid UTF-8 into a `VARCHAR`
`CHARACTER SET utf8` column?

 U+1F47D EXTRATERRESTRIAL ALIEN

Ill-formed sequences and encoding mismatches

- MySQL < 5.5.3 (2010) UTF-8

```
Incorrect string value: '\xF0\x9F\x91\xBD...' for column 'dat
```

In MySQL, use `utfmb4` (\geq 5.5.3, 2010)

<https://mathiasbynens.be/notes/mysql-utf8mb4>

Ill-formed sequences and encoding mismatches

Can crash your program

- 🐍² Python 2

```
>>> '\x81'.decode('utf-8')  
# UnicodeDecodeError: 'utf8' codec can't decode byte  
# 0x81 in position 0: unexpected code byte
```

- 💎 Ruby 1.9

```
'ü'.encode('ISO-8859-1') + 'ü'  
# incompatible character encodings: ISO-8859-1 and  
# UTF-8 (Encoding::CompatibilityError)  
  
# or sometimes: invalid multibyte char (US-ASCII)
```

Solution: use languages/libraries which handle Unicode strings right

Buffer overflows

- Do not assume Unicode strings are of fixed-length

```
Fluß → FLUSS → fluss
```

```
>> 'ﷲ'.length
```

```
1
```

```
>> 'ﷲ'.normalize('NFKC').length
```

```
18
```

Solution: use languages/libraries which handle Unicode strings right

```
> 1 + 1;
```

```
← 2
```

```
> 1 + 1;
```



```
←  SyntaxError: illegal character 
```


; U+037E GREEK QUESTION MARK

[A list of similar characters](#)

Resources

- [Unicode publications](#)
- [Unicode technical reports](#)
- [Unicode data files](#)
- [Unicode public files](#)
- [Emoji charts](#)
- [Emoji slides](#)
- [Unicode character inspector](#)
- [UTF-8 decoder](#)
- [Big List of Naughty Strings](#)
- [Personal names around the world](#)
- [Falsehoods Programmers Believe About Phone Numbers](#)
- *Unicode Demystified: A Practical Programmer's Guide to the Encoding Standard* by Richard Gillam