Rainbow Forth

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Disclaimer

- This is my first Forth implementation
- I have undoubtedly made bad design choices
- Chuck would no doubt be horrified with the ugliness of my design

Overview

- The colorForth Dialect
- Design Choices
- Tools
- Implementation
- Demo!
- Language Exploration
- Future Directions

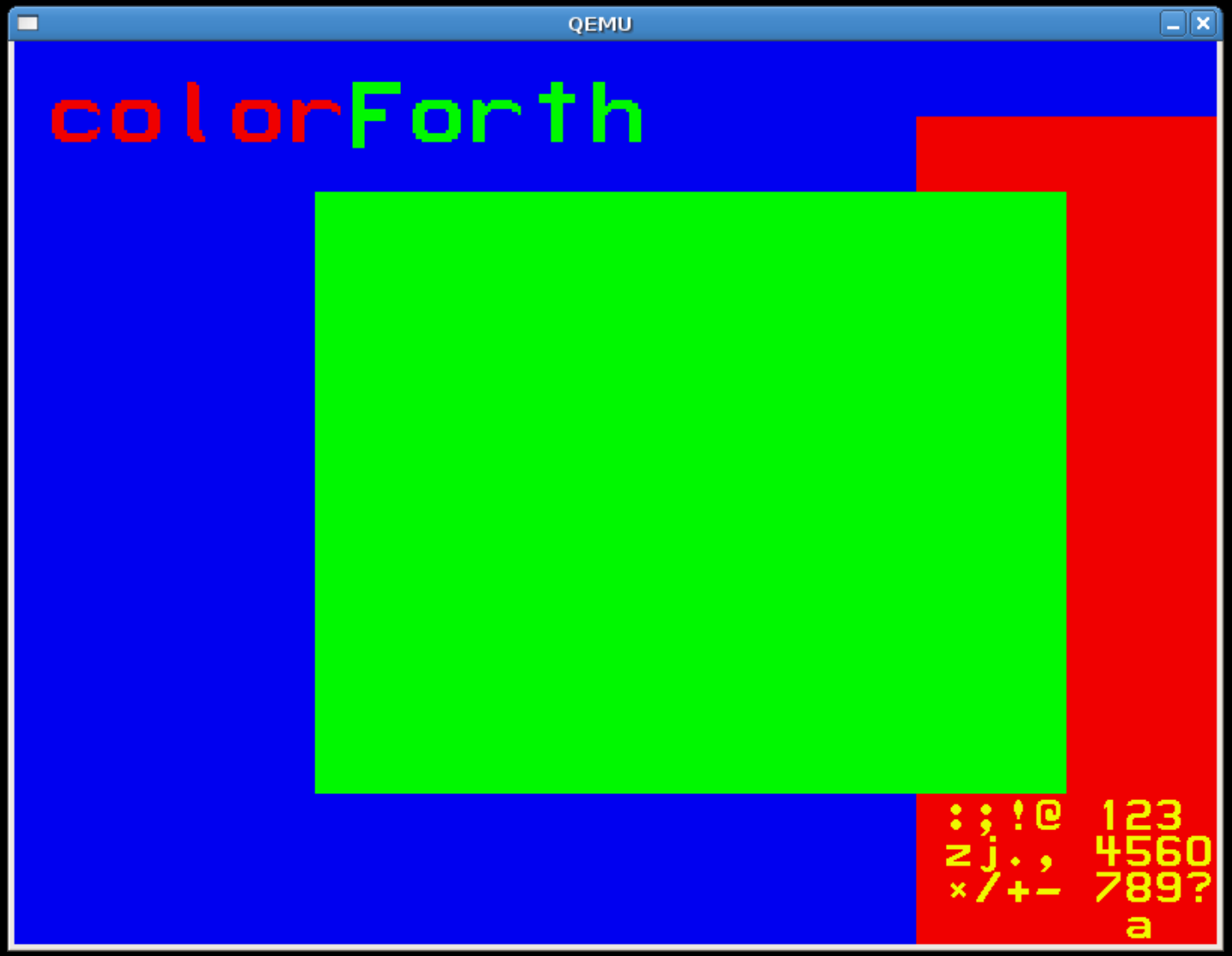
The colorForth Dialect

- Created by Chuck Moore circa 2000?

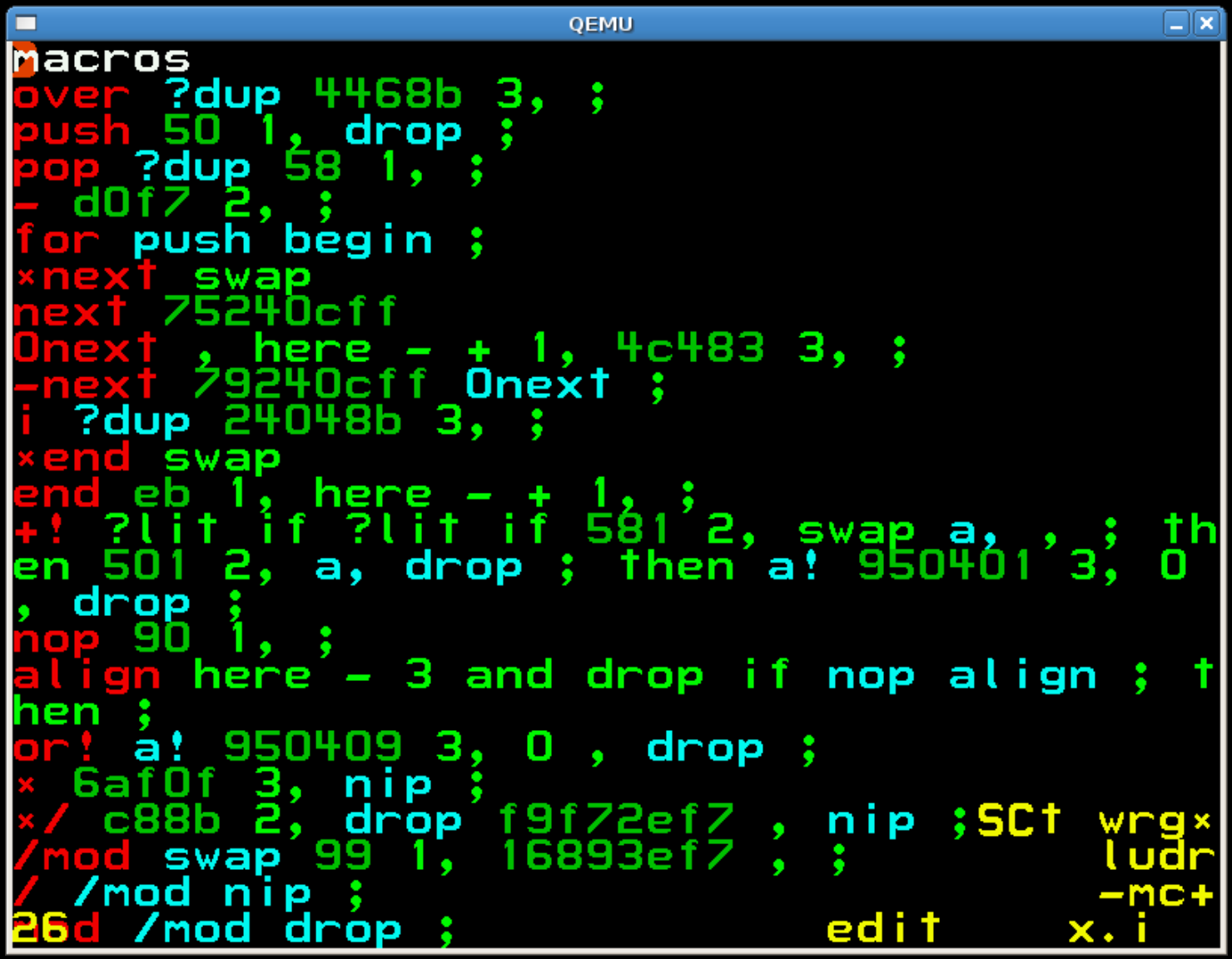
colorForth Features

- Stand-alone! Includes operating system.
- Compact! 2K bytes for core software.
- Fast! Optimized object code.
- Simple! Applications stored as source. No object library.
- Innovative! Text compressed and pre-parsed.
- Unique! 27-key Dvorak keyboard.

colorForth Startup Screenshot



colorForth Editor Screenshot



colorForth Colors

- comment
- create
- execute
- compile
- inline
- variable

colorForth vs Traditional Forth

- word --> (word)
- word --> : word | create word
- word --> [word]
- word --> word
- word --> ' word compile,
- word --> variable word

colorForth Advantages

- No look-ahead needed for parsing
- All places that create words are marked
- Fewer line noise characters
- Easier to understand compiler
- Color replaces parsing for both humans and compiler

colorForth Drawbacks

- Non-standard
- Parser is less changeable than Forth
- Incompatible with conventional operating systems
- Dvorak scares off QWERTY users

Introducing...

Rainbow Forth

Differences from colorForth

- 64x16 ASCII source blocks
- Invisible color tags after each word
- No shadow blocks
- C compatible register choices
- Bootstrapped from C instead of Assembly
- More conventional word definitions
- QWERTY keyboard input
- literal is not called on yellow-green transition
- Hexadecimals are marked with 'h'
- Linux and Windows support (not bootable)

Major Design Choices

- Source Block Format
- Memory Layout
- Dictionary Format
- Registers
- Bootstrapping Method

Source Block Format

- 64 x 16 = 1,024 Blocks
- Spaces indicate color as a suffix
- 32 is white, 255-250 are red-magenta
- Spacial control is retained (and no waste)
- Example:

```
square n--n**2 dup * ;

square_n--n**2_dup_*_;_
```

Memory Layout

- C Call Stack for RSTACK
- Small DSTACK
- Code Heap (for dictionary words)
- Data Heap (for variables and allot)

Dictionary Format

- Linked list of Dictionary Entries
- Dictionary Entry
  - Next Word
  - Code Address
  - Data Address
  - Is Macro?
  - Smudged
  - Name Length
  - Name Characters

Register Usage

- EAX - scratch
- EBX - Top of Stack
- ECX - scratch
- EDX - scratch
- ESI - unused
- EDI - Execution Context Pointer
- EBP - Data Stack Pointer
- ESP - Return Stack Pointer

Bootstrapping Method

- Implement editor in C
- Implement minimal compiler harness in C
- No assembler in compiler harness
- Dictionary structure defined in C
- Harness executes Forth words to generate code
- Harness passes entry points for OS to Forth

Tools

- Subversion
- Debian Linux
- Cygwin
- Sourceforge.net

Subversion

- Version control system
- Successor to CVS and RCS
- Keeps a snapshot of each change
- Allows Internet collaboration
- Checkout a copy with:
  svn checkout http://rainbowforth.svn.sourceforge.net/svnroot/rainbowforth
- Keep it up to date with:
  svn up
- Submit changes with:
  svn commit *(requires sourceforge.net account)*

Debian Linux

- Popular Linux Distribution
- Install developer tools with simple commands:

```
aptitude install gcc make ncurses-dev
```

Cygwin

- Unix-like environment on Windows
- Includes GNU C compiler
- Includes GNU Make
- Includes Subversion client
- Native Windows applications supported
- Great for cross platform builds

Sourceforge.net

- Free hosting for Open Source or Public Domain Projects
- Bug Tracker
- Subversion Server

Implementation

- Overview
- Color Console
- Editor
- Compiler Harness
- System Call Access

Implementation Overview

- < 2,000 total lines of C
- < 600 lines in compiler harness
- No register assumptions made
- Dictionary format is fixed
- 22 blocks in core system

Color Console

- Ncurses on Linux
- WIN32 Console API on Windows
- Wrap in a common interface
- Supports Color, Underline/Reverse Video

Editor

- Block at a time
- Saves as you go
- Arrow keys move cursor
- PgUp and PgDn move between blocks
- Ins, Del, Backspace
- Cut (Ctrl-X), Copy (Ctrl-C), Paste (Ctrl-V)
- Ctrl-G to just to a block number
- Ctrl-R to run a block
- F2-F8 to select color
- Ctrl-Q / Escape to Quit

Editor Interface

Compiler Harness

- C code compiles by calling a few Forth words
- These Forth words are defined using a small set of built-in words
- Small table of C entry points allow Forth to access system resources

Harness Required Words

- execute-forth
- literal
- compile,
- variable

Harness Supplied Words

- macro
- forth
- smudge
- unsmudge
- b,
- windows?
- load
- thru
- heap-dump
- word-dump

Harness Supplied Entry Points

- load
- print_number
- key
- emit
- library_load
- library_symbol

System Calls

- Windows Raw System Calls
- Linux Raw System Calls
- Windows Dynamic Libraries
- Linux Dynamic Libraries

Windows Raw System Calls

- How you call them changes in each version
- It varies by processor version!
  - int 2Eh (intel pre-pentium II, amd pre-64-bit)
  - sysenter (intel 32/64-bit)
  - syscall (amd 64-bit)
- Call number goes in EAX, but the numbers change!
  - NtWriteFile (0xC8 on WinNT4, 0xED on Win2000, 0x112 on WinXP, 0x11C on Win2003, 0x164 on Vista)

Linux Raw System Calls

- int 80h call the system
- Call number goes in EAX
  - read=0, write=1, open=2, close=3, etc...
- Parameters go in ECX, EDX, ESI, EDI, EBP
- Return value in EAX

Windows Dynamic Libraries

- HANDLE LoadLibrary(const char *name);
  GetProcAddress(HANDLE, const char *name);
- For example:
  MessageBeep(int style);
  lives in USER32.DLL

Linux Dynamic Libraries

- void *dlopen(const char *name, int flags);
  void *dlsym(void *h, const char *name);
- For example:
  double cos(double);
  lives in libm.so

Demo

DEMO

Language Exploration

- Lookup color
- Auto-literals
- CREATE DOES>
- Do we need macros/cyan?
- Should macro be one-shot?
- How to handle Strings?
- push pop vs >R R>

Lookup Color

- Need a way to get address of a word
- One primary/secondary color left blue
- Should go on compile time stack
- Example:

```
output-emit
to-printer printer-emit literal output-emit ! ;
to-screen screen-emit literal output-emit ! ;
emit output-emit @ execute ;
```

Auto-literals

- Should yellow-green transition compile a literal?
- Example:

  ~pi 22 7 / ; (colorForth)

  ~pi 22 7 / literal ; (Rainbow Forth)
- Assumes compile time calculations are more common than state changing words
- Useful in 2 out of about 20 current uses

CREATE DOES>

: defining-word create allocation does> action ;
defining-word instance-name

defining-word allocation does> action ;
instance-name defining-word

CREATE DOES> example

```
: pair create , , does> dup cell+ @ swap @ ;
5 7 pair p
```

```
pair , , does> cell+ @ swap @ ;
5 7 p pair
```

Do we need macros/cyan?

- Macros allow inline code without direct compiler support
- Cyan highlights that something special is going on
- Someone using a word doesn't need to guess what color (green usually is right)
- Macros and regular words can coexist
- max 2dup < if nip else drop then ;
  is more awkward than
  max 2dup < if nip else drop then ;

Should macro be one-shot?

- **macro** and **forth** have state, much like **hex** and **decimal**
- Maybe **macro** should be one-shot like **immediate**?
- Or separate one-shot word **:macro**?

How to handle constant Strings?

- Add a new color?
- Get strings only from blocks or data files?
- Parse quotes?
- Reuse red compile words !!!!
- Examples:

```
hi HelloWorld! last-name literal ;

XOpenDisplay 1 cimport return-value ;
```

push pop vs >R R>

- Looks less like line-noise
- Matches assembler push/pop intuition
- Doesn't look like a comparison
- No shift key
- But >R R> is shorter

Future Directions

- Peephole Optimizer
- Rewrite editor in colorForth
- Bootable Version
- Cross Platform Graphics Wrapper