Creating a Functional, Distributable RSA App

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Overview

- Motivation
- Design Criteria
- Julia
- RSA Review
- Program Schematic
- Encoding Methods
- Demo

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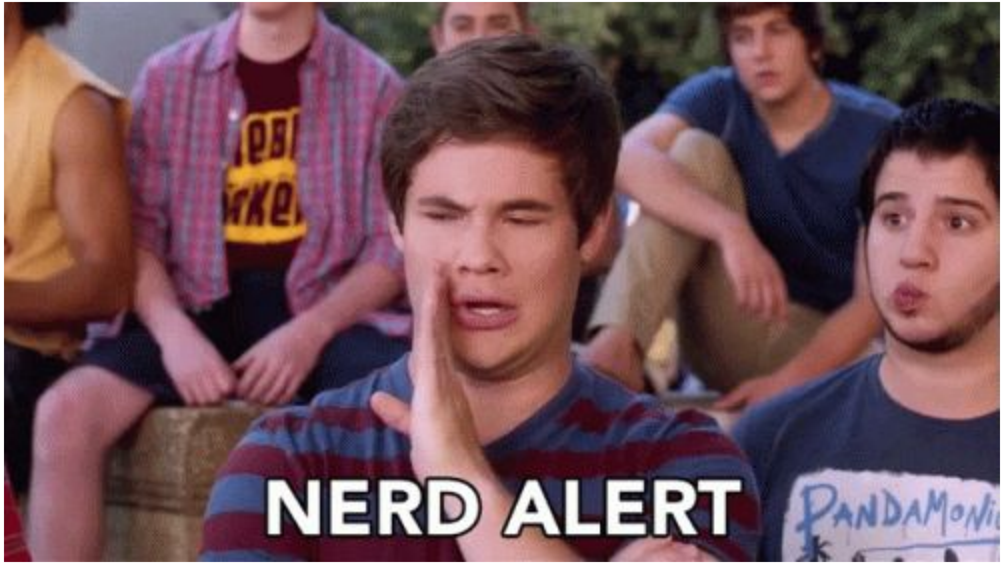
Motivation

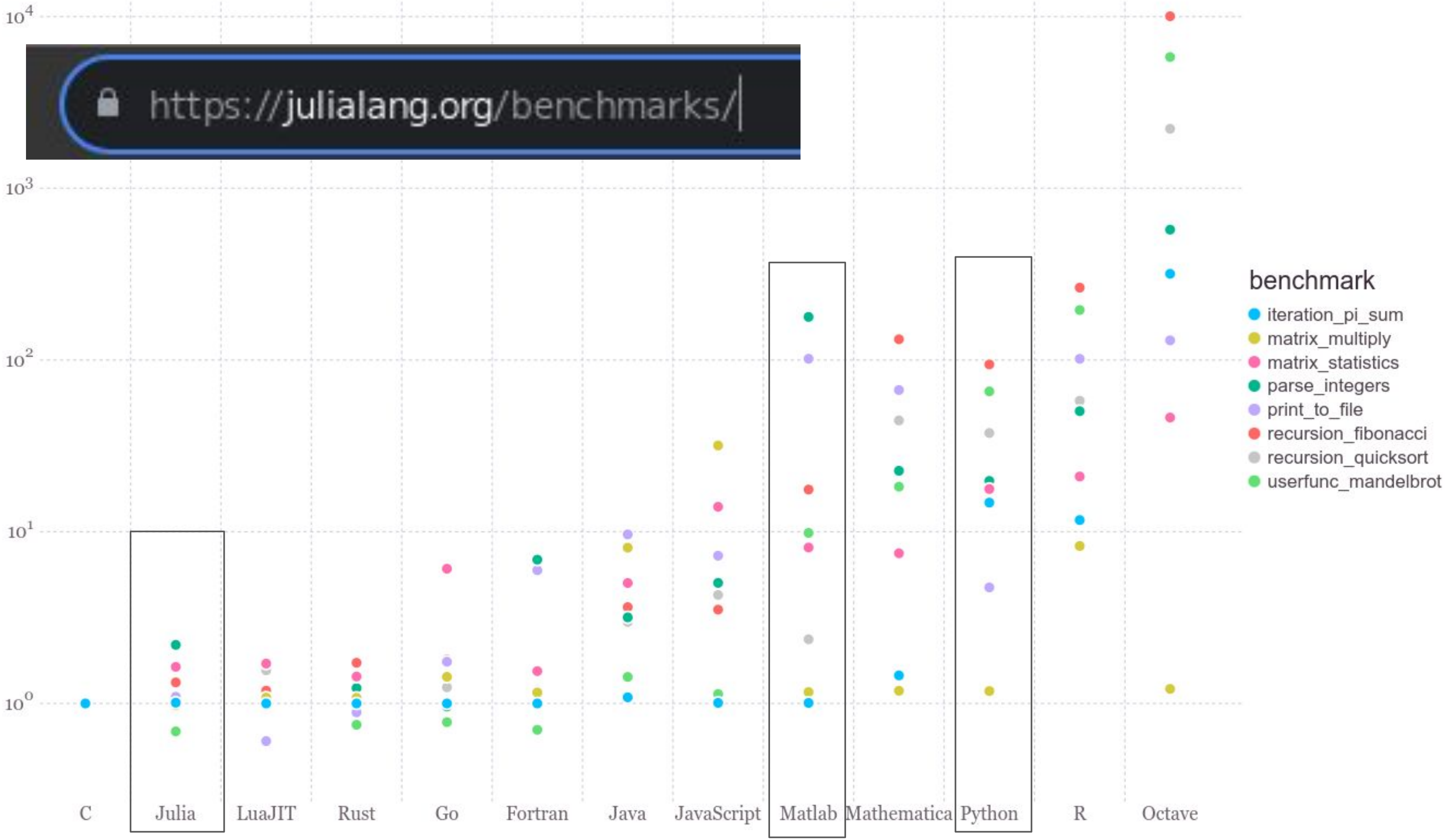


Design Criteria

- Polished enough to share a GitLab repository with other users and implement for fun with just a readme file.
- Keys saved as files for repeated use and distribution.
- Messages loaded and retrieved as files so the program can be run from command line and encoded/encrypted messages emailed as attachments or shared from public cloud storage.

Julia (https://julialang.org/)

- Open-source (MIT license) language – freely distributable.
- Nearly “machine speed” for many operations.
- Handles integers of arbitrary size (“BigInt”).
- Matlab style REPL for debugging.



https://julialang.org/benchmarks/

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RSA Review

- m = plaintext message
- c = ciphertext
- n, e = public key
- d = private key
- p, q = large primes

$$n = pq$$

$$\phi(n) = (p-1)(q-1)$$

$$d = e^{-1}(mod\, \phi_n)$$

$$c = m^e(mod\, n)$$

$$m = c^d(mod\, n)$$

Program Schematic

- Key generation function
  - Generate public and private keys
  - Save as output files
- Encryption function
  - Read in a file
  - Read in encryption keys
  - Encode the message
  - Encrypt the message
- Decryption function
  - Read in a ciphertext file
  - Read in decryption key
  - Decrypt the message
  - Decode the message

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Encoding Methods - Down the Rabbit Hole

- Text
  - ASCII (English letters only) -> UTF-8
  - “The Absolute Minimum Every Programmer Should Know About Unicode and Character Sets (No Excuses!)”
- Images
  - Pixels: RGB -> 3D matrix -> color planes
  - “Wingdings”:
    - JPEGs are Huffman coded
    - PNGs use libpng
- Office files
  - Combine text and images with some formatting wrappers

```
\ED\C2\FE\22\BC\C6\D6\C3\C4\37\3A\4F\8C\AE\AD\2C\D6\77\69\E6\46
\B3\49\E1\2B\95\5D\A4\F5\CE\01\3E\83\2A\1B\1C\E4\0A\EB\E1\F2\2D
\26\E0\B9\95\71\B6\E0\C8\FB\4A\F0\38\50\D9\1D\7A\0A\4D\5D\8A\2E
\B5\C4\37\D9\A3\B0\BF\0A\F2\99\6E\35\D8\DE\66\76\C9\62\70\33\F8
\01\5E\06\B2\7F\29\D4\3F\98\1B\70\04\80\18\A9\1C\ED\27\86\19\AE
\43\4A\85\73\0B\46\D9\2B\F2\B0\6E\3D\3D\6B\1A\49\EE\25\B1\11\97
\03\B6\32\A0\FA\6E\3C\0E\3A\D4\46\CD\1A\B6\D4\8F\A3\AF\A5\D3\2F
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\7A\31\E0\76\3C\0E\BF\C4\9A\8E\93\73\FB\3A\E8\29\71\73\75\34\A7
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\64\86\C0\50\47\23\24\F0\38\7D\55\51\6C\A6\6B\6F\0B\EA\D3\40\93
\C1\0B\FA\0E\E7\9A\EF\7C\44\FA\A5\BF\8A\7C\09\3A\26\9F\00\B4\F1
```

Encoding Methods - Escaping the Rabbit Hole

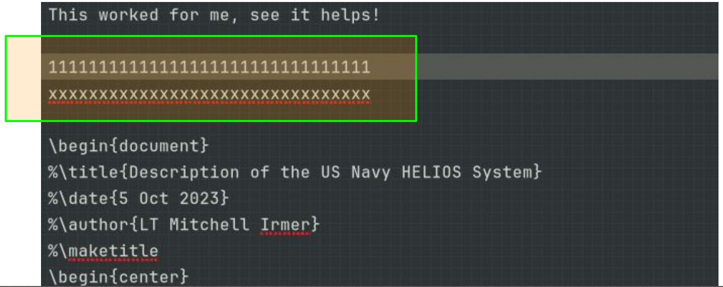
- 8-bit Unsigned Integers (UInt8)
  - 0-255, written as 0x00 to 0xff.
  - Makes data accessible as a vector of arbitrary length at the cost of making the data much larger.
  - Most important: this is the default “read” method in Julia.
- Method:
  - Convert vector of UInt8 to vector of BigInt and raise to encryption. exponent modulo public n.
  - Combine 7 consecutive BigInt into one block (compression).
  - Store blocks in new vector, save as a ciphertext file.

Encoding Methods - Data Compression

- Combining 7 UInt8 into a single BigInt block before encryption

Extension	Plain	Cipher (No Compression)	Cipher (Blocksize = 7)
.txt	5.0 kB	846.8 kB	121 kB
.odt	55 kB	7.6 MB	1.1 MB
.pdf	1.1 MB	188.2 MB	27.3 MB
.jpg	4.6 MB	Didn’t attempt, probably ~790 MB	111 MB

Cryptanalyzing the Ciphertext (.txt codewords)



```
This worked for me, see it helps!

11111111111111111111111111111111
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

\begin{document}
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%\date{5 Oct 2023}
%\author{LT Mitchell Irmer}
%\maketitle
\begin{center}
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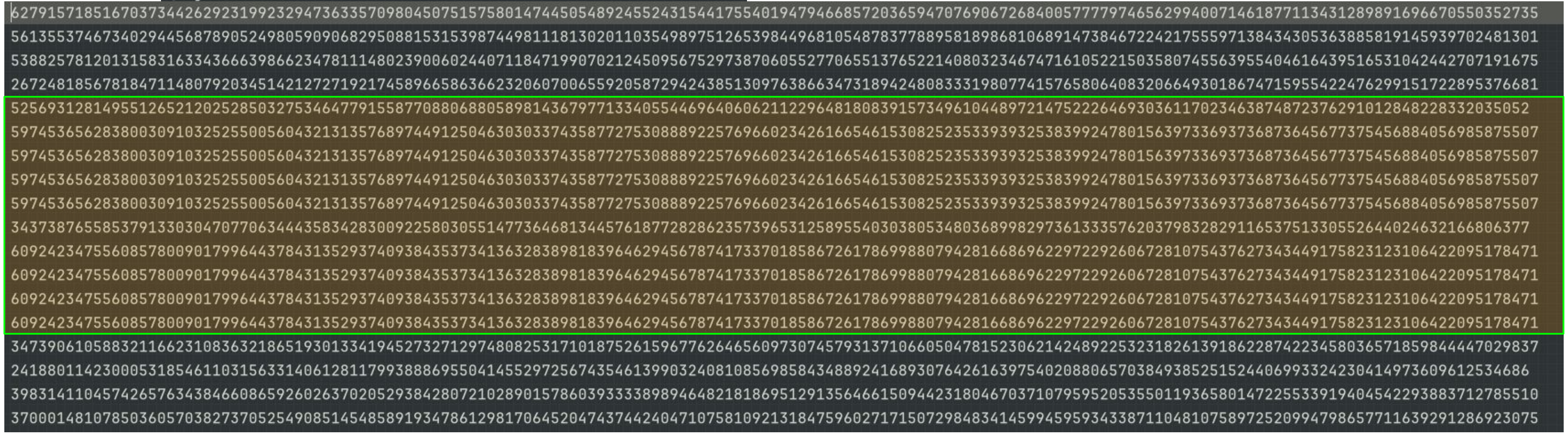

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```
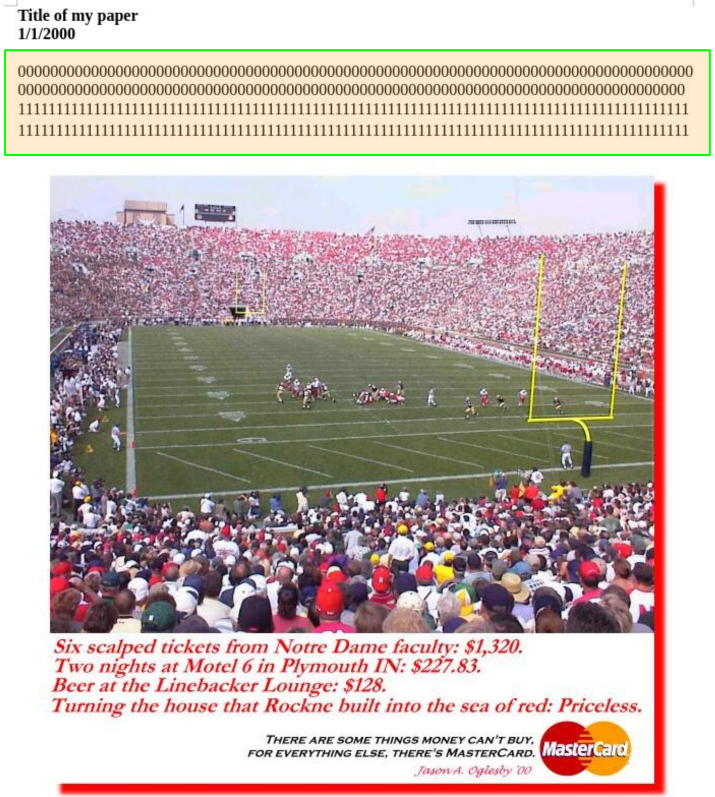
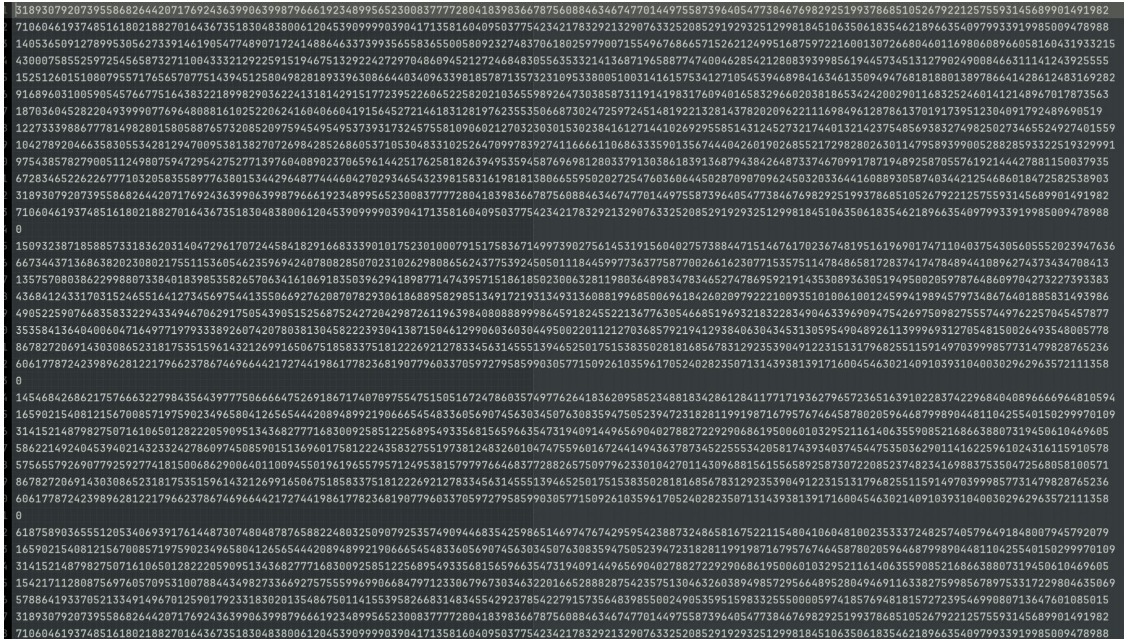

Cryptanalyzing the Ciphertext (.odt)



Title of my paper
1/1/2000

00000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
1111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
1111111111111111111111111111111111111111111111111111111111111111111111111111111111111111

Six scalped tickets from Notre Dame faculty: $1,320.
Two nights at Motel 6 in Plymouth IN: $227.83.
Beer at the Linebacker Lounge: $128.
Turning the house that Rockne built into the sea of red: Priceless.
THERE ARE SOME THINGS MONEY CAN'T BUY,
FOR EVERYTHING ELSE, THERE'S MASTERCARD.
MasterCard
Jason A. Oglesby '00



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Demo

- Alice and Bob exchange keys.
- Alice sends an encrypted file to Bob.
- Bob decrypts and opens the file.

References

- https://julialang.org/benchmarks
- MA4570: class notes and coursework.ipynb
- https://www.joelonsoftware.com/2003/10/08/the-absolute-minimum-every-software-developer-absolutely-positively-must-know-about-unicode-and-character-sets-no-excuses/
- https://web.stanford.edu/class/ee398a/handouts/lectures/08-JPEG.pdf
- Sea of Red photo: huskermax.com