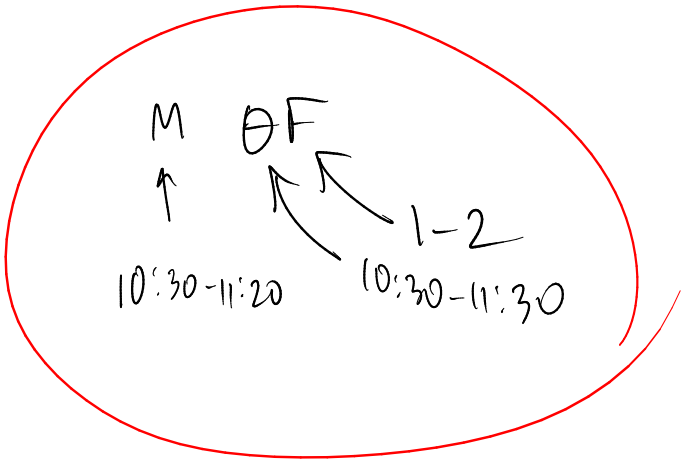
# (1) Administrative comments

Error in 6.6 exercise 30

$$y_k = \frac{v_k^{-1}\, w(v_k^{-1})}{\prod_{\substack{j=0 \\ j\neq k}}^{\ell-1} (1 - v_j v_k^{-1})} = \frac{-w(v_k^{-1})}{\sigma'(v_k^{-1})}$$

Office hours next week




recall usual office hours

10:30 - 11:20 M

12 - 1 W

# 2D barcodes

## ① Reed-Solomon codes

The two 2D barcode standards we're going to discuss are both more interesting than 1D barcodes from the perspective of coding theory because they both include error correction.

In particular they both use Reed-Solomon codes.

Briefly. When we made BCH codes we took a primitive $n^{th}$ root of unity $\alpha$. We took some consecutive powers of $\alpha$ to build our code. If our code is over $\mathbb{F}_q$ then $\alpha$ can be in $\mathbb{F}_{q^m}$

If you take $\alpha \in \mathbb{F}_q$ and otherwise proceed as for BCH codes then you get a Reed-Solomon code

This extra property gives Reed-Solomon codes extra mathematical structure.

eg we can get that an $(n,k)$ Reed-Solomon code has distance $n-k+1$

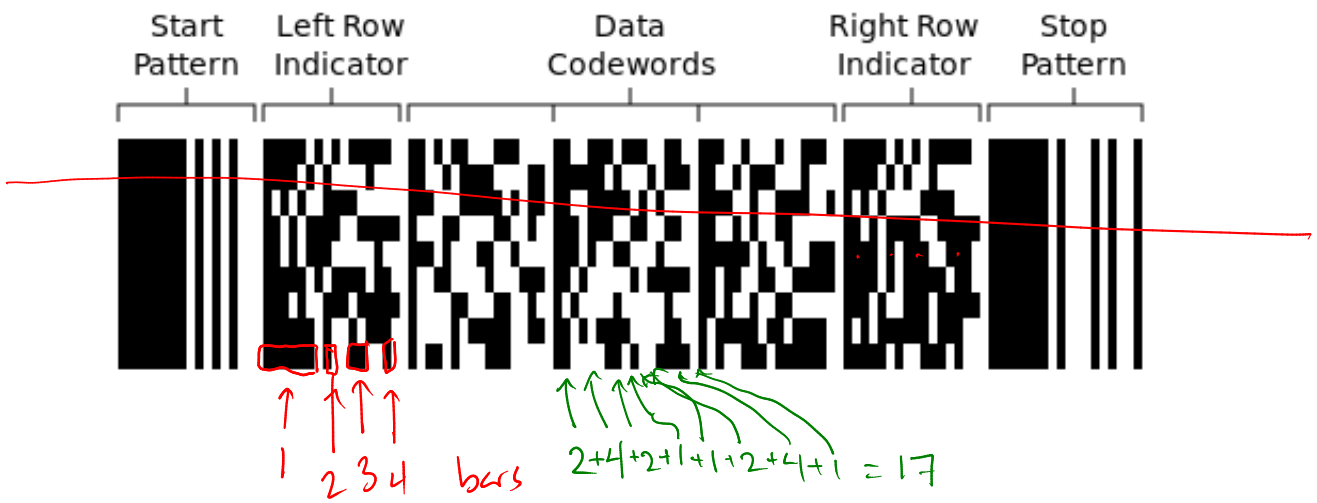
To find out more on Reed-Solomon codes see ch 7 of the textbook. (Also our project will discuss them)

## (2) PDF 417

The 2D bar code on your BC driver's license is PDF 417

PDF 417 is a stacked bar code, ie it is made of little 1D barcodes on top of each other. You can read it with a linear scanner. But not as compact as other 2D bar codes.

The 417 in the name refers to the fact that every codeword has 4 bars and each codeword is 17 units long




We want to read this with a linear scanner but we may scan a bit diagonally so the codewords also encode what row they're in. Actually they just encode their row number modulo 3. This is done by having 3 distinct patterns to represent each codeword → one pattern for rows $\equiv 0 \mod 3$
another for rows $\equiv 1 \mod 3$
the last for rows $\equiv 2 \mod 3$

This way if the scanner gets skewed you'll know that this happened and how much

There are 929 codewords and how these are mapped to message characters varies depending on the application.

For the error correction view each codeword now as a symbol from $\mathbb{F}_{929}$ (note 929 is prime) so have a sequence of elements in $\mathbb{F}_{929}$. Break it into blocks and encode with a Reed-Solomon code, put the result in the barcode

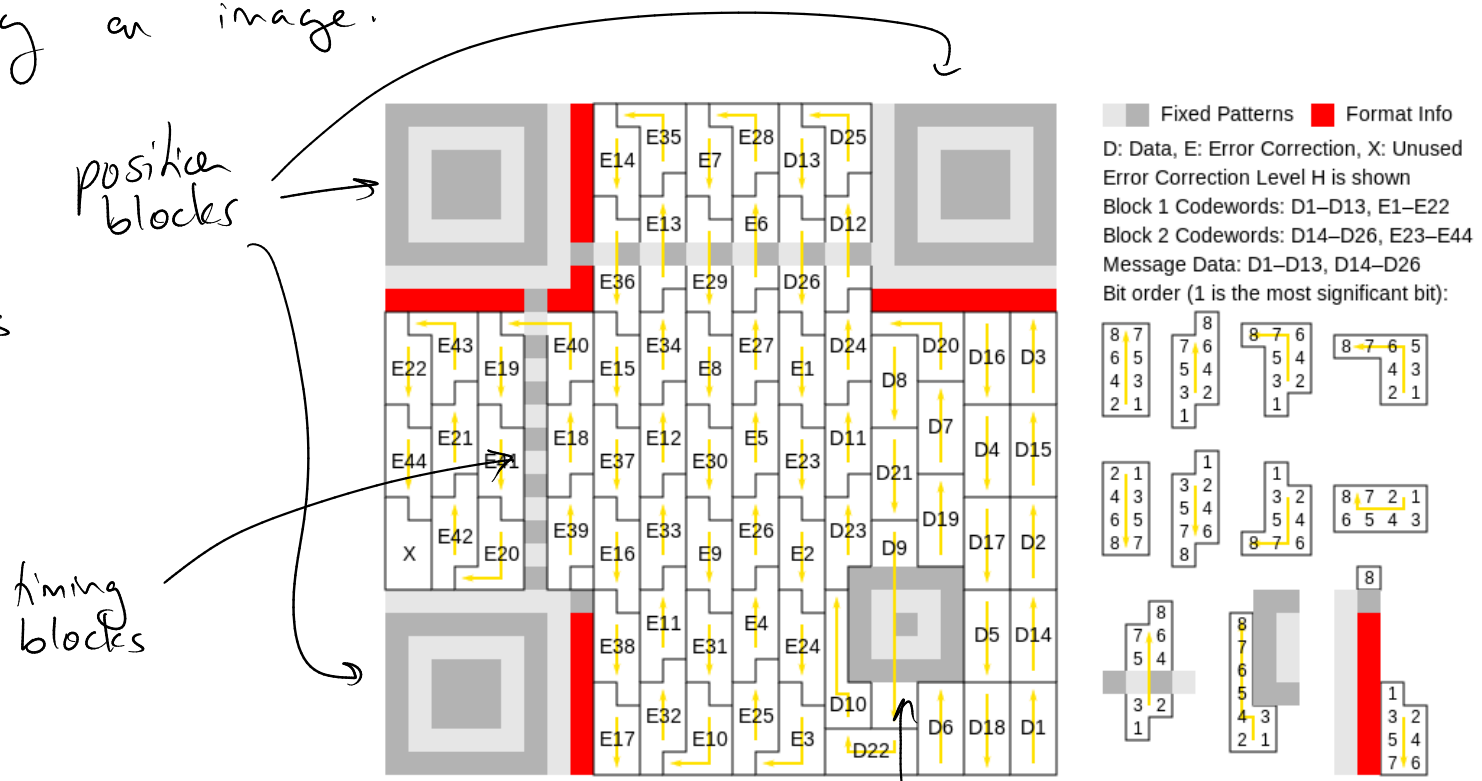
PDF 417's standard allows for anywhere between 2 and 512 parity check symbols!

This choice is encoded in the row indicator columns (along with other info)

PDF 417 shows up on drivers licenses because it is an acceptable format for the US RealID program

# ③ QR codes

QR codes are a different kind of 2D barcode called a matrix code. They are more compact but need to be read by taking an image.




The codewords are 8-bit blocks which twist around through the image.

As before we now switch to viewing each codeword as a letter from $\mathbb{F}_{2^8}$ and then our message is a vector in $\mathbb{F}_{2^8}^{\ell}$ so break into blocks and encode with a Reed-Solomon code. For this standard $n \leq 255$ so for large amounts of data will have more than one patch of data, error correction.

The code could have read problems if the stuff in the middle had large black or white patches which look too much like the position or alignment blocks.

This is solved with a mask. You have a mask like a checkerboard or diagonal lines and then XOR it with the non fixed part of the QR code.

The format info sections encode the error correction level and the mask

So how much of a QR code CAN be missing?

Sources
http://en.wikipedia.org/wiki/PDF417
http://en.wikipedia.org/wiki/QR_Code
http://keremerkan.net/qr-code-and-2d-code-generator/