How we represent bits, numbers, letters?

Communicating in the Blink of an Eye

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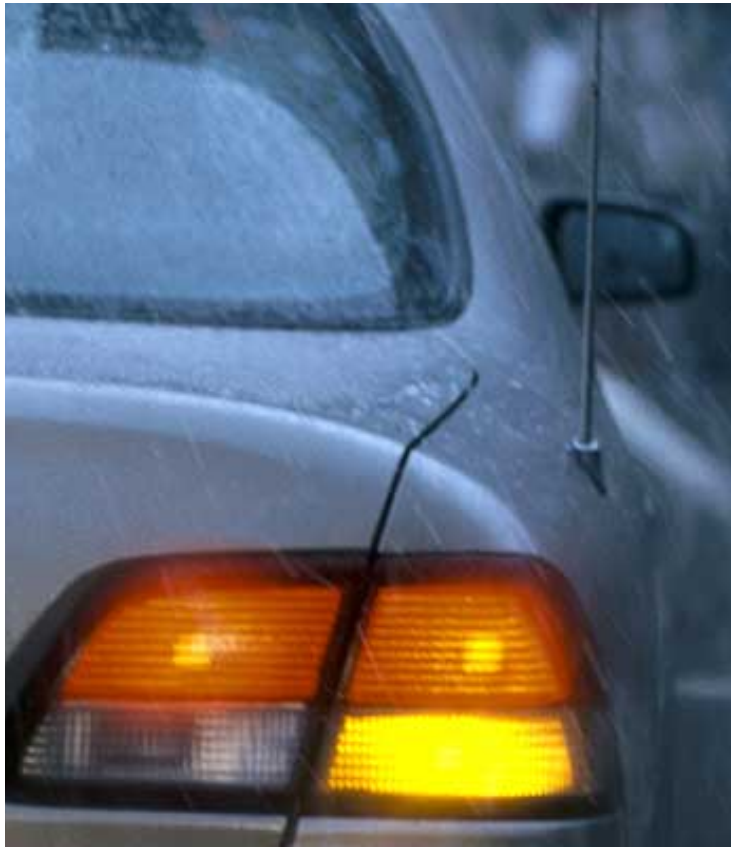
Today… Bits

- Key principle: Information is the presence or absence of a phenomenon at given place/time
- Turn signal is an example
  - Phenom: Flashing light
  - Present: Flashing
  - Absent: Off
  - Info: Present == intention to turn
  - Place (side of car)
  - Time: now



A General Idea

- The Presence and Absence of a phenomenon at a specific place and time abbreviated: PandA
- Phenomena: light, magnetism, charge, mass, color, current, …
- Detecting depends on phenomenon – but the result must be discrete: it was detected or not; there is no option for "sorta there"
- Place and time apply, but usually default to "obvious" values; not so important to us
- Many alternatives …

Alternatives …

- "Presence and absence" is too long, use 0, 1
- At the coffee shop

  - In multi-state cases, pick one for present, all others are absent
  - Two states, means this is a binary system

A Curious Story…

The Diving Bell and the Butterfly

Jean-Dominique Bauby

Asking Yes/No Questions

- A protocol for Yes/No questions
  - One blink == Yes
  - Two blinks == No
- PandA implies that this is not the fewest number of blinks … really?

Asking Letters

In English ETAOINSHRDLU…

Compare Two Orderings

- How many questions to encode:

  Plus ça change, plus c'est la même chose?

- Asking in Frequency Order:

  ESARINTULOMDPCFBVHGJQZYXKW

Compare Two Orderings

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- Asking in Frequency Order:
  ESARINTULOMDPCFBVHGJQZYXKW
- Asking in Alphabetical Order:
  ABCDEFGHIJKLMNOPQRSTUVWXYZ

12 16

Compare Two Orderings

- How many questions to encode:

  Plus ça change, plus c'est la même chose?

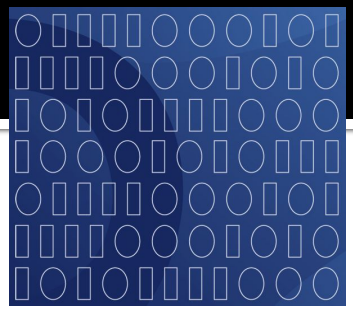
- Asking in Frequency Order: 247
  ESARINTULOMDPCFBVHGJQZYXKW
- Asking in Alphabetical Order: 324
  ABCDEFGHIJKLMNOPQRSTUVWXYZ

An Algorithm

- Spelling by going through the letters is an algorithm
- Going through the letters in frequency order is a program (also, an algorithm but with the order specified to a particular case, i.e. FR)
- The nurses didn't look this up in a book … they invented it to make their work easier; they were thinking computationally, though they probably didn't know it

Bits





- PandA is a *binary representation* because it uses 2 patterns

  Bit – it's a contraction for "binary digit"

  -- a position in space/time capable of being set and detected in 2 patterns

  Sherlock Holmes' s *Mystery of Silver Blaze* -- a popular example where "absent" gives information … the dog didn't bark, that is the phenomenon wasn't detected

Bytes

- A byte is eight bits treated as a unit
  - Adopted by IBM in 1960s
  - A standard measure ever since
  - Bytes encode the Latin alphabet using ASCII -- the American Standard Code for Information Interchange

0101 0101
0101 0111

ASCII

ASCII	0000 0000	0000 0001	0000 0010	0000 0011	0000 0100	0000 0101	0000 0110	0000 0111	0000 1000	0000 1001	0000 1010	0000 1011	0000 1100	0000 1101	0000 1110	0000 1111
0000	NU	SH	SX	EX	ET	EQ	AK	BL	BS	HT	LF	YT	FF	CR	S0	SI
0001	DL	D1	D2	D3	D4	NK	SY	EΣ	CN	EM	SB	EC	FS	GS	RS	US
0010		!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
0011	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
0100	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
0101	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
0110	`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
0111	p	q	r	s	t	u	v	w	x	y	z	{	|	}	~	DT
1000	80	81	82	83	IN	NL	SS	ES	HS	HJ	YS	PD	PV	RI	S2	S3
1001	DC	P1	PZ	SE	CC	MM	SP	EP	Q8	QQ	QA	CS	ST	OS	PM	AP
1010	AO	¡	¢	£	♀	¥	¦	§	¨	©	♂	«	¬	-	®	¯
1011	°	±	²	³	´	µ	¶	·	¸	¹	º	»	¼	½	¾	¿
1100	À	Á	Â	Ã	Ä	Å	Æ	Ç	È	É	Ê	Ë	Ì	Í	Î	Ï
1101	Ð	Ñ	Ò	Ó	Ô	Õ	Ö	×	Ø	Ù	Ú	Û	Ü	Ý	Þ	β
1110	à	á	â	ã	ä	å	æ	ç	è	é	ê	ë	ì	í	î	ï
1111	ð	ñ	ò	ó	ô	õ	ö	÷	ø	ù	ú	û	ü	ý	þ	ÿ

0100 0011
0101 0011
0101 0000

0100 1000|0111 0101|0111 0011|0110 1011|0110 1001|0110 0101|0111 0011|0010 0001

UTF-8

Uniform Transformation Format for bytes (UTF-8) is universal … all characters have a place: 1,2,3,4 B

لماذا لا يتكلمون اللّغة العربية فحسب؟
Защо те просто не могат да говорят **български**?
Per què no poden simplement parlar en **català**?
他們爲什麼不說中文（**台灣**）？
Proč prostě nemluví **česky**?
Hvorfor kan de ikke bare tale **dansk**?
Warum sprechen sie nicht einfach **Deutsch**?
Μα γιατί δεν μπορούν να μιλήσουν **Ελληνικά**;
Why can't they just speak **English**?
¿Por qué no pueden simplemente hablar en **castellano**?
Miksi he eivät yksinkertaisesti puhu **suomea**?
Pourquoi, tout simplement, ne parlent-ils pas **français** ?
למה הם פשוט לא מדברים **עברית**?
Miért nem beszélnek egyszerűen **magyarul**?
Af hverju geta þeir ekki bara talað **íslensku**?
Perché non possono semplicemente parlare **italiano**?
なぜ、みんな**日本語**を話してくれないのか？
세계의 모든 사람들이 **한국어**를 이해한다면 얼마나 좋을까?
Waarom spreken ze niet gewoon **Nederlands**?
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Dlaczego oni po prostu nie mówią po **polsku**?
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Varför pratar dom inte bara **svenska**?
ทำไมเขาถึงไม่พูดภาษาไทย
Neden **Türkçe** konuşamıyorlar?

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Uniform Transformation Format for bytes (UTF-8) is universal … all characters have a place: 1,2,3,4 B

- 100,000 characters

¿sıɥʇ pɐɐɹ noʎ nɐɔ

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Encoding Information

- Bits and bytes encode the information, but that's not all
  - Tags encode format and some structure in word processors
  - Tags encode format and some structure in HTML
  - In the *Oxford English Dictionary* tags encode structure and some formatting
  - Tags are one form of meta-data: *meta-data* is information about information

OED Entry For Byte -- Metadata

byte (bait). *Computers*. [Arbitrary, prob. influenced by bit *sb.*[4] and bite *sb.*] A group of eight consecutive bits operated on as a unit in a computer. **1964** ***Blaauw*** & ***Brooks*** in *IBM Systems Jrnl.* III. 122 An 8-bit unit of information is fundamental to most of the formats [of the System/360]. A consecutive group of *n* such units constitutes a field of length *n*. Fixed-length fields of length one, two, four, and eight are termed bytes, halfwords, words, and double words respectively. **1964** *IBM Jrnl. Res. & Developm.* VIII. 97/1 When a byte of data appears from an I/O device, the CPU is seized, dumped, used and restored. **1967** ***P. A. Stark*** *Digital Computer Programming* xix. 351 The normal operations in fixed point are done on four bytes at a time. **1968** *Dataweek* 24 Jan. 1/1 Tape reading and writing is at from 34,160 to 192,000 bytes per second.

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<e><hg><hw>byte</hw> <pr><ph>baIt</ph></pr></hg>. <la>Computers</la>.
<etym>Arbitrary, prob. influenced by <xr><x>bit</x></xr> <ps>n.<hm>4</hm></ps>and
<xr><x>bite</x> <ps>n.</ps> </xr></etym> <s4>A group of eight consecutive bits
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<a>Brooks</a> <bib>in</bib> <w>IBM Systems Jrnl.</w> <lc>III. 122</lc> <qt>An 8-
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Representing Information

- Today, we have seen …
  - Bits encode numbers using the binary representation 11 1110 0111
  - Bits encode letters using ASCII for North American and Western European languages

- This suggests a principle we will soon argue:
  - All information can be represented with bits

Summary

- Computers join physical & logical domains so physical devices do our logical work
  - Symbols represent things 1-to-1: 0, 1
  - Create symbols by grouping patterns: 0101 0111
  - PandA representation is fundamental: present?
  - Bit, a place where 2 patterns set/detect
  - ASCII is a byte encoding of Latin αbet
  - In addition to content, encode structure: meta