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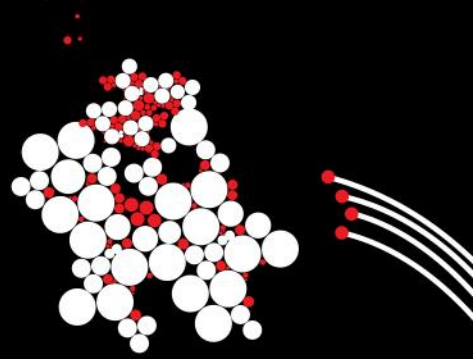
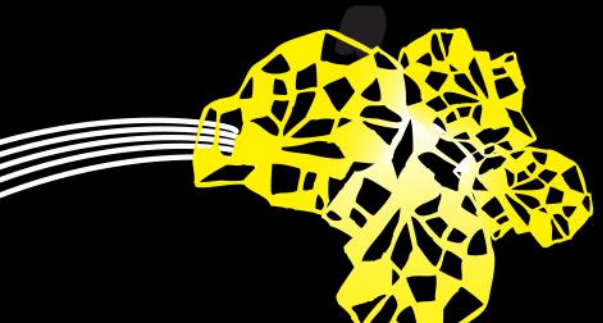


Binary-to-text encodings

Topic of Software Systems (TCS module 2)

Lecturer: Maarten Everts



REPRESENTING BINARY DATA (BYTE ARRAYS)

A byte-array:

```
byte[] data;
```

How to print its content?

Turning Strings into byte-arrays (using default encoding).

```
byte[] data = "Software Systemen".getBytes();
```

As a list of numbers?

```
23, 24, 37, 64, 62
```

ASCII control characters

00	NULL	(Null character)
01	SOH	(Start of Header)
02	STX	(Start of Text)
03	ETX	(End of Text)
04	EOT	(End of Trans.)
05	ENQ	(Enquiry)
06	ACK	(Acknowledgement)
07	BEL	(Bell)
08	BS	(Backspace)
09	HT	(Horizontal Tab)
10	LF	(Line feed)
11	VT	(Vertical Tab)
12	FF	(Form feed)
13	CR	(Carriage return)
14	SO	(Shift Out)
15	SI	(Shift In)
16	DLE	(Data link escape)
17	DC1	(Device control 1)
18	DC2	(Device control 2)
19	DC3	(Device control 3)
20	DC4	(Device control 4)
21	NAK	(Negative acknowl.)
22	SYN	(Synchronous idle)
23	ETB	(End of trans. block)
24	CAN	(Cancel)
25	EM	(End of medium)
26	SUB	(Substitute)
27	ESC	(Escape)
28	FS	(File separator)
29	GS	(Group separator)
30	RS	(Record separator)
31	US	(Unit separator)
127	DEL	(Delete)

ASCII printable characters

32	space	64	@	96	`
33	!	65	A	97	a
34	"	66	B	98	b
35	#	67	C	99	c
36	$	68	D	100	d
37	%	69	E	101	e
38	&	70	F	102	f
39	'	71	G	103	g
40	(	72	H	104	h
41	)	73	I	105	i
42	*	74	J	106	j
43	+	75	K	107	k
44	,	76	L	108	l
45	-	77	M	109	m
46	.	78	N	110	n
47	/	79	O	111	o
48	0	80	P	112	p
49	1	81	Q	113	q
50	2	82	R	114	r
51	3	83	S	115	s
52	4	84	T	116	t
53	5	85	U	117	u
54	6	86	V	118	v
55	7	87	W	119	w
56	8	88	X	120	x
57	9	89	Y	121	y
58	:	90	Z	122	z
59	;	91	[	123	{
60	<	92	\	124	|
61	=	93	]	125	}
62	>	94	^	126	~
63	?	95	_		

REPRESENTING NUMBERS (RECAP MODULE 1)

$0 \cdot 2^7 + 1 \cdot 2^6 + 1 \cdot 2^5 + 0 \cdot 2^4 + 1 \cdot 2^3 + 1 \cdot 2^2 + 0 \cdot 2^1 + 1 \cdot 2^0$

01101101_2

binary
(base 2)

$1 \cdot 8^2 + 5 \cdot 8^1 + 5 \cdot 8^0$

155_8

octal
(base 8)

$1 \cdot 10^2 +$

d
(b

$6 \cdot 16^1 + 13 \cdot 16^0$

$6D_{16}$

hexadecimal
(base 16)

$0_{10} = 0_{16}$
$1_{10} = 1_{16}$
$2_{10} = 2_{16}$
$3_{10} = 3_{16}$
$4_{10} = 4_{16}$
$5_{10} = 5_{16}$
$6_{10} = 6_{16}$
$7_{10} = 7_{16}$
$8_{10} = 8_{16}$
$9_{10} = 9_{16}$
$10_{10} = A_{16}$
$11_{10} = B_{16}$
$12_{10} = C_{16}$
$13_{10} = D_{16}$
$14_{10} = E_{16}$
$15_{10} = F_{16}$

ASCII/UTF-8 representation: ‘m’

REPRESENTING BINARY DATA

A byte-array:

```
byte[] data;
```

How to print its content?

Hexadecimal!

Turning Strings into byte-arrays (using default encoding).

```
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```

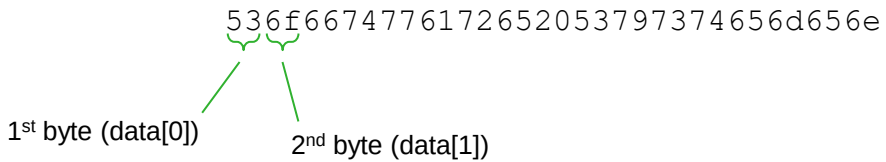

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53	5	85	U	117	u
54	6	86	V	118	v
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56	8	88	X	120	x
57	9	89	Y	121	y
58	:	90	Z	122	z
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49	1	81	Q	113	q
50	2	82	R	114	r
51	3	83	S	115	s
52	4	84	T	116	t
53	5	85	U	117	u
54	6	86	V	118	v
55	7	87	W	119	w
56	8	88	X	120	x
57	9	89	Y	121	y
58	:	90	Z	122	z
59	;	91	[	123	{
60	<	92	\	124	|
61	=	93	]	125	}
62	>	94	^	126	~
63	?	95	_		

Use more printable characters: base64

A MORE (SPACE) EFFICIENT BINARY-TO-TEXT ENCODING: BASE64

Value	Char	Value	Char	Value	Char	Value	Char
0	A	16	Q	32	g	48	w
1	B	17	R	33	h	49	x
2	C	18	S	34	i	50	y
3	D	19	T	35	j	51	z
4	E	20	U	36	k	52	0
5	F	21	V	37	l	53	1
6	G	22	W	38	m	54	2
7	H	23	X	39	n	55	3
8	I	24	Y	40	o	56	4
9	J	25	Z	41	p	57	5
10	K	26	a	42	q	58	6
11	L	27	b	43	r	59	7
12	M	28	c	44	s	60	8
13	N	29	d	45	t	61	9
14	O	30	e	46	u	62	+
15	P	31	f	47	v	63	/

6 bits per character: $2^6 = 64$ different characters (26 + 26 + 10 + 2)

Text content	M	a	n
ASCII	77 (0x4d)	97 (0x61)	110 (0x6e)
Bit pattern	0 1 0 0 1 1 0 1	0 1 1 0 0 0 0 1	0 1 1 0 1 1 1 0
Index	19	22	5	46
Base64-encoded	T	W	F	u

Note: padding is needed!

BASE64 EXAMPLES

```
byte[] data = "Software Systemen".getBytes();
```

Base64 ⇨ `U29mdHdhcmUgU3lzdGVtZW4=`

```
byte[] data = "Software Systemen 2018".getBytes();
```

Base64 ⇨ `U29mdHdhcmUgU3lzdGVtZW4gMjAxOA==`

```
byte[] data = " Software Systemen 2018".getBytes();
```

Base64 ⇨ `IFNvZnR3YXJlIFN5c3RlbWVuIDIwMTg=`

padding

NOTES ON ENCODING

- Use libraries for this! (e.g., Apache Commons Codec library)
- Superfluous remark: encoding is not encryption!

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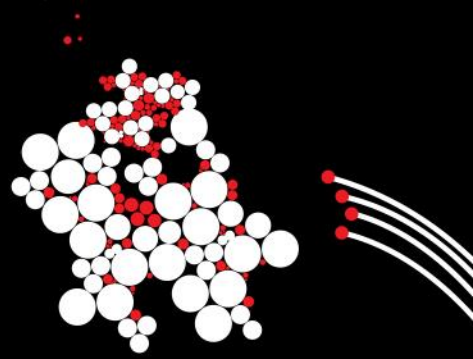

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