



Forth for Arduino Uno

Maker Faire

May 21-22, 2011

Chen-Hanson Ting

Silicon Valley Forth Interest Group



Summary

- What is Forth?
- Dissecting Forth
- Forth for Arduino Uno Board
- Demonstrations



What is Forth?

- Forth is an operating system.
- Forth is a programming language.
- Forth is the simplest man-machine interface.
- Some unique features of Forth



Forth is an operating system

- You type in a list of Forth commands.
- Forth executes these commands in sequence, and waits for the next list of commands.

- Example:

```
123 dup * .
```

```
15129 ok
```



Forth is a Programming Language

- New commands are compiled to replace lists of existing commands.

```
: <name> <list of commands> ;
```

- **Example:**

```
    : square dup * ;
```

```
123 square .
```

```
15129 ok
```



Forth is the Simplest Man-Machine Interface.

- Most Forth commands can be interactively tested and debugged.
- Bottom-up programming allows building and testing reliable applications.
- Memory and I/O devices can be examined and programmed interactively.



Unique Features of Forth

- Very simple, English-like syntax
- Very small and best suited for microcontrollers
- Very friendly way to interact with microcontrollers
- DIY programming language and operating system



Dissecting Forth

- List processing
- Text interpreter
- Forth compiler
- Dual stack architecture



List Processing

- Text interpreter interprets lists of Forth commands in text form.
- Forth compiler compiles lists of commands into lists of tokens stored in memory.
- Forth inner interpreter processes token lists in memory.



Text Interpreter

- Text interpreter interprets lists of commands in text form.

- Examples:

```
13 DUP * .
```

```
WORDS
```

```
HEX
```

```
100 DUMP
```



A Few Forth Commands

- + - * / mod
- and or xor not
- key emit type dump
- @ ! c@ c! cmove fill erase
- dup drop swap over rot
- If-else-then, begin-while-repeat,
for-next



Forth Compiler

- Forth compiler is the text interpreter operating in compiling mode.
- Forth compiler creates new commands to replace lists of commands.



Forth Compiler

- All computable problems can be solved by repeatedly compiling new commands to replace lists of existing commands.
- Syntax of Forth compiler:

```
: <name> <list of commands> ;
```



Forth Compiler

- Examples:

```
: SQUARE DUP * ;
```

```
: HELLO CR ." HELLO, WORLD!" ;
```

```
: FIBONACCI ( n -- )
```

```
  0 1 ROT
```

```
  FOR SWAP OVER + NEXT
```

```
  DROP ;
```



Dual Stack Architecture

- Forth commands can form simple, linear token lists because Forth uses two stacks.
- A return stack to store return addresses for nested commands.
- A parameter stack to store parameters passed among nested commands.



Forth for Arduino Uno

- AmForth by Matthias Trute,
GNU Public License v2,
<http://amforth.sourceforge.net/>
- SwiftX AVR for Atmel AVR, from FORTH, Inc.
Free evaluation version,
<http://www.forth.com/embedded>
- 328eForth by Chen-Hanson Ting,
<http://www.offete.com>



ATmega328 on Arduino Uno

- 8 Bit microcontroller, 131 instructions
- 32KB Flash, 2 KB RAM, 1 KB EEPROM
- 3 Counter/Timers
- 6 Channels 10-bit ADC
- USART, SPI, I2C, ISP
- 23 Programmable I/O lines



328eForth for Arduino Uno

- Subroutine Threaded Model
- Fully optimized for ATmega328
- Interpreter is in the Bootloader section
- Compiler and new commands are in main flash section
- Optimized flash programming to add new commands



Demo of 328eForth

- Turn LED on and off

HEX

```
20 24 C! ;set Pin 13 as output
```

```
20 23 C! ;toggle Pin 13
```

- Turn beeper on and off

```
40 2A C! ;set Pin 6 as output
```

```
42 44 C! ;set Timer0 CTC mode
```

```
FF 47 C! ;maximum count for Timer0
```

```
3 45 C! ;prescaler=3, start beeper
```

```
0 45 C! ;prescaler=0, stop beeper
```



Trying 328eForth?

- For a free copy of 328eForth, send an email to: ting@offete.com



Take Home Messages

- Forth is simple.
- Forth is easy.
- Forth is interactive.
- Forth liberates you while other programming languages enslave you.
- Forth lets you be your own master.



Forth Organizations

- Forth Interest Group <http://www.forth.org>
A repository of public domain Forth systems and Forth documentation
- FORTH, Inc. <http://www.forth.com>
SwiftForth, SwiftX for many microcontrollers
- MicroProcessor Engineering, Ltd.
<http://www.mpeforth.com>
VFX Forth, Forth 7 Cross Compiler



Silicon Valley Forth Interest Group (SVFIG)

- SVFIG meets every month at Stanford University to discuss the Forth language and its applications.
- For meeting announcements, please check:

<http://www.forth.org/svfig/next.html>

<http://www.meetup.com/SV-FIG/>



Thank You
