Ambient Intelligence

Barcodes

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Plan

- Characteristics of an identification method
- Study of barcodes standards
  - UPC and EAN 13

Characteristics of an identification method

- Logical characteristics
  - Uniqueness
  - Fault and error tolerance
- Physical characteristics
  - Readability (human and machine)
  - Coupling to the object
  - Reading time
  - Complexity of readers

Barcodes

- Information is coded in the width of parallel bars and spaces

This is a one-dimension (1-D) linear code

- Typically bars are printed in black over a white background (it is required to have high contrast zones)
- Inexpensive automatic identification method
  - Barcodes: ~ € 0,001
  - RFID passive tags: ~ € 0,04 - € 0,20

Barcodes

- Machine readable symbols that store identifying data about a part or product with which they are associated
- Symbols are read by a barcode scanner and are decoded and processed to extract data for a variety of uses
  – For example: pricing, order fulfillment, traceability through production, sortation, shipping, etc.
- Barcode technologies provide a fast and reliable data collection to ensure part or product traceability, error-proof assembly processes and enhance customer service

Barcodes standards

- There are many specifications and standards for barcodes
  – Examples for 1-D linear codes:
    - Plessey, UPC, Codabar, Code 25 – Non-interleaved 2 of 5, Code 25 – Interleaved 2 of 5, Code 39, Code 93, Code 128, Code 128 A/B/C, Code 11, CPC Binary, DUN 14, EAN 2, EAN 5, EAN 8, EAN 13, GS1-128, (UCC/EAN-128), GS1 DataBar (RSS), ITF-14, Latent image barcode, Pharmacode, PLANET, POSTNET, OneCode, MSI, PostBar, RM4SCC / KIX, Telepen, etc.

0123 4565

(almost 2-D)

UPC Code

- UPC – Universal Product Code
- Published in 1973 by a group of industry and retail associations, to improve the processes of sale and inventory management
- Is mostly used in the USA and Canada
- Europe uses EAN – European Article Number (also called *International* Article Number)

EAN is a superset of UPC

UPC Coding

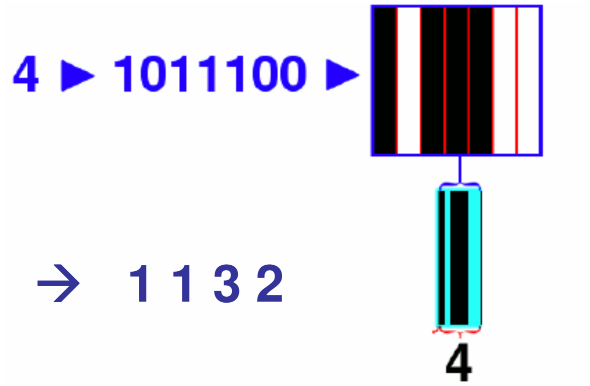
- UPC-A encodes 12 decimal digits using the format
  S L L L L L L M R R R R R R E
- Guard bars:
  - S = Start
  - M = Middle
  - E = End
- Decimal digits:
  - L (left) and R (right) sections
  - Each represents 6 digits
  - L = prefix (identifies the number system used by following digits)
  - R = Error detecting check digit

1 2 3 4 5 6 7 8 9 9 9 9

L L L L L L R R R R R R

UPC Coding

- Each digit is represent by a 7 bit code



- They correspond to 2 bars and 2 spaces of different widths
- Bars and spaces always alternate
- L digits start with Space; R digits start with Bar

Encoding

- Each digit is represented by a unique pattern of two bars and two spaces
- The bars and spaces are variable width; they may be one, two, three or four units wide
  - The total width for a digit is always seven units
- Bars and spaces always alternate
- Start = End = 111 (bar, space, bar)
- Middle = 11111 (space, bar, space, bar, space)
- Digits in left area: **space**, bar, space, bar
- Digits in right area: **bar**, space, bar, space
- Quite zones (before S and after E)

Quite zones

1 23456 78999 9

Encoding

- Left-side digits have odd parity - total width of the black bars is an odd number
- Right-side digits have even parity
- So, a scanner can determine whether it is scanning from left-to-right or from right-to-left

Digit	Code L	Code R
0	0001101	1110010
1	0011001	1100110
2	0010011	1101100
3	0111101	1000010
4	0100011	1011100
5	0110001	1001110
6	0101111	1010000
7	0111011	1000100
8	0110111	1001000
9	0001011	1110100

Numbering

- There are different possibilities to encode each digit, depending on the first digit (L)
- Values for first digit (prefix)
  - 0, 1, 6, 7, 8: For most products. The LLLLL digits are the manufacturer code, and the RRRRR digits are the product code.
  - 2: Reserved for local use (store/warehouse), for items sold by variable weight. For variable-weight items the LLLLL is the item number, and the RRRRR is either the weight or the price, with the first R determining which.
  - 3: Drugs by National Drug Code number (USA).
  - 4: Reserved for local use (store/warehouse), often for loyalty cards or store coupons.
  - 5, 9: Coupons: The manufacturer code is the LLLLL, the first 3 RRR are a family code (set by manufacturer), and the next 2 RR are a coupon code. This 2-digit code determines the amount of the discount, according to a table set by the GS1 US.

Numbering

- UPC-A provides a theoretical maximum of 1 trillion (10^12) unique barcodes
- In practice the number of barcodes is limited by the standards used to create them
- For instance, the last digit is the check digit and therefore can only be one correct value. This gives 100,000,000,000 (10^11) possibilities.
- Restrictions on the first digit further reduce this number (e.g.: 5x10^10).
- Five digits for a manufacturer (10^5 = 100,000 worldwide companies)
- Five digits for a part or product (10^5 = 100,000 products for each manufacturer)

Check digit

- In the UPC-A system, the check digit is calculated as follows:
  - Add the digits in the odd-numbered positions (first, third, fifth, etc.) together and multiply by three.
  - Add the digits in the even-numbered positions (second, fourth, sixth, etc.) to the result.
  - Find the result modulo 10 (i.e. the remainder when divided by 10).
  - If the result is not zero, subtract the result from ten.
- Example for barcode "036000 29145x" (x = unknown check digit)
  - Add the odd-numbered digits (0 + 6 + 0 + 2 + 1 + 5 = 14)
  - Multiply by three (14 × 3 = 42)
  - Add the even-numbered digits (42 + (3 + 0 + 0 + 9 + 4) = 58)
  - Calculate modulo ten (5<u>8</u> mod 10 = 8) → Remainder of the division by 10 (equal to least significant digit). If remainder is 0, check digit is 0.
  - Subtract from ten (10 – 8 = 2)
  - The check digit is thus 2.
- The check digit can detect 100% of single digit errors and 89% of transposition errors.

UPC → EAN-13

- EAN – *International* Article Number
- Superset of UPC
  - Adds an extra digit in the beginning of a UPC number
  - Expands 10 times the number of unique values
  - UPC coding is valid for EAN-13 with the extra digit = 0

    UPC value “123456 789012” = EAN-13 value “**0** 123456 789012”
  - Point-of-sale systems can now understand both equally
- EAN-13 indicates the manufacturer’s country
- All products marked with an EAN will be accepted in North America
- Any product with an existing UPC does not have to be re-marked with an EAN
- UPC is being phased-out

Questions?

Ambient Intelligence

Barcodes
EAN13, 2D codes

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Plan

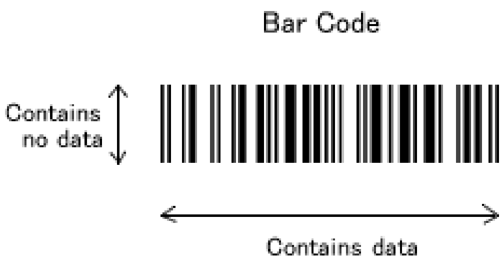
- Barcodes
- Linear barcodes
- Barcodes 2D
- Cases study

Barcode

- An optical machine-readable representation of data
  - Data is represented by varying the widths and spacings of parallel lines
- First use:
  - Identification of railroad cars (1967)
  - First use of UPC – Universal Product Code: 1974 (chewing gum pack)
- Most common use nowadays:
  - Supermarket checkout systems

Linear barcodes

- Linear because data is only on one dimension



Barcodes

- Universal Product Code (UPC) common formats:

Standard UPC-A	GTIN-12 in UPC-A	Standard UPC-E
123456 789999	1 23456 78999 9	234569

- Used mostly in USA and Canada
- Is being phased out → EAN

Barcode

- EAN – European Article Number

  → International Article Number (but still EAN)

- EAN-13 – 13 digits (12 + 1 check)
  - Superset of UPC
  - Defined by the standards organization "**GS1**"
  - Used worldwide for marking products often sold at retail point of sale
  - Numbers encoded in UPC and EAN barcodes are known as Global Trade Item Numbers (GTIN)

Global Trade Item Number (GTIN)

- Identifies product information (number usually read through a bar code scanner)
- Identifier is unique and universal
- GTINs may be 8, 12, 13 or 14 digits long
- GTIN-13s may be encoded in EAN-13 and other codes

Examples of GTIN codes

GTIN-12
(UPC-12)
0 12345 67890 5

GTIN-13
(EAN / UCC-13)
0 123456 789012 >

GTIN-8
(EAN / UCC-8)
0123 4567

GTIN-14
(GS1-128 or ITF-14)
0 00 12345 60001 2

GTIN formats

Num.-system	GTIN-Format													
Position of digits	*T1*	*T2*	*T3*	*T4*	*T5*	*T6*	*T7*	*T8*	*T9*	*T10*	*T11*	*T12*	*T13*	*T14*
GTIN-14	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	N14
GTIN-13	0	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13
GTIN-12	0	0	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12
GTIN-8	0	0	0	0	0	0	N1	N2	N3	N4	N5	N6	N7	N8

- Example for GTIN-13
  - N1-N2 / N1-N3 – Country code (assigned by GS1)
  - N1-N6 / N1-N7 – Company prefix (assigned by GS1)
  - N8-N12 – Item code (allocated by the company)
  - N13 – Check digit

GS1 country codes

- Some examples:
  - 000 – 019 U.S. and Canada
  - 300 – 379 France and Monaco
  - . . .
  - 400 – 440 Germany (440 code inherited from old East Germany on reunification, 1990)
  - 450 – 459 Japan
  - 460 – 469 Russia
  - . . .
  - 500 – 509 United Kingdom
  - 520 – 521 Greece
  - . . .
  - 539 Ireland
  - 540 – 549 Belgium and Luxembourg
  - **560 Portugal**
  - 569 Iceland
  - . . .
  - 840 – 849 Spain
  - . . .

If first digit = **2**: Reserved for local use (store/warehouse), for items sold by variable weight

EAN barcode – Encoding rules

- EAN-13 encoding rules encode the leading 13th digit by modifying the encoding of the left-hand half of the barcode
- The original rules for UPC are treated as a '0' if read as EAN-13. A UPC barcode XXXXXXXXXXXX therefore is the EAN-13 barcode 0XXXXXXXXXXXX.

First digit	Coding pattern
0	EEEEEE
1	EEOEOO
2	EEOOEO
3	EEOOOE
4	EOEEOO
5	**EOOEEO**
6	EOOOEE
7	EOEOEO
8	EOEOOE
9	EOOEOE

E = Even (normal)
O = Odd (inverted)

First digit

5 901234 123457 >

Coding pattern applies to left digits

EAN encoding rules

- First digit coding
  - Applies only to left digits (6 digits)
  - Right digits use always "Even" coding

First digit	Coding pattern
0	EEEEEE
1	EEOEOO
2	EEOOEO
3	EEOOOE
4	EOEEOO
5	EOOEEO
6	EOOOEE
7	EOEOEO
8	EOEOOE
9	EOOEOE

Digit coding

	Even (normal)	**O**dd (inverted)
0	3211	1123
1	2221	1222
2	2122	2212
3	1411	1141
4	1132	2311
5	1231	1321
6	1114	4111
7	1312	2131
8	1213	3121
9	3112	2113

EAN encoding rules

- Digits coding

space / **bar** / **space** / **bar**

Left digits may be coded like this (Even) or "inverted" (Odd)

bar / **space** / **bar** / **space**

Right digits <u>always</u> coded in this way (even)

Example: 0 (even) = 3211 0 (odd) = 1123

EAN encoding rules

- Calculation of checksum digit (rightmost digit)
  - Calculated from the data digits before it.
  - The checksum is calculated taking a varying **weight** value **times** each **number** in the barcode to make a **sum**.
  - The weight for a specific position in the EAN code is either 3 or 1, which alternate so that the final data digit has a weight of 3; the same algorithm is used in other GTINs and the Serial Shipping Container Code (SSCC).
  - In an **EAN-13** code, the weight is 1 for odd positions and 3 for even positions (weights for EAN-13 are: 1, 3, 1, 3, 1, 3, 1, 3, 1, 3, 1, 3).
  - The checksum digit is then the digit which must be added to this sum to get a number evenly divisible by 10.
- Example:
  - If the sum is 63 1xN1 + 3xN2 + 1xN3 + 3xN4 + 1xN5 + 3xN6 + 1xN7 + 3xN8 + 1xN9 + 3xN10 + 1xN11 + 3xN12
  - 63 modulo 10 = 3
  - 10 minus 3 makes the checksum = 7

2D barcodes

- Market requested:
  - Codes capable of storing more information, more character types (not just numbers), and that could be printed in a smaller space.
- Approach
  - Increasing the number of bar code digits or layout multiple bar codes
  - Problems:
    - enlarge the bar code area
    - complicate reading operations
    - increase printing cost
- Solution: 2D barcode
  - QR code (1994)

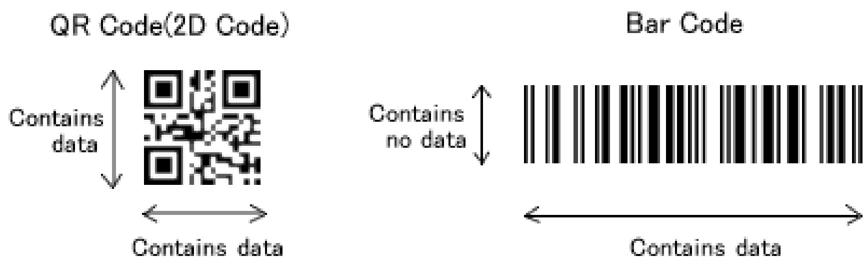
Multiple bar code layout

2D Code with stacked bar codes

2D Code (matrix type)

2D barcodes

- QR Code = Quick Response code

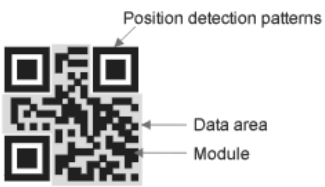


Typical 2D Codes

	QR Code	PDF417	DataMatrix	Maxi Code
Developer (country)	DENSO (Japan)	Symbol Technolog. (USA)	RVSI Acuity CiMatrix (USA)	UPS (USA)
Type	Matrix	Stacked Bar Code	Matrix	Matrix
Numeric capacity	7,089	2,710	3,116	138
Alphanumeric	4,296	1,850	2,355	93
Binary	2,953	1,018	1,556	
Kanji (Japan)	1,817	554	778	
Main features	Large capacity, small printout size High speed scan	Large capacity	Small printout size	High speed scan
Standardiza-tion	AIM International JIS, ISO	AIM International ISO	AIM International ISO	AIM International ISO

QR Code (Quick Response Code)

- High Capacity Encoding of Data
- Small Printout Size
- Dirt and Damage Resistant
- Readable from any direction in 360°



QR Code uses

- Initially used to track parts in vehicle manufacturing
- Now: much wider range of applications, including commercial tracking, entertainment and transport ticketing, product marketing and in-store product labeling.
- Many applications target mobile-phone users (via mobile tagging).
- Users may receive text, add a vCard contact to their device, open a Uniform Resource Identifier (URI), or compose an e-mail or text message after scanning QR codes.
- Google has a popular API to generate QR codes
- Apps for scanning QR codes can be found on nearly all smartphone devices.

Case study (1)

- Logistics Control System for Food Products
  - 2D barcode: **QR code**
  - Product code, expiration date, manufacturing history, and other data are encoded into QR Code
  - The data is used for logistics management of food products
- Benefits
  - Enables first-in first-out execution based on expiration date control
  - Improves traceability based on manufacturing history control

Case study (2)

- Shipping Control System for Garment Products
  - 2D barcode: **QR code**
  - Shipping destination, product code, color, size, and other data are encoded into QR Code for printing on shipping instructions of garment products.
  - The data is used for shipping control
- Benefits
  - Prevents shipping mistakes
  - Enables instant gathering of shipping instruction data using handy terminals

References

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Barcodes
EAN13 Example

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Barcode Template
EAN13

EAN13 encoding example

Digit	Even (normal)	Odd (inverted)
0	3211	1123
1	2221	1222
2	2122	2212
3	1411	1141
4	1132	2311
5	1231	1321
6	1114	4111
7	1312	2131
8	1213	3121
9	3112	2113

First Digit	Coding pattern
0	EEEEEE
1	EEOEOO
2	EEOOEO
3	EEOOOE
4	EOEEOO
5	EOOEEO
6	EOOOEE
7	EOEOEO
8	EOEOOE
9	EOOEOE

3211 2221 1222 1123 2122 1141 2221 3211 1411 1312 1132 ?

2 0 1 1 0 2 3 1 0 3 7 4 4

E E O O E O

1 3 1 3 1 3 1 3 1 3 1 3 weights

2 + 0 + 1 + 3 + 0 + 6 + 3 + 3 + 0 + 9 + 7 + 12 = 46

10 – 6 = 4

Questions?

Barcodes
Code 128

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Code 128

- Very effective, high-density symbology
- Permits encoding of alphanumeric data
  – Can encode all 128 ASCII characters
- Includes verification protection via a checksum digit
- Widely implemented in many applications (particularly, where a relatively large amount of data must be encoded in a relatively small amount of space)
- Its specific structure allows numeric data to be encoded at, effectively, double-density.

Parts of a Code 128

- A leading "quiet zone“
- A start code (there are 3 start codes possible)
- The data (any number of characters)
- A check character
- A stop code
- A trailing “quiet zone”

Start Code

- Code 128 has three “character sets” (A, B and C)
- The start code defines which character set to use
  - Start-A, Start-B, Start-C
    (The character set may be changed in the middle of the barcode)

- Start Code A allows encoding all the standard alphanumeric characters plus control characters and special characters
- Start Code B includes all standard alphanumeric characters plus <u>lower case</u> alpha and special characters
- Start Code C includes a set of 100 digit pairs from 00 to 99 and can be used to double the density of encoding numeric-only data

Changing character set in the middle of a symbol

- Use the special character CODE
  - Applies to all subsequent characters
- Use the special character SHIFT
  - Changes the next character and only changes between Code Set A and Code Set B or the reverse

Encoding

- Each symbol is made up of 11 black or white modules

  Stop code, however, is made up of 13 modules
- The 11 modules correspond to 3 bars and 3 spaces
- Bars and spaces can vary between 1 and 4 modules wide

Encoding

Value	Code A	Code B	Code C	Pattern B S B S B S	What ASCII Code Do I Print?
0	SP	SP	00	2 1 2 2 2 2	SP (ASCII 32)
1	!	!	01	2 2 2 1 2 2	! (ASCII 33)
2	"	"	02	2 2 2 2 2 1	" (ASCII 34)
3	#	#	03	1 2 1 2 2 3	# (ASCII 35)
4	$	$	04	1 2 1 3 2 2	$ (ASCII 36)
5	%	%	05	1 3 1 2 2 2	% (ASCII 37)
6	&	&	06	1 2 2 2 1 3	& (ASCII 38)
7	'	'	07	1 2 2 3 1 2	' (ASCII 39)
8	(	(	08	1 3 2 2 1 2	((ASCII 40)
9	)	)	09	2 2 1 2 1 3	) (ASCII 41)

Value	Code A	Code B	Code C	Pattern B S B S B S	What ASCII Code Do I Print?
10	*	*	10	2 2 1 3 1 2	* (ASCII 42)
11	+	+	11	2 3 1 2 1 2	+ (ASCII 43)
12	,	,	12	1 1 2 2 3 2	, (ASCII 44)
13	-	-	13	1 2 2 1 3 2	- (ASCII 45)
14	.	.	14	1 2 2 2 3 1	. (ASCII 46)
15	/	/	15	1 1 3 2 2 2	/ (ASCII 47)
16	0	0	16	1 2 3 1 2 2	0 (ASCII 48)
17	1	1	17	1 2 3 2 2 1	1(ASCII 49)
18	2	2	18	2 2 3 2 1 1	2 (ASCII 50)
19	3	3	19	2 2 1 1 3 2	3 (ASCII 51)

Encoding

Value	Code A	Code B	Code C	Pattern B S B S B S	What ASCII Code Do I Print?
20	4	4	20	2 2 1 2 3 1	4 (ASCII 52)
21	5	5	21	2 1 3 2 1 2	5 (ASCII 53)
22	6	6	22	2 2 3 1 1 2	6 (ASCII 54)
23	7	7	23	3 1 2 1 3 1	7 (ASCII 55)
24	8	8	24	3 1 1 2 2 2	8 (ASCII 56)
25	9	9	25	3 2 1 1 2 2	9 (ASCII 57)
26	:	:	26	3 2 1 2 2 1	: (ASCII 58)
27	;	;	27	3 1 2 2 1 2	; (ASCII 59)
28	<	<	28	3 2 2 1 1 2	< (ASCII 60)
29	=	=	29	3 2 2 2 1 1	= (ASCII 61)

Value	Code A	Code B	Code C	Pattern B S B S B S	What ASCII Code Do I Print?
30	>	>	30	2 1 2 1 2 3	> (ASCII 62)
31	?	?	31	2 1 2 3 2 1	? (ASCII 63)
32	@	@	32	2 3 2 1 2 1	@ (ASCII 64)
33	A	A	33	1 1 1 3 2 3	A (ASCII 65)
34	B	B	34	1 3 1 1 2 3	B (ASCII 66)
35	C	C	35	1 3 1 3 2 1	C (ASCII 67)
36	D	D	36	1 1 2 3 1 3	D (ASCII 68)
37	E	E	37	1 3 2 1 1 3	E (ASCII 69)
38	F	F	38	1 3 2 3 1 1	F (ASCII 70)
39	G	G	39	2 1 1 3 1 3	G (ASCII 71)

Encoding

Value	Code A	Code B	Code C	Pattern B S B S B S	What ASCII Code Do I Print?
40	H	H	40	2 3 1 1 1 3	H (ASCII 72)
41	I	I	41	2 3 1 3 1 1	I (ASCII 73)
42	J	J	42	1 1 2 1 3 3	J (ASCII 74)
43	K	K	43	1 1 2 3 3 1	K (ASCII 75)
44	L	L	44	1 3 2 1 3 1	L (ASCII 76)
45	M	M	45	1 1 3 1 2 3	M (ASCII 77)
46	N	N	46	1 1 3 3 2 1	N (ASCII 78)
47	O	O	47	1 3 3 1 2 1	O (ASCII 79)
48	P	P	48	3 1 3 1 2 1	P (ASCII 80)
49	Q	Q	49	2 1 1 3 3 1	Q (ASCII 81)

Value	Code A	Code B	Code C	Pattern B S B S B S	What ASCII Code Do I Print?
50	R	R	50	2 3 1 1 3 1	R (ASCII 82)
51	S	S	51	2 1 3 1 1 3	S (ASCII 83)
52	T	T	52	2 1 3 3 1 1	T (ASCII 84)
53	U	U	53	2 1 3 1 3 1	U (ASCII 85)
54	V	V	54	3 1 1 1 2 3	V (ASCII 86)
55	W	W	55	3 1 1 3 2 1	W (ASCII 87)
56	X	X	56	3 3 1 1 2 1	X (ASCII 88)
57	Y	Y	57	3 1 2 1 1 3	Y (ASCII 89)
58	Z	Z	58	3 1 2 3 1 1	Z (ASCII 90)
59	[	[	59	3 3 2 1 1 1	[(ASCII 91)

Encoding

Value	Code A	Code B	Code C	Pattern B S B S B S	What ASCII Code Do I Print?
60	\	\	60	3 1 4 1 1 1	\ (ASCII 92)
61	]	]	61	2 2 1 4 1 1	] (ASCII 93)
62	^	^	62	4 3 1 1 1 1	^ (ASCII 94)
63	_	_	63	1 1 1 2 2 4	_ (ASCII 95)
64	NUL	'	64	1 1 1 4 2 2	` (ASCII 96)
65	SOH	a	65	1 2 1 1 2 4	a (ASCII 97)
66	STX	b	66	1 2 1 4 2 1	b (ASCII 98)
67	ETX	c	67	1 4 1 1 2 2	c (ASCII 99)
68	EOT	d	68	1 4 1 2 2 1	d (ASCII 100)
69	ENQ	e	69	1 1 2 2 1 4	e (ASCII 101)

Value	Code A	Code B	Code C	Pattern B S B S B S	What ASCII Code Do I Print?
70	ACK	f	70	1 1 2 4 1 2	f (ASCII 102)
71	BEL	g	71	1 2 2 1 1 4	g (ASCII 103)
72	BS	h	72	1 2 2 4 1 1	h (ASCII 104)
73	HT	i	73	1 4 2 1 1 2	i (ASCII 105)
74	LF	j	74	1 4 2 2 1 1	j (ASCII 106)
75	VT	k	75	2 4 1 2 1 1	k (ASCII 107)
76	FF	l	76	2 2 1 1 1 4	l (ASCII 108)
77	CR	m	77	4 1 3 1 1 1	m (ASCII 109)
78	SO	n	78	2 4 1 1 1 2	n (ASCII 110)
79	SI	o	79	1 3 4 1 1 1	o (ASCII 111)

Encoding

Val ue	Code A	Code B	Code C	Pattern B S B S B S	What ASCII Code Do I Print?
80	DLE	p	80	1 1 1 2 4 2	p (ASCII 112)
81	DC1	q	81	1 2 1 1 4 2	q (ASCII 113)
82	DC2	r	82	1 2 1 2 4 1	r (ASCII 114)
83	DC3	s	83	1 1 4 2 1 2	s (ASCII 115)
84	DC4	t	84	1 2 4 1 1 2	t (ASCII 116)
85	NAK	u	85	1 2 4 2 1 1	u (ASCII 117)
86	SYN	v	86	4 1 1 2 1 2	v (ASCII 118)
87	ETB	w	87	4 2 1 1 1 2	w (ASCII 119)
88	CAN	x	88	4 2 1 2 1 1	x (ASCII 120)
89	EM	y	89	2 1 2 1 4 1	y (ASCII 121

Value	Code A	Code B	Code C	Pattern B S B S B S	What ASCII Code Do I Print?
90	SUB	z	90	2 1 4 1 2 1	z (ASCII 122)
91	ESC	{	91	4 1 2 1 2 1	{ (ASCII 123)
92	FS	|	92	1 1 1 1 4 3	| (ASCII 124)
93	GS	}	93	1 1 1 3 4 1	} (ASCII 125)
94	RS	~	94	1 3 1 1 4 1	~ (ASCII 126)
95 (Hex 7F)	US	DEL	95	1 1 4 1 1 3	DEL (ASCII 127)
96 (Hex 80)	FNC 3	FNC 3	96	1 1 4 3 1 1	Ç (ASCII 128)
97 (Hex 81)	FNC 2	FNC 2	97	4 1 1 1 1 3	ü (ASCII 129)
98 (Hex 82)	SHIFT	SHIFT	98	4 1 1 3 1 1	é (ASCII 130)
99 (Hex 83)	CODE C	CODE C	99	1 1 3 1 4 1	â (ASCII 131)
100 (Hex 84)	CODE B	FNC 4	CODE B	1 1 4 1 3 1	ä (ASCII 132)
101 (Hex 85)	FNC 4	CODE A	CODE A	3 1 1 1 4 1	à (ASCII 133)
102 (Hex 86)	FNC 1	FNC 1	FNC 1	4 1 1 1 3 1	å (ASCII 134)

Start Code and Stop Code

Value	Start Code	Pattern B S B S B S	What ASCII Code Do I Print?
103 (Hex 87)	START (Code A)	2 1 1 4 1 2	‡ (ASCII 135)
104 (Hex 88)	START (Code B)	2 1 1 2 1 4	ˆ (ASCII 136)
105 (Hex 89)	START (Code C)	2 1 1 2 3 2	‰ (ASCII 137)
106 (Hex 6A)	STOP (All Codes)	2 3 3 1 1 1 2	Š (ASCII 138)

Checksum character

- Take the value of the start character (103, 104, or 105) and make that the starting value of the running checksum
- Start with the first data character, take its value (between 0 and 102, inclusive) multiply it by its character position (1) and add that to the running checksum
- Take each additional character in the symbol, take its value, and multiply it by its character position, and add the total to the running checksum
- Divide the resulting running checksum by 103. The remainder becomes the checksum character which is added to the end of the symbol

Example: Encode “CSE370”

- Start code and data
  - Start-A = 103 = “211412” (bar, space, bar, …, space)
  - C = 35 = “131321”
  - S = 51 = “213113”
  - E = 37 = “132113”
  - 3 = 19 = “221132”
  - 7 = 23 = “312131”
  - 0 = 16 = “123122”
- Checksum
  - 103 + 35*1 + 51*2 + 37*3 + 19*4 + 23*5 + 16*6 = 638
  - Remainder of 638 divided by 103 = 20
  - 20 = “221231”
- Stop code
  - “2331112”

Questions?

Ambient Intelligence

Barcodes Advantages/Disadvantages

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Advantages of barcodes

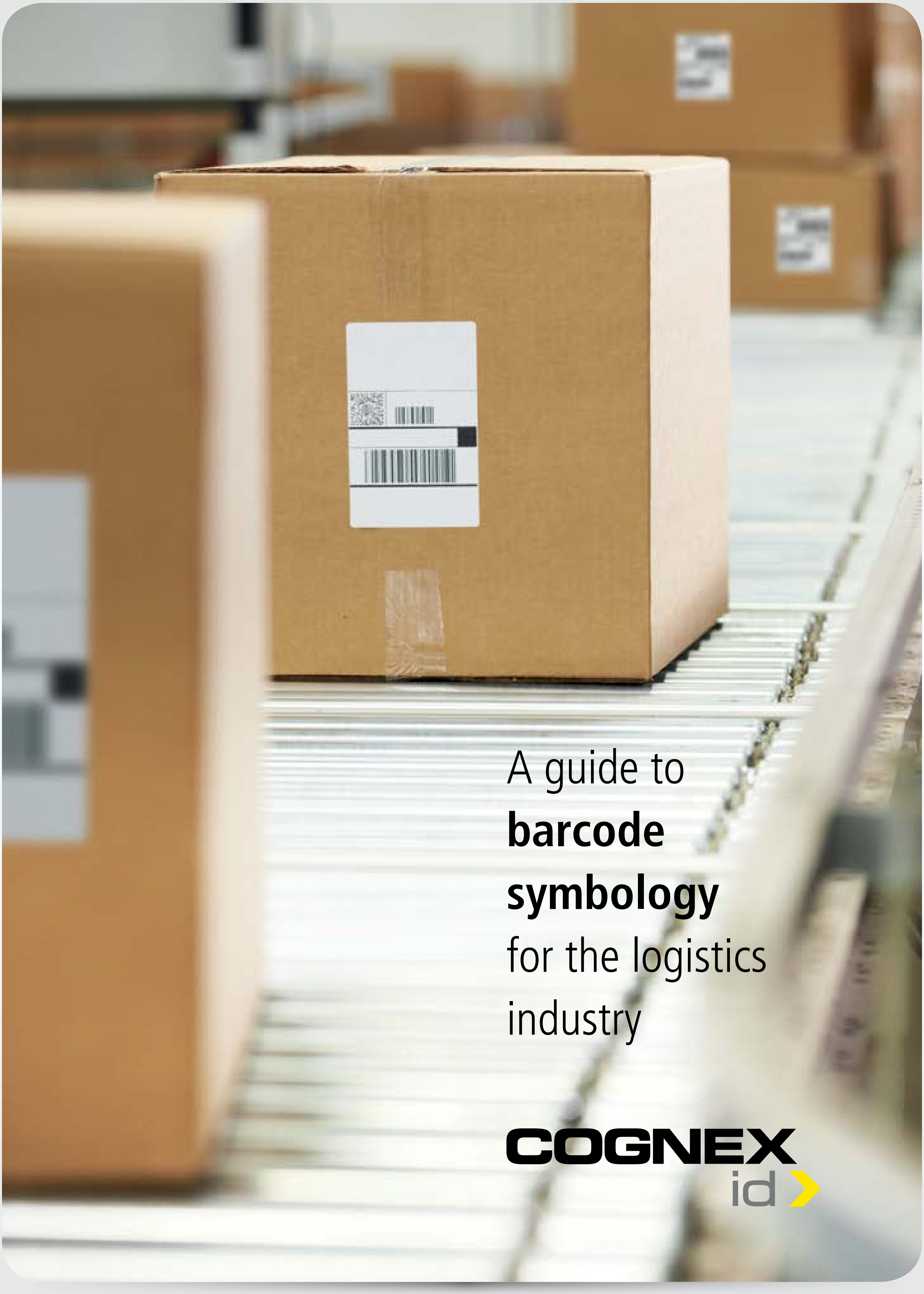
- Barcodes are printed on virtually every product that is sold today, allowing them to be quickly identified by a checkout scanner or at any point along the supply chain.
- Products are marked with a barcode, either stamped on a pallet or printed on the box they are shipped in, facilitating their ability to be tracked as they pass through intermediate warehouses and shipping vehicles.
- Some of these vehicles, including train cars and trailers, are marked with their own barcodes so that they themselves can be readily identified and tracked.
- Clearly the ability to identify products by quickly scanning a label is an advantage.

Disadvantages of barcodes

- Barcodes are limited in terms of the amount of information they can carry.
- Barcodes are easily smudged, damaged or lost.
- They require physical scanning and must therefore be visible and accessible to the scanning device, which implies that the package on which they are printed must be positioned or oriented in a particular way as it passes through the scanner, a process that often involves human intervention and, therefore, added cost.

Conclusion

- Disadvantages:
  – Limited information-carrying capacity
  – Physical vulnerability
  – Need for a human in the loop
- Conclusion: a better technology is required in modern supply chains:
  – RFID – Radio Frequency IDentification



A guide to **barcode symbology** for the logistics industry

COGNEX id

Symbology in barcodes

Barcode technologies provide fast reliable data collection to ensure item or package traceability, and enhance customer service.

Barcodes are machine readable symbols that store identifying data about the package or item with which they are associated. These symbols, when read by a barcode scanner, are decoded, recorded, and processed to extract the data for a variety of uses (e.g., pricing, order fulfillment, traceability through production, sortation, shipping, etc.)

Over the years, different forms of barcodes have been developed to help businesses around the world. These include:

1-D linear barcodes

A 1-D (one-dimensional) barcode is the typical style with which we are most familiar. All the information in the code is organized horizontally in bar and space widths and read left to right by a scanner. Several versions of 1-D codes store only numerical data while others can encode additional characters. The height of the code varies based on the space available on a product and the ability of a barcode reader to read a small or large sized barcode.

2-D matrix codes

In the 2-D (two-dimensional) matrix code type, the data is encoded as black and white 'cells' (small squares) arranged in either a square or rectangular pattern. As well as being able to encode huge amounts of data, the matrix code improves readability and resistance to poor printing. They also include redundant data so even if one or more cells are damaged, the code is still readable.

Postal codes

This type of barcode lies somewhere in between a 2-D and a 1-D linear barcode. Instead of encoding data in the black bar and white space widths, these primarily use the height of the bars. The majority of postal codes only use numbers, but a few are now starting to include letters as well.

Stacked linear barcodes

A stacked linear barcode is one of two types of 2-D barcodes. These simply consist of multiple linear barcodes that are layered on top of one another, allowing a greater amount information to be encoded. However, to fully decode the data, a barcode reader must be able to simultaneously read the code both horizontally and vertically.

Decoding a barcode

Let's take a closer look at the makeup of two of the most common barcode types:

Universal Product Code (UPC)

8 75678 16412 1

HUMAN READABLE CODE

The first six digits are the manufacturer identification number which they pay an annual fee for and the next five digits are an item number.

CHECK DIGIT

Calculated by a formula using the other numbers in the code, it enables the barcode reader to determine if it scanned the number correctly.

Data Matrix

CLOCKING PATTERN

Provides a count of the number of rows and columns in the code.

CELL

DATA REGION

Can be text or numeric data up to 2,335 alphanumeric characters. Redundant data is often included so even if one or more cells are damaged, the code is still readable.

FINDER OR 'L' PATTERN

Helps a barcode reader locate and determine the orientation of the code.

The evolution of barcodes

A brief history

It might be hard to remember a time when barcodes were not part of our daily lives, but it was not until the 1970s that they first made an impact. Although the first patent was actually issued in 1952, it was still some time later that they were first commercially used to label railroad cars.

However, it took until June 1974 before the first scanner was installed at a Marsh's supermarket in Ohio, USA, allowing a product with a barcode attached to be read for the very first time. Unassumingly, this was just a simple packet of Wrigley's® chewing gum.

Today's application

Decades after that first scan, we can hardly imagine a world without barcodes. Available in various guises, barcodes continue to benefit industries that manufacture, buy, sell and distribute products. They help collect data faster and more reliably, improve decision making, eliminate the possibility of human error, reduce employee training time and track products throughout their lifecycle. They are also extremely versatile, inexpensive to design and print and ultimately reduce costs.

Quite simply they have changed the way businesses work across the globe.

1-D linear barcodes

1-D linear barcodes are probably the most commonly recognized style of barcode used today. The following selection of symbols help illustrate their multiple forms:

Code 128

Code 128 is a more recently introduced symbol and the most robust 1-D barcode type. The number 128 refers to the ability to hold any character of the ASCII 128 character set. That includes all digits, characters and punctuation marks. This makes it fairly compact and very powerful as it enables diverse storage of data.

CODE128

Typical Usage: **Logistics**

Encoding Type: Alphanumeric | **Format:** Multi-width | **Check Digit:** Required

UPC-A

By far the most common and well-known barcode used in the U.S., UPC-A encodes 12 digits of data. The first digit is the number system character followed by a five-digit manufacturer number, a five-digit product number and a final check digit. Due to its limited encoding, UPC-A is primarily used in retail.

0 12345 67890 1

Typical Usage:
Retail & Supermarkets in United States

Encoding Type: Numeric
Format: Multi-width | **Check Digit:** Required

EAN-13

EAN-13 is the European counterpart of the UPC-A symbol. The main difference between them is that the EAN-13 encodes an extra digit of data to make a total of 13. The first two digits of the barcode identify a specific country and the check digit is the last number of the second group of six digits.

0 123456 789012

Typical Usage:
Retail & Supermarkets in Europe

Encoding Type: Numeric
Format: Multi-width | **Check Digit:** Required

UPC-E

UPC-E is a condensed variation of a UPC-A barcode. The code is condensed as a result of eliminating 'extra' zeros from the digital data. Because the resulting barcode is about half the size of a UPC-A barcode, it is generally used on very small packaging where space is limited.

0 123456 7

Typical Usage:
Small Retail Packages in United States

Encoding Type: Numeric
Format: Multi-width | **Check Digit:** Required

EAN-8

EAN-8 is the EAN equivalent of UPC-E in the sense that it provides a short barcode. Set in two groups of four numbers, it is composed of two flag digits, five data digits and one check digit. This is primarily used on small packaging where space is limited.

1234 4567

Typical Usage:
Small Retail Packages in Europe

Encoding Type: Numeric
Format: Multi-width | **Check Digit:** Required

Each of these requires registration to an association to assign unique serial data.

1-D linear barcodes

Code 39

Code 39, also known as '3 of 9 Code', was the first symbol to use numbers and letters. It is a variable-length barcode that is self-checking so a check digit normally isn't necessary, but is recommended. Its popularity is due to its ability to encode up to 43 numbers, letters and other characters. Code 39 is still widely used, especially in non-retail environments.

Encoding Type: Partial alphanumeric | **Format:** Wide/narrow | **Check Digit:** Optional

CODE39

Typical Usage: **Military & Automotive**

Extended Code 39

Extended Code 39 uses a combination of two standard Code 39 characters to encode every one of the 128 ASCII characters. It also allows for special characters, such as lowercase letters. Generally, the more special characters that are used, the longer the barcode will become. Most barcode readers will not automatically read Extended Code 39 without custom configuration.

Encoding Type: Partial alphanumeric | **Format:** Wide/narrow | **Check Digit:** Optional

C39Ext

Typical Usage: **Military & Automotive**

Code 93

Code 93 was designed to encode data more compactly and with higher data redundancy than with older multi-length barcode types such as Code 39.

Encoding Type: Alphanumeric | **Format:** Multi-width | **Check Digit:** Required

CODE93

Typical Usage: **Military, Automotive & Healthcare**

Interleaved 2 of 5

Interleaved 2 of 5 encodes any even number of numeric characters. Unlike Standard 2 of 5 (a.k.a. Industrial 2 of 5), which only encodes information in the width of the bars, Interleaved 2 of 5 encodes data in the width of both the bars and spaces. This allows Interleaved 2 of 5 to achieve higher density encoding.

Encoding Type: Numeric | **Format:** Wide/narrow | **Check Digit:** Optional

0123456789

Typical Usage: **Distribution & Warehousing**

Stacked linear barcodes

GS1 DataBar Stacked

GS1 DataBar Stacked barcodes are designed to condense the GTIN into a more compact and square barcode suitable for use on smaller packages (such as the label stickers on fresh produce).

Typical Usage:
Supermarkets

Encoding Type: ASCII characters | **Format:** Wide/narrow
Check Digit: Required

PDF417

PDF417 barcodes can store up to 1,800 printable ASCII characters or 1,100 binary characters per symbol. It is also possible to break large amounts of data into several PDF417 codes which are linked together. In theory, there is no limit to the amount of data that can be stored in a group of PDF417 symbols.

Typical Usage:
U.S. Driver's Licenses & Logistics

Encoding Type: ASCII characters | **Format:** Wide/narrow
Check Digit: Required

Postal codes

Over the years nearly every country in the world has developed their own postal codes to best suit their needs. However, in recent times there has been a move towards standardizing them.

POSTNET

The POSTNET (Postal Numeric Encoding Technique) barcode is used by the U.S. Postal Service to automatically sort mail. Unlike most other barcodes in which data is encoded in the width of the bars and spaces, POSTNET actually encodes data in the height of the bars.

Intelligent Mail Barcode

The IMB (Intelligent Mail Barcode) is a U.S. Postal Service barcode used to sort and track letters and flats. In addition to the ZIP code used to generate a POSTNET barcode, the IMB carries sender's information.

2-D matrix codes

2-D symbologies are a more recent addition to the world of barcodes. By storing data both horizontally and vertically, significantly more can be encoded than is possible with a 1-D barcode. The following examples demonstrate the more popular ones available.

Data Matrix

Data Matrix codes allow encoding of large amounts of data (up to 2,335 alphanumeric or 3,116 numerical characters) and use an error correction system to read codes that are as much as 40% damaged. They are made up of black and white cells in a square or rectangular pattern, a finder pattern and a timing pattern (see page three).

Typical Usage:
Aerospace, Components, U.S. Mail, HIBC, Defense, & Printed Media

MaxiCode

MaxiCode is a fixed-size code which holds up to 93 data characters. It is composed of a central bulls-eye locator and offset rows of hexagonal elements. It was created by United Parcel Service® to allow quick, automated scanning of packages on high-speed conveyor lines (high powered image-based barcode readers can read a MaxiCode on a carton traveling at up to 550 feet/minute or 168 meters/minute).

Typical Usage:
Logistics

QR

QR (Quick Read) codes contain square blocks of black cells on a white background with finder patterns in the top left, top right, and bottom left corners. QR was developed with the intention of being used for tracking parts during vehicle assembly. However, it has grown in popularity since the introduction of readers on smartphones, and it is now commonly used in printed marketing materials.

Typical Usage:
Automotive Parts & Commercial Marketing

Aztec

Named after the resemblance of the central finder pattern to an Aztec pyramid, the code is built on a square grid with a bulls-eye pattern at its center for locating the code. Data is encoded in concentric square rings around the bulls-eye pattern. Aztec codes have the potential to use less space than other matrix barcodes because they do not require a surrounding blank 'quiet zone'.

Typical Usage:
Travel Tickets & Car Registration Documents

Reading barcodes

There are many types of barcode scanners on the market that address the many applications that use barcodes. Decoding capability, performance reliability and communications are key to getting the data into the system.

Ranking barcode readers

The most important way to rank barcode reader performance is by its read rate. Read rate is the number of barcodes read divided by the number attempted. It's usually expressed as a percentage and the closer to 100%, the better. Read rate is the best measure of how reliable and robust the reader is to the barcodes seen on the factory floor.

Barcode quality feedback

In many production lines, it is important to maintain the barcode print quality at a high level to ensure that the code can be read by other readers in the product distribution chain. Image-based readers can provide this feedback on every code they read.

Extracting the data

After marking the package or item and reading the code, the data is stored or used within the plant or distribution center's MES (Manufacturing Execution System). If available, Ethernet communication is the fastest and most reliable method of data transfer.

CALCULATING READ RATE

If 9,900 barcodes are successfully read in 10,000 attempts, the read rate is calculated:

9,900 ÷ 10,000 = .99 or 99%

Cognex barcode readers offer high read rates, industrial connectivity, and reliable performance, and come in many shapes and sizes:

- Fixed-mount
- Handheld
- Mobile Computers
- Verifiers

From the smallest and highest performing fixed-mount readers for direct part mark and high-speed code reading, to the widest range of handheld readers, Cognex has the solution for you.

Get more information about Cognex image-based readers at:

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COGNEX id

Ambient Intelligence

RFID
Radio Frequency Identification

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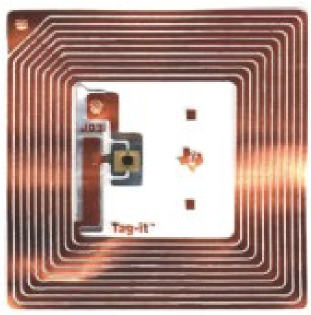
What is RFID?

- **<u>R</u>**adio **<u>F</u>**requency **<u>Id</u>**entification
- Identification system that consists of chip-based **tags** (*transponders*) and **readers**
- Data is stored and retrieved remotely using **radio waves**
  - Product information
  - Onboard sensors



What is RFID?

- Auto-ID data collection system for identifying, tracking and doing management of material flow

- Basic concept behind RFID is same as “Mirror-Sunlight-Reflection theory”

Brief History

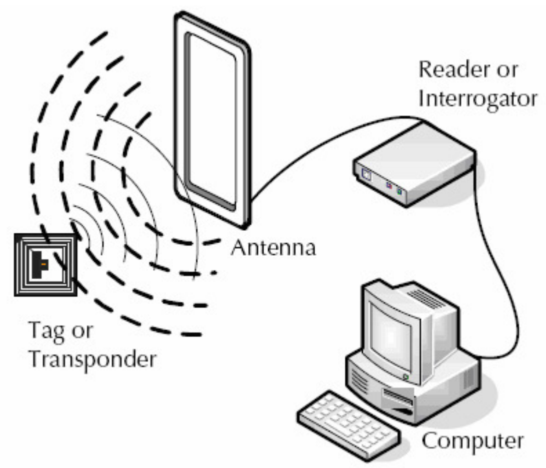
- Invented and used from early 1940’s
- Commercial Operation begun in the 1960’s
- In 1970’s developers, inventors, companies, academic institution and government sectors were actively working on RFID
- Most common applications are
  - Track objects, animals or persons,
  - Identify goods in supply chain,
  - Reusable containers,
  - Track high value items,
  - Security,
  - Controlling access to buildings,
  - Ticketing systems,
  - Payment systems.

Tags Types

- **Passive**
  - Require no internal power source or maintenance
  - Powered by the reader
  - Tag reflects radio signal from reader
  - Short Read Range (cm / m)
- **Active**
  - Require a power source
  - Tag transmits radio signal
  - More reliable and efficient in rugged environments
  - High Read Range (100 m)

Active tag

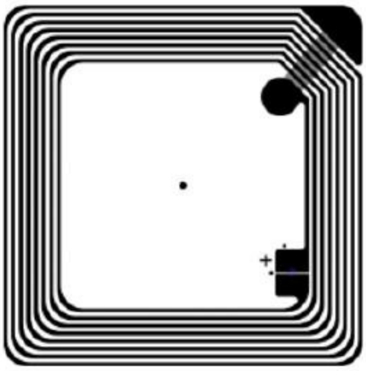
Components of an RFID system



- RF signal transmitted by the reader (through the “antenna”) powers the tag
- Tag becomes active and can receive and “transmit”
- Requires no line-of-sight (like barcodes do)
- Different frequencies can be used (LF, HF, UHF, …)
  - Reader and tag must operate at the same frequency

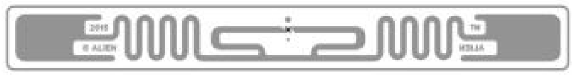
Common frequencies of operation

HF (High Frequency)
13,56 MHz



Coupling element: coil

UHF (Ultra High Frequency)
860 - 960 MHz

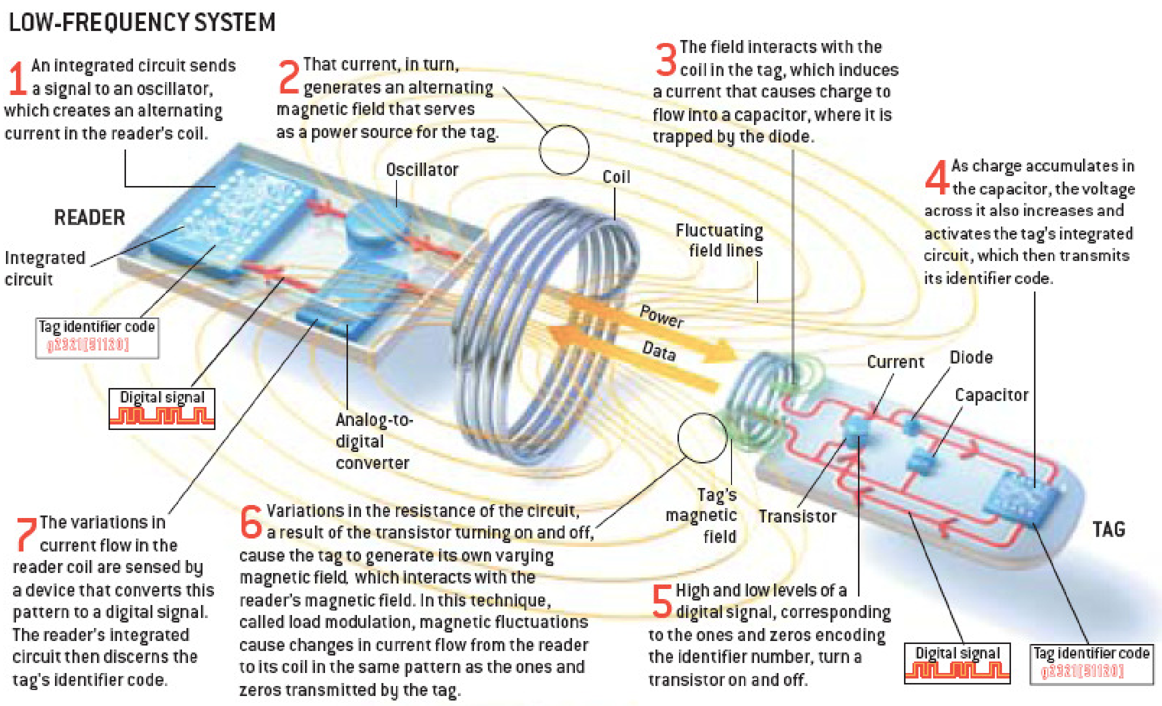


Coupling element: antenna

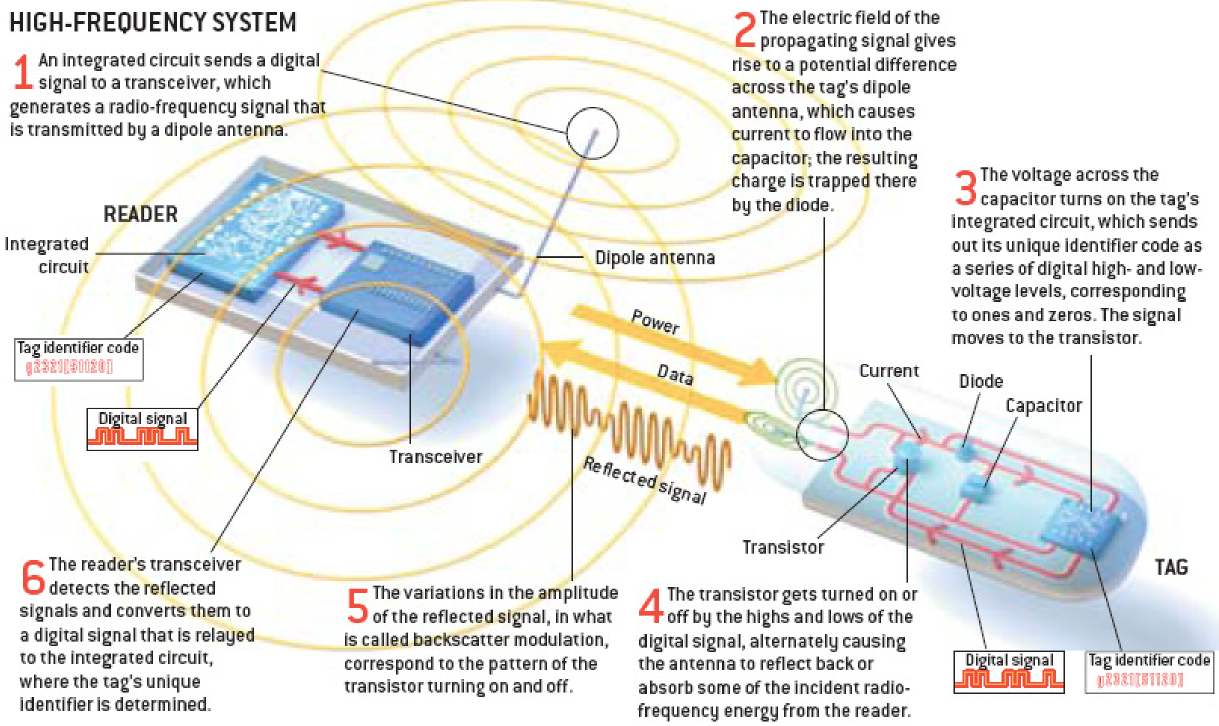
LF (Low Frequency)
< 135 KHz

Coupling element: coil

Interaction details (LF+HF)



Interaction details (UHF)



RFID Standards

- Tracking Animals
  - ISO 11784 – Specifies the structure of the ID code
  - ISO 11785 – Specifies how transponder (*tag*) is activated
  - ISO 14223/1 – Specifies RF code for advanced transponders
- Credit Cards
  - ISO 15693 – Specifies modulation and coding schemes
- Passports and proximity cards
  - ISO 14443 – Specifies modulation and coding schemes
- General Frequency bands
  - ISO 18000 series

Standard RFID Operating Frequencies

- ISO 18000-2
  - <135 KHz

  LF
- ISO 18000-3
  - 13.56 MHZ

  HF
- ISO 18000-4
  - 2.45 GHz
- ISO 18000-6
  - 860-960 MHz

  UHF
- ISO 18000-7
  - 433 MHZ (active)

  Used in active tags

ISO 18000-2 (LF)

- Operates at <135 KHz
- Inductive (uses a coil)
- Short range (a few centimeters)
- Low data rate
- Unaffected by presence of water
- Fairly costly because of coil in tag

ISO 18000-3 (HF)

- Operates at 13.56 MHz
- Inductive (uses a coil)
- Mid range: 70 – 125 cm
- Moderate data rate
- Not to much affected by water
- Low cost
- Read / write capable
- Thin flexible form factor (smart label)

ISO 18000-6 (UHF)

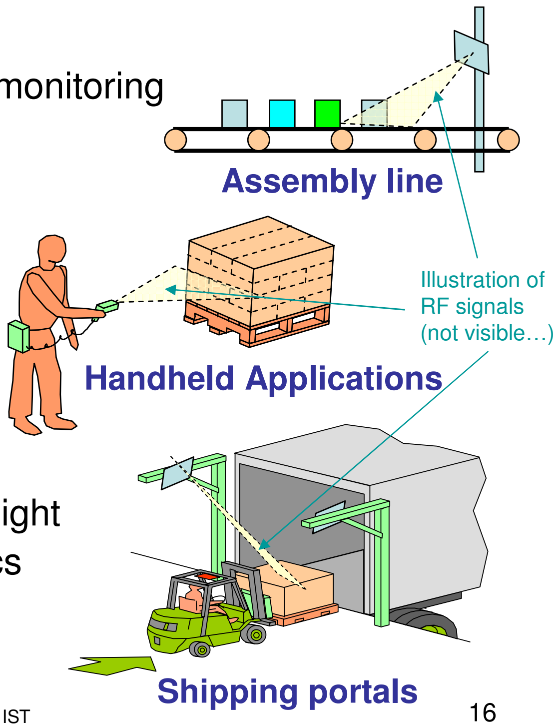
- Operates between 860 – 960 MHz
- Propagating (uses an antenna)
- Long range: 2 - 5 meters
- High data rate
- Can be problematic near metal and water
- Low cost
- Read / write capable
- The future for mass application RFID

Tags can be attached to almost anything

- Pallets or cases of products
- Vehicles
- Company assets
- Personal items such as apparel, luggage, laundry
- People, livestock, or pets
- High value electronics such as computers, TVs, …

Applications

- Manufacturing and Processing
  - Inventory and production process monitoring
  - Warehouse order fulfillment
- Supply Chain Management
  - Inventory tracking systems
  - Logistics management
- Retail
  - Inventory control and customer insight
  - Auto checkout with reverse logistics

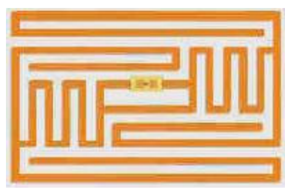


Applications

- Security
  - Access control
  - Counterfeiting and Theft control/prevention
- Location Tracking
  - Traffic movement control and parking management
  - Wildlife/Livestock monitoring and tracking

Applications

- Electronic Product Code (EPC)
- Proximity cards
- Keyless entry



Applications

- Payment tokens
  - Contact-less credit cards
  - Automatic toll-payment
- Ticketing systems
- Passports

Applications

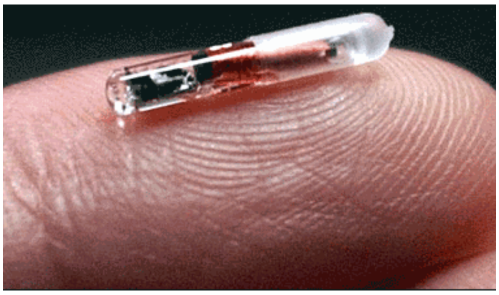
- Tracking books in libraries / bookstores

  Used for identification
  and as security device

- Inventory control
- Hospital patients tracking

Applications

- Animal and human tracking



RFID-privacy legislation…

Privacy Concerns

- Clandestine tracking
- Inventorying

Protecting Privacy

- Kill function
- Normal tags
  - Prevents unauthorized readings
  - Blocks electric waves
  - Jamming and interference
- Smart tags
  - Rewritable memory
  - Anonymous-ID scheme

Requirements for consumer use

- Notify the consumer
- Visible and easily removable tags
- Disabled at point of sale
- Tag the product’s packaging

Open issues

- Rogue scanning and eavesdropping
  - Rogue scanning range
  - Tag-to-reader eavesdropping
  - Reader-to-tag eavesdropping
- Authentication
- Denial of service

Conclusion

- RFID has many potential uses
- Privacy and security concerns must be addressed
- Cost is still high for many applications

EPC - Electronic Product Code

Prof. Renato Nunes

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EPC – Electronic Product Code

- Identification code stored on an RFID tag
- Is a unique number that identifies a specific item and allows its tracking along all stages of the supply chain
- Contains a wide range of information unique to that item including the manufacturer, SKU, product information and serial number when applicable

SKU – Stock Keeping Unit

EPC Tag Data Standard (TDS)

- Defines the Electronic Product Code™ (EPC), and also specifies the memory contents of Gen2 RFID Tags.
- TDS covers:
  - The specification of the Electronic Product Code, including its representation at various levels of the EPC global Architecture and it correspondence to GS1 keys and other existing codes.
  - The specification of data that is carried on Gen 2 RFID tags, including the EPC, “user memory” data, control information, and tag manufacture information.

(See slide 12)

Electronic Product Code (EPC)

- Universal identifier for any physical object.
- It is used in information systems that need to track or otherwise refer to physical objects.
- Within computer systems, including electronic documents, databases, and electronic messages, the EPC takes the form of an Internet Uniform Resource Identifier (URI). This is true regardless of whether the EPC was originally read from an RFID tag or some other kind of data carrier. This URI is called the “Pure Identity EPC URI.”
- Example of a Pure Identity EPC URI:

  urn:epc:id:sgtin:0614141.112345.400

(URN = Uniform Resource Name)

Encoding EPCs onto RFID tags

- A very large subset of applications that use the Electronic Product Code also rely upon RFID Tags as a data carrier.
- RFID is often a very appropriate data carrier technology to use for applications involving visibility of physical objects, because RFID permits data to be physically attached to an object such that reading the data is minimally invasive to material handling processes.
- Owing to memory limitations of RFID tags, the EPC is not stored in URI form on the tag, but is instead encoded into a compact binary representation. This is called the "EPC Binary Encoding."

Serialized Global Trade Item Number (SGTIN)

- Assigns a unique identity to an instance of a trade item, such as a specific instance of a product.
- General syntax:
  – urn:epc:id:sgtin:CompanyPrefix.ItemReference.
    SerialNumber
- Example:
  – urn:epc:id:sgtin:0614141.112345.400

Serial Shipping Container Code (SSCC)

- Assigns a unique identity to a logistics handling unit, such as a the aggregate contents of a shipping container or a pallet load.
- General syntax:
  - urn:epc:id:sscc:CompanyPrefix.SerialReference
- Example:
  - urn:epc:id:sscc:0614141.1234567890

Serialized Global Location Number (SGLN)

- Assigns a unique identity to a physical location, such as a specific building or a specific unit of shelving within a warehouse.
- General syntax:
  - urn:epc:id:sgln:CompanyPrefix.LocationReference.Extension
- Example:
  - urn:epc:id:sgln:0614141.12345.400

Global Returnable Asset Identifier (GRAI)

- Assigns a unique identity to a specific returnable asset, such as a reusable shipping container or a pallet skid.
- General syntax:
  – urn:epc:id:grai:CompanyPrefix.AssetType. SerialNumber
- Example:
  – urn:epc:id:grai:0614141.12345.400

Global Individual Asset Identifier (GIAI)

- Assigns a unique identity to a specific asset, such as a forklift or a computer.
- General syntax:
  – urn:epc:id:giai:CompanyPrefix.IndividulAssetReference
- Example:
  – urn:epc:id:giai:0614141.12345400

more identifiers…

- Global Service Relation Number (GSRN)
- Global Document Type Identifier (GDTI)
- General Identifier (GID)
- US Department of Defense Identifier (DOD)

Memory Organization of Gen 2 RFID Tags

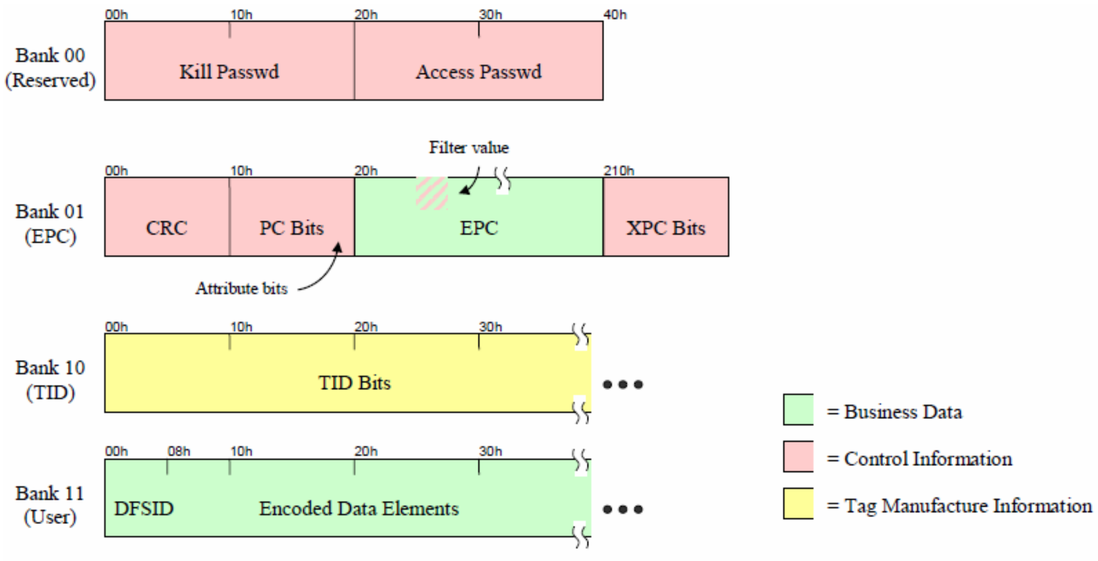
- Types of Tag Data
  - **Business Data Information** - describes the physical object to which the tag is affixed. This information includes the Electronic Product Code (EPC) that uniquely identifies the physical object, and may also include other data elements. This information is what business applications act upon.
  - **Control Information** - Information that is used by data capture applications to help control the process of interacting with tags. Control Information includes data that helps a capturing application filter out tags from large populations to increase read efficiency, special handling information that affects the behavior of capturing application, information that controls tag security features, and so on.

    Unlike Business Data, Control Information has no equivalent in bar codes or other data carriers.
  - **Tag Manufacture Information** - Information that describes the tag itself, as opposed to the physical object to which the tag is affixed. Tag Manufacture information includes a manufacturer ID and a code that indicates the tag model. It may also include information that describes tag capabilities, as well as a unique serial number assigned at manufacture time.

    Usually, Tag Manufacture Information is like Control Information in that it is used by capture applications but not directly passed to business applications. Like Control Information, Tag Manufacture Information has no equivalent in bar codes or other data carriers.

Gen 2 Tag Memory Map

- Four separately addressable banks, numbered 00, 01, 10, and 11.



Reserved Memory
(Bank 00)

- This memory bank stores the kill password and the access password (each are 32 bits).
- The kill password permanently disables the tag (very rarely used).
- The access password is set to lock and unlock the tag's write capabilities.
- This memory bank is only writable if you want to specify a certain password. Most users do not use this memory area unless their applications contain sensitive data. It cannot store information besides the two codes.

EPC Memory
(Bank 01)

- This memory bank stores the Electronic Product Code (EPC).
- It has a minimum of **96 bits** of writable memory.
- The EPC memory is what is typically used in most applications if they only need 96 bits of memory.
- There are some tags that have the capability of allocating more bits to the EPC memory from the user memory.
- This is the first writable memory bank.

TID Memory
(Bank 10)

- Stores the unique Tag ID number
  (done by the manufacturer when the IC is manufactured)
- Typically, this memory portion cannot be changed.

User Memory
(Bank 11)

- If the user needs more memory than the EPC section has available
- Certain ICs have extended user memory which can store more information
  - There is no standard in how many bits of memory are writable on each tag
  - Typically, the extended memory is no more than 512 bits
  - There are some high memory tags with up to 4K or 8K bytes of memory.
- This is the second writable memory bank for Gen 2 ICs.

Filter Value

- The filter value is additional control information that may be included in the EPC memory bank (01) of a Gen 2 tag.
- Allows an RFID reader to select or deselect the tags corresponding to certain physical objects, to make it easier to read the desired tags in an environment where there may be other tags present.
- **Example**:
  - If the goal is to read the single tag on a pallet, and it is expected that there may be hundreds or thousands of item-level tags present, the performance of the capturing application may be improved by using the Gen 2 air interface to select the pallet tag and deselect the item-level tags.

Multiple tags – The "Tag Collision" problem

- When multiple tags are in range of the reader:
  - All the tags will be excited at the same time and the answers will overlap ("collide") making it very difficult or impossible to read their ids.

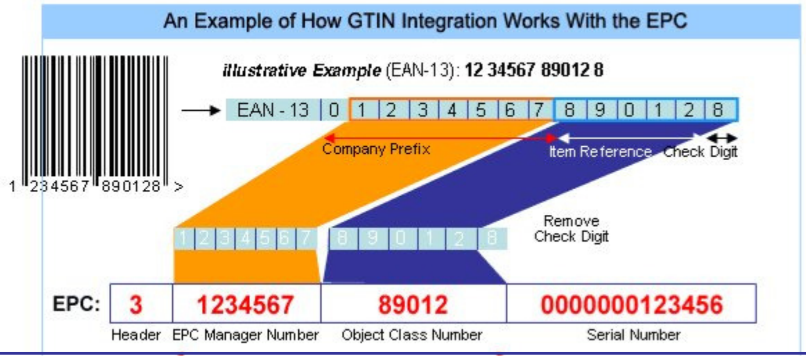
- Collision avoidance mechanisms
  - Probabilistic
    - Tags generate a random number based on a slot size
    - When the reader broadcasts that number the tag will answer
  - Deterministic
    - Reader searches for specific tags (may use the *Filter Value*)
    - Other algorithms exist

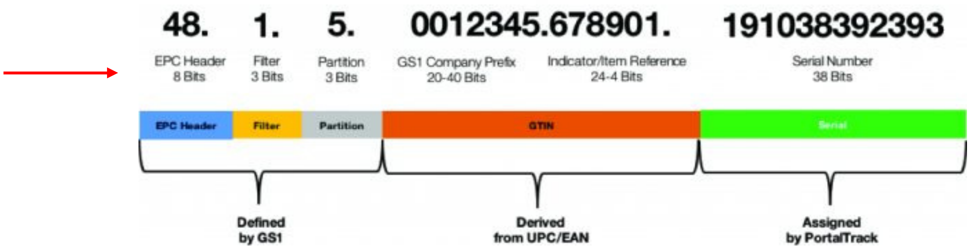
Reader Collision Problem

- Reader-Reader Interference
- Reader-Tag Interference

- Solutions:
  - Only reader to reader interference
    - Assign different operating frequencies
  - Only multiple reader to tag interference
    - Assign different time slots for operation
  - Both types of interference
    - First allot different time slots, then frequencies

Illustration of GTIN integration in EPC





96 bits

Questions?