BadBarcode: How to hack a starship with a piece of paper

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Who am I ?

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- Embedded Device Security
- Firmware Reverse-Engineering
- Big Fan of IoT

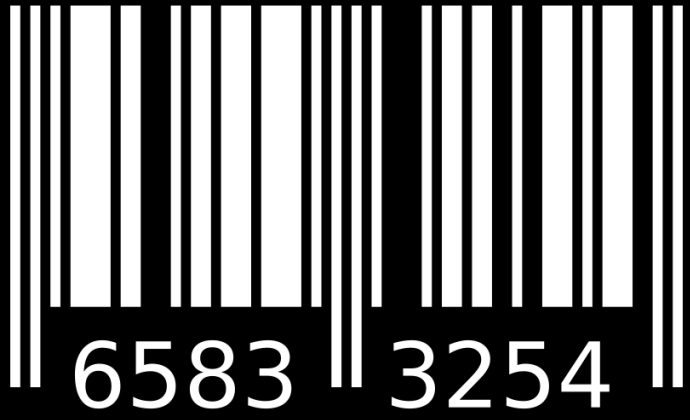
Wait, hack a starship?

SPECIFICATION SHEET

Symbol M2000 Cyclone

Hands-free bar code scanner

About Barcode



Though often be ignored, barcode is the most ancient technology of IoT.

What is barcode?

- Barcode is an optical machine-readable representation of data relating to the object to which it is attached;
- Originally barcodes(1D) systematically represen hs and spacings

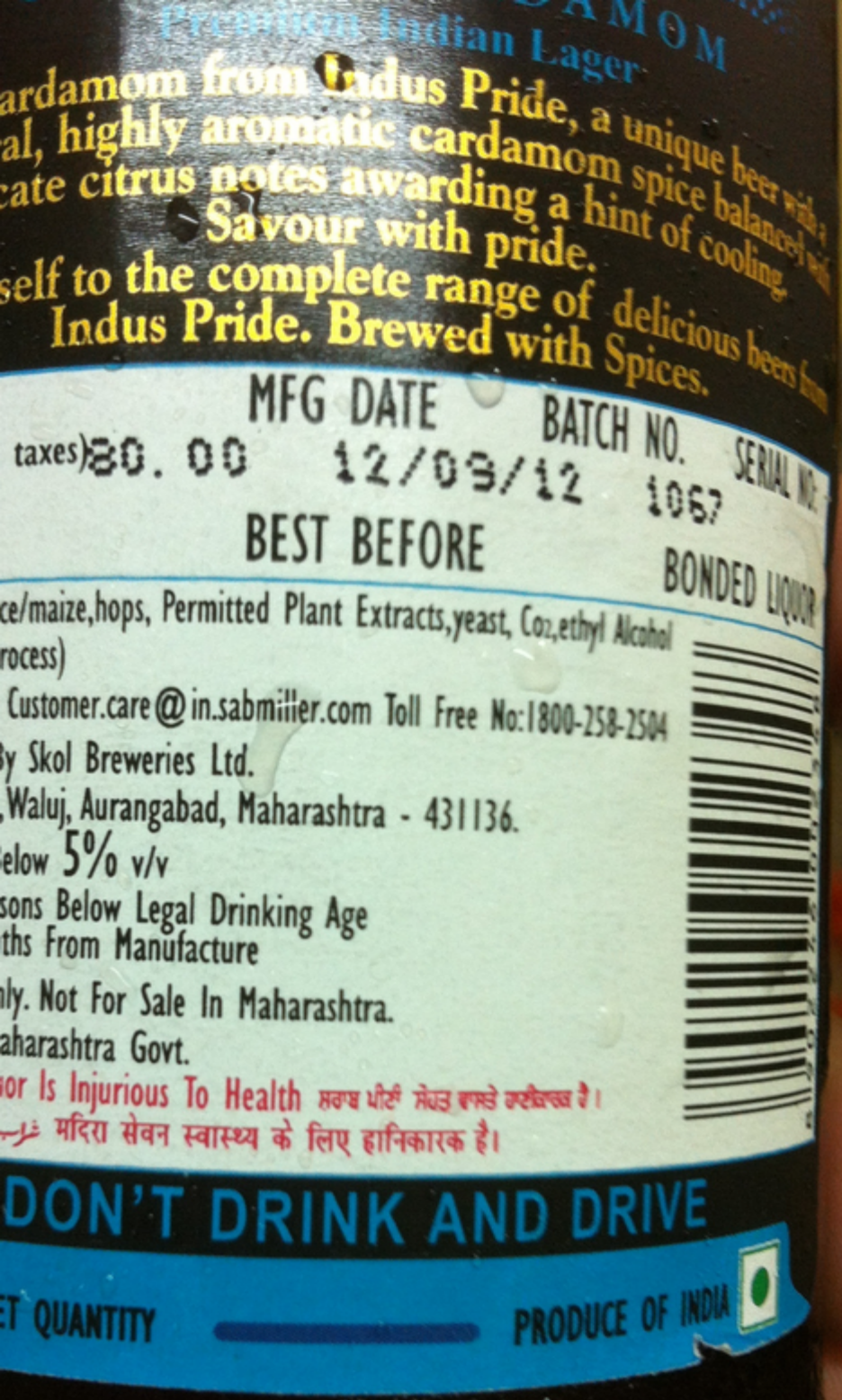
1D Barcode

QR Code

- RECYCLABLE
- COMPOSTABLE
- REUSABLE

100% Recyclable Material
Please Recycle This Bag

MADE IN U.S.A.
DURO BAG MFG. CO.


AMOM
Premium Indian Lager
ardamom from Indus Pride, a unique beer with a
al, highly aromatic cardamom spice balanced with
cate citrus notes awarding a hint of cooling.
Savour with pride.
self to the complete range of delicious beers from
Indus Pride. Brewed with Spices.
MFG DATE
BATCH NO.
SERIAL NO:
taxes)80.00
12/03/12
1067
BEST BEFORE
BONDED LIQUOR
ce/maize,hops, Permitted Plant Extracts,yeast, Co2,ethyl Alcohol
rocess)
Customer.care@in.sabmiller.com Toll Free No:1800-258-2504
y Skol Breweries Ltd.
,Waluj, Aurangabad, Maharashtra - 431136.
elow 5% v/v
sons Below Legal Drinking Age
ths From Manufacture
nly. Not For Sale In Maharashtra.
aharashtra Govt.
or Is Injurious To Health
मदिरा सेवन स्वास्थ्य के लिए हानिकारक है।
DON'T DRINK AND DRIVE
ET QUANTITY
PRODUCE OF INDIA

AIR CANADA

Class | Classe

ECONOMY CLASS / CLASSE ECONOMIQUE

Flight & Date | Vol et date: AC 231

Gate | Porte: A12

Seat | Place: 26B

Where not prohibited by law
Sauf où la loi l'interdit

Boarding time
Heure d'embarquement

From | De

To | Destination

Name | Nom

Airline use | À usage interne: 0081A YYC27670

Boarding Pass | Carte d'accès à bord

Name | Nom

Seat & Class | Place et classe: 26B Y

To | Destination

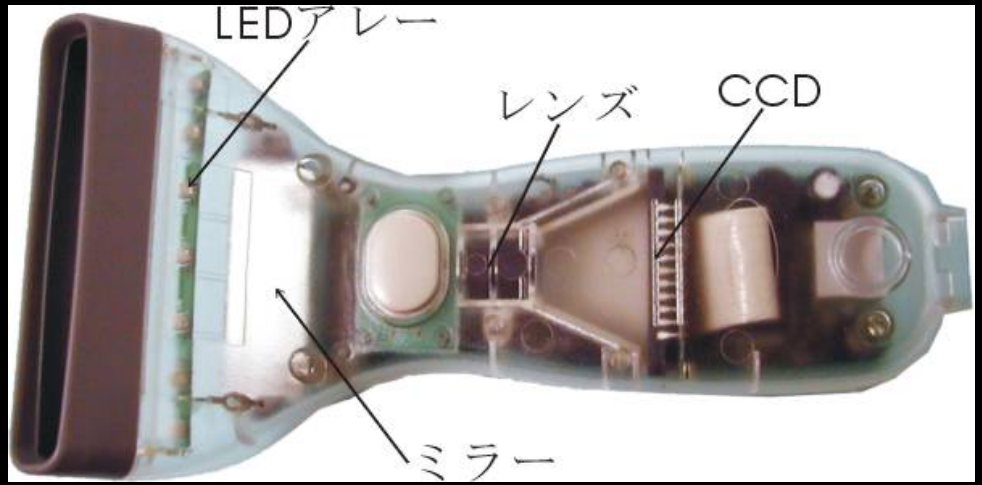
Remarks | Observations

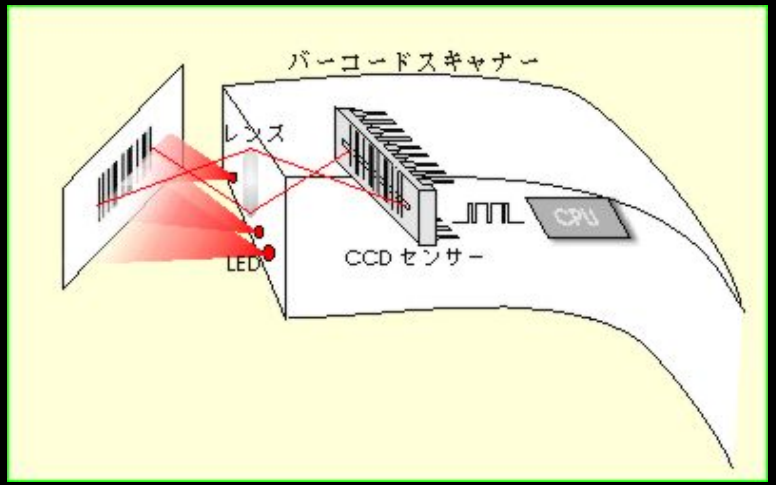
Barcode Symbology

- Every barcode includes:
  - Quiet Zone: Blank margin, No Information, Tell where barcode starts and stops;
  - Start character(s): Special pattern for barcode starts;
  - Data: Includes Numeric, Alpha-Numeric, Full ASCII chars depending on different barcode protocols;
  - Stop character(s): Special pattern for barcode ends.
- Some barcode have checksum bits/character(s)

Barcode Scanners

Scanner Inside





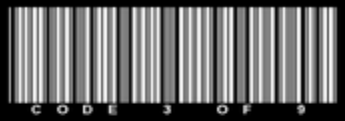
How Barcode Scanner Work

LED	Code 39	RS232
Laser	Code 128	PS/2
CCD	QR Code	USB HID
CMOS	…	…
…		

Protocols

Code 93

Code 39



CODABAR

Code 128

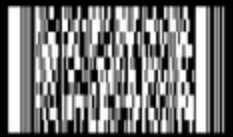
EAN-13

Interleaved 2 of 5

Standard (Industrial)
2 of 5

UPC-A

PDF417



Data Matrix

QR

MicroPDF417

Code 128

- Full ASCII Encode Ability, Effictive and High-Density
- 4 Function Codes Availiable For Manufacture
- Three Character Sets: CodeA, CodeB, CodeC
  - Unprintable ASCII can be encoded by CodeA
  - CodeC encodes only two-digit numbers
  - CharSets are chosen automatically
  - Encoder can hybridize three code sets

In addition to supporting standard protocols, many manufacturers also typically implement some of their unique features in scanners.

Scanner Manufactures

- Symbol (Zebra)
- HoneyWell
- TaoTronics
- ESky
- ACCESS IS
- UNITECH
- AIBO
- Newland

- Copycat products

Barcode Scanner Is Everywhere

Previous Work on Barcodes Security

“Toying with Barcodes”, Phenoelit, 24C3

- Barcode driven buffer overflow
- Barcode driven format string
- Barcode driven SQL injection
- Barcode driven XSS

Other Scenarios

- Predict and recreate barcodes
- Duplicate barcodes
- Phishing attacks by QR code

However, most of previous research focused on the application that do not properly process data from barcodes

Our Research：BadBarcode

What is BadBarcode?

- Many barcode scanners are keyboard emulation device
- Some barcode protocols, like Code 128, supports ASCII control characters
- Almost every barcode scanner support Code 128
- Almost every barcode scanner has its own additional keyboard emulation features

So, is it possible to open a shell and “type” commands by barcodes like a keyboard?

ASCII Table

Hex	ASCII	Scan code	Hex	ASCII	Scan code	Hex	ASCII	Scan code
00	NUL	CTRL+2	0B	VT	CTRL+K	16	SYN	CTRL+V
01	SOH	CTRL+A	0C	FF	CTRL+L	17	TB	CTRL+W
02	STX	CTRL+B	0D	CR	CTRL+M	18	CAN	CTRL+X
03	ETX	CTRL+C	0E	SO	CTRL+N	19	EM	CTRL+Y
04	EOT	CTRL+D	0F	SI	CTRL+O	1A	SUB	CTRL+Z
05	ENQ	CTRL+E	10	DLE	CTRL+P	1B	ESC	CTRL+[
06	ACK	CTRL+F	11	DC1	CTRL+Q	1C	FS	CTRL+\
07	BEL	CTRL+G	12	DC2	CTRL+R	1D	GS	CTRL+]
08	BS	CTRL+H	13	DC3	CTRL+S	1E	RS	CTRL+6
09	HT	CTRL+I	14	DC4	CTRL+T	1F	US	CTRL+-
0A	LF	CTRL+J	15	NAK	CTRL+U	7F	DEL	*

ASCII Control Characters

- Combination key, like "Ctrl+ ", is mapped to a single ASCII code
- Encode these chars with Code 128 ,scan it with scanner, and finally a combination key was sent to computer
- No Win keys, Alt keys, or other function keys support
- Though only “Ctrl+*” keys can be sent, it still poses threat to kiosks! WHY?

Dialog Attack

- Common Hotkeys are registered by many programs, like: CTRL+O, CTRL+P
- Hotkeys can launch common dialogs, like OpenFile, SaveFile, PrintDialog and etc
- These dialogs offer us opportunity to browse file system, launch browsers and execute program
- And the most essential thing is "Besides barcode scanner, touch screen is often available as input device in kiosks."

Demo 1: Dialog Attack

If there is no touch screen, is it possible to make a blind attack?

What about Win+R?

ADF(Advanced Data Formatting)

- Symbol Technologies Invent this
- Scanned data can be edited to suit particular requirements before transmitted to host device
- Specified Key can be sent to computer
- Set up ONLY by scanning barcodes！

ADF

Actions	Examples
Send data	Send all or part of data
Setup fields	Move cursor
Modify data	Remove spaces and others
Data padding	Pad data with space or zero
Beep	Beep 1,2,3 times
Send Keystrokes	Send ctrl+, alt+,shft+ etc keys.
Send GUI Keys	Send GUI+ keys.
Send Right Control	Send right contrl stroke.

Demo 2: ADF Attack

Can this attack be cooler ?
Can we do it automatically?

What about making an android APP?

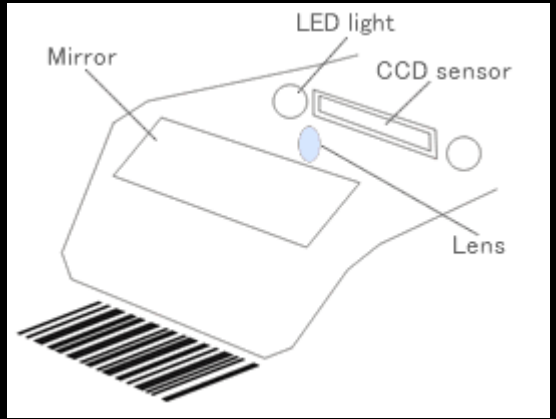
Unfortunately, not all scanners support read barcodes from LCD/LED screen.

Though scanners which read barcodes from LCD/LED screen exist, many of them read barcodes from materials which can absorb and reflect light of certain wavelength.

However, LCD/LED screen display images by modulating backlight rather absorbing and reflecting lights, which means total black for barcode scanners.

Display Technology

- CRT
- LCD
- OLED
- Electronic Paper



The answer is Kindle

- Kindle use E-ink technology
- It display words and images based on absorb and reflect light, just like a paper
- High Resolution, Up to 300 PPI
- Programmable, of course after Jailbreak.

Kindle is perfect BadBarcode tool !

Demo 3: Fully-automated ADF Attack

Can we execute a command
by only one single barcode?

Yes, for some products, it is possible

But, the product in the next demo is widely used in many really serious places, like airports, so we would not disclose details this time

Let’s just see the demo

Demo 4: A Piece of Paper Attack

Summary

BadBarcode is not a vulnerability of a certain product. It's even difficult to say that BadBarcode is the problem of scanners or host systems.

So when we discovered BadBarcode, we even do not know which manufacturer should be reported.

Although our demos is based on Windows, but in fact it can attack any system as long as there is appropriate hotkey.

Summary

- BadBarcode is really a serious problem
  - Host system using keyboard emulation barcode scanner is potentially vulnerable
  - Kiosks with touch screen and barcode scanner are easy to be compromised
  - Barcode scanner that support ADF or some special keyboard emulation features can be utilized to achieve automatic and advanced attack
- Other device via keyboard emulation connection might suffer from the same problem
  - Keyboard Wedge RFID/NFC Reader ?

Security Suggestions

- For barcode scanner manufactures
  - Do NOT enable ADF or other additional features by default
  - Do NOT transmit ASCII control characters to host device by default
- For host system manufactures
  - Do NOT use keyboard emulation barcode scanner as far as possible
  - Do NOT implement hotkeys in application, and disable system hotkeys

Acknowledgement

- My leader : tombkeeper
- All team members in Xuanwu Lab


Q&A