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Token System for Payment Terminals

Yet Another Forth Objects Package

Adaptive Digital Filters

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The FORML Conference is sponsored by the Forth Interest Group.
A Platform-Independent Token System for Payment Terminals
by Peter Johannes, Stephen Pelc, and Elizabeth Rather

The financial industry is scrambling to implement new instruments intended to revolutionize personal finance. Smart cards, debit cards, electronic purses, and more are buzzwords that, in certain audiences, electrify with their implications. Hardware constraints are a significant part of the puzzle—how to pack transaction-supporting applications into the amount of RAM that can fit onto a plastic card of the usual proportions—which also happens to contain a microprocessor and I/O. Forth is a natural in constrained environments and, as it turns out, is playing a leading role in the development of this new technology.

A Simple Implementation of the Kermit Protocol in Pygmy Forth
by Frank Sergeant

Frank Sergeant, whose Pygmy Forth has a following among those who appreciate Forth in its lean-and-mean aspect, presented a description of his Kermit implementation in the preceding issue. Herewith: the code.

Yet Another Forth Objects Package
by Anton Ertl

Programmers often must treat several data structures similarly in some respects, but differently in others. A big CASE structure would not be very elegant, and would require maintenance. In a nutshell, this is the problem object-oriented systems solve. After criticizing the Neon model in the last issue, the author presents a model he finds better, and its implementation.
EDITORIAL

Vote With Your Feet

Errata

With much fanfare in our preceding issue, we welcomed a new advertiser whose services will be of interest to many of our readers. Unfortunately, during a last-minute production frenzy as we shuffled the pagination, the ad was accidentally dropped. We offer our apologies to Kevin Martin—whose ad does appear in this issue—and to any readers who may have been inconvenienced.

FORML

Once again, we remind everyone that the annual FORML Conference is not being held on the U.S. holiday of Thanksgiving this year. (See the ad on our inside front cover.) We may seem to be belaboring the point but, for many years Forth folk from this country who have family obligations found themselves unable to attend (at least, not without some guilt). The fact of FORML during holidays became engrained in our collective consciousness, a background irritant for those who couldn’t be there for that reason. Many people requested a change and, this time, the organizers were able to accommodate those requests.

We hope you will vote with your feet this year (or with your frequent flyer mileage), and show your support of the new dates with your attendance at this remarkable gathering. So much goes on at FORML that it is difficult to report in writing about it. Suffice it to say, for now, that the marvellous location is surpassed only by the conference itself.

Of course, we enjoy cross-pollination with everyone who is doing interesting new work in Forth so, if you happen to be attending EuroForth (see the ad on our back cover), we’d welcome more news about European activities! (And a hearty thank you to the European authors who have been writing lately—your contribution and influence is welcome.)

Corporate membership program

One of the relatively new ways to benefit from membership in the Forth Interest Group is via a corporate membership. Some companies have taken advantage of the added benefits of this level of membership, and some who previously were individual members have converted to the new program. We will be listing our corporate members in the next issue; if you are unfamiliar with the program, please contact the FIG office, who will be more than happy to explain the program to you.

Thanks for the articles, now write more...

The response to our recent request for articles has been gratifying. Thanks to those who responded, we have good material on hand for the next issue, and promises of more. Material is pledged which will interest Forth experts and relative beginners.

To my dismay, when I entered the editorial arena (too many years ago to discuss), I found that, just as we produced a fine issue and were ready to celebrate, another issue’s deadlines were looming and advance plans had to be made for the one after that. Only with a consistent and reliable source of material can we produce the kind of publication that will serve our readers and the public, and that will represent the exciting Forth work that is being done out there.

So even while we prepare to publish the material in the next issue, and to thank you again for the contributions, we must reiterate that your articles and code are more than welcome—they are needed! And don’t forget that, even in this time of on-line communications, substantive letters to the editor are also meaningful ways to contribute.

Besides, we like to get mail. Can we look forward to hearing from you?

Marlin Ouverson
editor@forth.org
No sooner had we finished the bulk mailing of the May/June issue of *Forth Dimensions* than the July/August issue was ready to go! We’re all working hard to get everything back on schedule after the move. Soon, perhaps we’ll be thinking of Carmel as the home of the Forth Interest Group, rather than its “moved to” location. I’m thinking this will happen by the time of FORML! After all, the conference is the last “first” for us here at the office. After spending the first part of this year processing your memberships and orders, I hope I get to meet a good number of you at FORML.

I was able to do just that at this year’s 17th annual Rochester Forth Conference, sponsored by the Institute for Applied Forth Research, Inc. This was the first year I attended, so I didn’t know what to expect. It was great fun! To have the opportunity to meet and talk to the people behind the articles in *Forth Dimensions*, and to put faces to the names we’ve been hearing in the main offices, added a touch of humanity to the workload.

A heartfelt thank you goes to both Larry and Brenda Forsley—they are excellent hosts who go out of their way to make the Rochester Forth Conference comfortable for all who attend. If you haven’t previously attended, you’ll definitely want to make it a date for next year. What a wonderful opportunity it is for everyone in the Forth community to have two conferences available for you to attend.

FORML, the West Coast conference, is coming up! It’s not too early to get your abstract, or even the title of your talk, to Guy Kelly, this year’s Conference Chair. The e-mail site FORML@forth.org has been set up for that purpose, as well as for pre-registration and other inquiries you might have. We look forward to hearing from you!

As you no doubt know by now, the date has been changed to the week before the U.S. Thanksgiving—to November 21 through 23. The reason for doing this was to make it more convenient for people to attend. If you haven’t been to the Monterey Peninsula during this time of year... let me tell you, it’s beautiful. The weather consists mostly of bright blue skies, temperatures in the 60’s... warm enough during the day that a favorite sweater or jacket is appropriate while walking around town or on the beach, yet cool enough in the evening that a fire in the fireplaces of the meeting rooms adds just the right touch to the atmosphere.

If you are wondering whether you should come as a family, please do; there are many things for families on the Peninsula. The Monterey Bay Aquarium is one of the finest in the world, and it has just finished construction of a new wing. There is a Natural History Museum in Pacific Grove that’s for everyone, and it has the added benefit of being free. A new Children’s Science Museum, which as of this date we haven’t been to (but that will change in the next month) has just opened. The Monterey Museum of Modern Art has lovely exhibits. There are also a dozen or so great parks and playgrounds.

And, of course, there’s Carmel. You can wander the quaint, winding streets and visit the Barnyard shopping center. The Peninsula also sports many brand-name outlet stores. So, if you are looking for a special gift for someone, you’ll probably find it here. Or, if you’d like some local flavor, how about visiting one of the numerous winery tasting rooms? If you like good wine, this region of California, like Napa, has vineyards producing world-class wines.

Guaranteed, if you bring the family, they won’t be bored! We’ve lived here for eight years and, even though our hearts are still rooted in New England (and, with it, the desire to move back someday), the Monterey Peninsula is a great place to visit.

More office business: new chapters are coming on board, and at the moment work is focused on revising and updating our FIG Chapter Kit. Those of you who have expressed interest: we will be getting back to you this next month. If you haven’t contacted the office and you’re interested in starting a chapter, now is a great time to begin. We now have Corporate Memberships, too. Our Corporate Members should have their listings of services and products in the next issue of *Forth Dimensions*.

The one thing you can count on these days is that things are constantly changing at the home office. And now is a great time to be part of that change!

*Cheers ‘til next time,
Trace Carter*
The final accolade: ISO/IEC Forth

On 15th April 1997, ISO/IEC 15145 “Information technology—Programming Languages—Forth” was published. Such an event is a coming of age for Forth. Surely the world has got to take it seriously now.

In large part, ISO15145 adopts the ANS Forth document. The initial proposal was that ISO/IEC should adopt the ANS Forth standard on-block in a Fast Track procedure. The SC 22 Secretariat forwarded the final text to ITTF for publication on November 27, 1996. In the disposition of comments document (SC 22 N 2343), the Secretariat states, “The editorial comments from the Netherlands and the ISO Central Secretariat have been incorporated in the revised DIS.

“...The comments from the United Kingdom concerning internationalization issues and requirements for embedded systems programmed in Forth will be addressed when the TC reconvenes in 1998. At that time, we will consider these and other needs that have arisen in this evolving technology.”

So what has changed between the two documents?

On opening the ISO/IEC version and ANS versions side by side, there is an obvious difference in style for the first few sections. The contents list reflects the major differences, which all seem, at first look, to be confined to sections 1 and 2.


1.1 Scope
1.1.1 Inclusions
1.1.2 Exclusions
1.2 Document organization
1.2.1 Word sets
1.2.2 Annexes
1.3 Future Directions
1.3.1 New technology
1.3.2 Obsolescent features
1.4 Normative references


2. Terms, notation and references
2.1 Definitions of terms
2.2 Notation
2.2.1 Numeric notation
2.2.2 Stack notation
2.2.3 Parsed-text notation
2.2.4 Glossary notation
2.3 References
Europay, the major European credit card organization (Eurocard, MasterCard in Europe, and other financial products) is developing technology to support smart cards—Integrated Circuit Cards, or ICCs—as the credit cards of the future. This will require new software in all credit card terminals, which range from 8051-based POS terminals to high-end ATMs. To facilitate this transition, they have designed a token-based system—conceptually similar to Open Firmware or Java—which is based on Forth. Using this Open Terminal Architecture (OTA), it will be possible for credit card issuers and acquirers to write application programs that will be completely platform independent and which will run on all OTA-compliant kernels.

The project has been under way for two years. FORTH, Inc. and MPE, Ltd. have been principal members of the design and development team, along with Europay. Prototype terminals were exhibited at a major Europay banking conference in June 1996, and production systems have been operating in the field in Prague, Czech Republic, since May 1997.

**Background**

Modern payment applications are moving to ICC technology. ICCs can significantly improve security of payment transactions by being able to manage encrypted account data offline, by participating actively in the transaction-validation process, and by being intrinsically extremely difficult to violate or reproduce. They can also contain code to enhance security algorithms, and the special data formats used by the ICCs-as cards. High-level libraries, terminal programs, and payment applications using standard kernel functions may be developed and compiled into token modules. These must be certified once; thereafter, they will run on any conforming terminal of the appropriate type (for example, ATM or POS) without change, regardless of the terminal’s CPU type or other architectural issues. Therefore, a significant consequence of OTA is a simplified and uniform set of test and certification procedures for all terminal functions.

To provide a common means of distributing programs in a compact, standard, machine-readable form, OTA uses a token system that is, in some respects, similar to Java byte-codes. An OTA token compiler converts source code to a string of tokens that is extremely compact (and therefore easy to transmit over phone lines or to read from an ICC), and is also easy for even simple processors to interpret with minimal overhead.

To summarize, OTA provides the following major benefits:

- A virtual machine with generalized ICC support functions, to be installed in each terminal only once. The kernel lifetime is expected to match that of the terminal (7–10 years).
- Terminal kernel certification independent of applications, so certification only needs to be done once for each terminal type. A terminal type is defined as a specific configuration of terminal CPU and I/O functions.
- Application certification procedures that are independent of the terminal on which the application will run, since all terminals provide the same virtual machine interface. Only one certification and validation is needed for tokenized software libraries, terminal programs, and payment applications, providing they run on certified OTA terminals.
- Standard downloading procedure for all terminal types, using compact token modules for minimum transmission time.
- Support for tokenized code on an ICC, to make maximum use of its storage capabilities and to minimize communication time between card and terminal.

OTA is based on Forth, extended with commands to facilitate development of payment applications. Forth was chosen by Europay because, of all standard interpretive-type languages, it provides the most compact and efficient means of representing both terminal programs and the code that may reside on the ICC itself. Compactness in terminal programs translates directly into reduced transmission time and cost for terminal updates, and compactness in ICC code results in increased capability and reduced transfer time between card and terminal.

For security reasons, OTA allows only run-time behavior in a terminal, so the virtual machine includes only a run-time subset of ANS Forth.

Both Forth and C compilers have been developed to support OTA tokens. VM implementations, applications, and libraries have been developed in both Forth and C.

**Open Terminal Architecture Features**

The specific characteristics of the architecture were designed and optimized for both compact and reasonably fast execution of typical payment functions on a wide variety of
CPUs. Many design decisions were heavily influenced by the extreme need for program security in payment terminals.

**Virtual Machine CPU**

The OTA virtual machine is based on a multi-stack architecture, as seen in Figure One. This architecture, derived from Forth, has been further modified for portability, code density, ease of compilation, and for use with other programming languages. For example, it contains frame memory for local variables used in C. Thus, OTA token compilers can be written not only for Forth, but also for C and other languages.

The VM is a byte-addressed, 32-bit machine, with 32-bit registers and stack elements. Despite some initial trepidation about implementing a 32-bit VM on processors such as the 8051, we have found ways to do so with remarkably good run-time performance.

**Memory**

OTA defines a single address space for programs. This address space is accessible for data storage only. Programs may not assume that executable code is in this address space. Depending on the actual processor, and on the mechanism used to convert the token image into executable tokens, the executable code may be in a different address space (shown as code space in Figure One), or may be under the control of a memory management unit. In any case, programs are not permitted to access their own program memory directly, and any attempt to do so will be flagged during the program certification procedure.

Addressable memory is further divided into sections:
- Initialized data space may be preset at compile time to values that will be instantiated in the target at run time.
- Uninitialized data space will be preset to binary zeroes in the target at run time.
- Extensible memory is temporarily allocated using a rub-

**Programs and Tokens**

The OTA token set provides program portability across multiple CPU types by passing source code programs of various types through a compiler whose output is a string of OTA tokens, which may be thought of as machine instructions for the OTA virtual machine. The tokens are organized into a module, which consists of a header, a section representing the module’s data items, lists of imported and exported functions (providing links to other modules), and the tokens themselves. Target terminals then process this code by instantiating the data space associated with the module, linking the module’s imports to functions exported by other modules, and finally interpreting the tokens. Figure Two illustrates this process.

The OTA token set covers three main areas. The first is the instruction set of a theoretical processor (the virtual machine), which provides the instructions necessary for the efficient execution of programs. The second supports I/O and communications functions. The third group consists of OTA-specific functions such as databases, a message database (potentially in several European languages), and support for Tag-Length-Value data formats (ISO 8825) used for communicating with the ICCs and for other data communications.

The OTA token set has been optimized for use on small terminals, with ease of compilation, ease of interpretation, and good code density. The most common functions, including most Forth primitives, are expressed in one-byte, or primary, tokens. Less frequently used functions are two-byte, or secondary, tokens. Some tokens also have associated values, for such things as literal values and branch offsets.

**System Components**

The purpose of OTA is to provide software to run in terminals used in payment applications. Conceptually, there are two hardware environments, and several classes of software. The hardware environments include the development system, which is based on a simple PC; and a target, which is some form of payment terminal. The entire
suite of software includes:

- development software, which runs on the PC and is available in two packages, for VM and application development, respectively;
- virtual machine implementations, which include all platform-specific software in a terminal and other mandatory standard functions;
- libraries, which provide general functions to support terminal programs and payment applications;
- applications, which are the functions specific to a particular payment product;
- terminal programs, which perform general non-payment terminal functions and include high-level mechanisms for selecting and executing transactions and associated applications; and
- test suites and platforms, for both VM implementations and token programs.

Terminal Target Environments

The target system is any one of a large variety of payment terminals. Actual products range from small, hand-held devices with simple, eight-bit microprocessors (such as the 8031/51 family), to 32-bit computers running operating systems such as Windows NT. In order to simplify the production, certification, and maintenance of software on such a wide variety of targets, OTA terminal code is based on a single virtual machine. The VM consists of a standardized set of functions whose CPU-specific implementation is optimized for that specific platform. Implementations currently operating in the field on eight different devices show that this approach provides good run-time performance, even on 8051 CPUs.

Virtual Machine

The OTA VM has standard characteristics that define addressing modes, stack usage, register usage, address space, etc. The virtual machine concept makes a high degree of standardization possible across widely varying CPU types, and simplifies program portability, testing, and certification issues.

The VM instruction set includes a selected subset of ANS Forth commands, plus a number of specialized OTA functions, such as terminal I/O support and token loader/interpreter support. Since it cannot itself be tokenized, and may reside in PROM, the VM is intended to be installed once, and not changed thereafter during the lifetime of the terminal. Therefore, its functions are carefully designed to be very general in nature and as complete as possible, in order to support a wide range of present and future terminal programs and applications.

Terminal manufacturers are responsible for providing a VM implementation on their terminals. This VM is developed and certified according to the OTA Virtual Machine Specification. Standard kernel functions not appropriate to a particular terminal type (e.g., the cash dispenser function on a POS terminal) are coded as null functions for that terminal, so every kernel has an identical set of functions and the testing and certification process is simplified. These null functions add very little to system overhead and complexity, and their advantage far outweighs their cost.

The terminal’s VM supports standard libraries and terminal programs and applications, which are written in high-level code for the virtual machine and are delivered as token modules, which will run on any standard VM.

Libraries

OTA libraries contain higher-level functions that support common features of terminal programs, such as language selection, and common features of applications, such as PIN verification. A terminal may contain several libraries, some accessible to all applications, and some restricted to particular applications or payment systems. Libraries are written and tokenized for the virtual machine, using functions provided in the kernel, and therefore can be run on any terminal.

Terminal Program

A terminal program consists of the high-level personality characteristic of this terminal type (POS, ATM, etc.). This includes the functions common to all transactions (e.g., card initialization and language selection), as well as the user interface required to select an application and process a transaction. The terminal program, at the highest level, is typically triggered by a card insertion. A terminal program is written for the virtual machine and is supplied in token form. It can, therefore, be run on any terminal of the appropriate type, and is easily changed by downloading over a network at any time. However, it frequently does incorporate platform-specific features, such as customized greeting messages, knowledge of particular screen-management capabilities, etc. These features are not included in the VM, as they may change on a time-scale shorter than the design lifetime of the VM. For example, a particular make of terminal may be used by a number of different merchants, each of which may request customized user menus.

Figure Two. Tokens may be generated from a variety of source formats, downloaded to a terminal, and then converted into executable code for that terminal by any of several different methods.
Applications

A terminal transaction will select an application as part of its processing flow. Applications fall into three general areas: stored value system (such as Europay's CLIP system, VISA CASH, or Mondex), debit cards, and credit cards; applications generally will vary in their method of processing a given transaction. Versions of these applications may be provided by different payment systems and may be further customized by individual issuers, acquirers, or even individual merchants (such as large chains or department stores). Applications are supplied in token form via the communications path and, if security considerations permit, may be enhanced by token programs on an ICC.

The Token Compiler and Token Loader/Interpreter

Libraries, applications, and terminal programs are written in high-level code for the virtual machine. The OTA development system includes a special compiler for this virtual machine, whose output consists of tokens. Tokens may be thought of as machine language instructions for the virtual machine. Tokens are either one or two bytes in length, and therefore represent the program in a form that is both CPU-independent and extremely compact (far more so, for example, than compressed source text).

Each OTA virtual machine contains a token interpreter (TLI), which processes a stream of tokens into an executable form. Once the kernel is installed in a terminal, the libraries, applications, and terminal programs can be downloaded into the terminal in a variety of ways (direct connection to an OTA development host, acquirer network, modem and dial-up telephone line, ICC, etc.). Program modifications and entire new applications may be downloaded in the same manner whenever needed. The VM implementation is designed to be so general purpose in nature that a wide range of present and future terminal programs and applications can be accommodated without modifications to the VM.

ICC Functions

One function of ICCs is to improve transaction security by incorporating and managing encrypted data and participating actively in the transaction-validation process. It is a natural feature of OTA to go beyond these functions and to provide for ICCs that also contain program code to enhance a terminal's transaction processing, thereby providing new opportunities for payment products and services. To facilitate this, a few sockets have been provided that can be plugged by issuer-specific functions such as loyalty programs, which may be invoked at appropriate points in the transaction processing. Europay does not currently propose that ICCs contain entire applications, but only plug behaviors that enhance existing terminal applications.

As far as security is concerned, the presumption is that if an ICC passes the decryption and data authentication tests performed by the terminal program, whatever functions and plug behaviors are on the card have been certified and are syn-

tactically valid. The terminal decides to allow or disallow the card's proposed actions only as controlled by the terminal access security functions.

Development Environments

An OTA development system is used to develop terminal software, either low-level VM implementations or high-level library or application software. Kernel development requires a target terminal to be connected, as the kernel is cross-compiled on the PC host and downloaded to the terminal across the Interactive Development Link. OTA libraries, terminal programs, and applications are also developed on the PC host. Because they are high-level code, they may also be executed on the host for preliminary testing, using a PC version of the standard kernel.

Since the requirements for developing and testing the VM implementation and high-level token modules differ significantly, two different tool chains have been developed: the Kernel Development Kit (KDK) for terminal VM implementors, and the Application Development Kit (ADK) for token program developers.

VM implementation tools

The KDK consists of a Windows-based cross-compiler and Interactive Development Environment (IDE), a test terminal consisting of a CPU, keypad, LCD display, serial ports, and memory sufficient to run a typical ICC application supplied in token form as a demo, and a VM implementation for that test terminal hardware (see Figure Three). Development software on the PC is based on ProForth for Windows, a product of MicroProcessor Engineering Ltd.

The VM implementation for the test terminal is supplied in source form, with documentation intended to support a developer porting this to a specific terminal of the same CPU type. As many terminal vendors have previously developed BIOS or OS functions (typically in C or assembler), a protocol is included that facilitates the use of this software to provide a defined set of functions (e.g., I/O functions) required by the VM. The kit also includes a terminal test suite and demo

Figure Three. A typical OTA development environment for a terminal. A small program to support the terminal end of the Cross-Target Link (XTL) protocol is included in the target during development.
Token module development tools

There are two major components to the Application Development Kit. These are the token compiler itself, and the Token Interactive Debugging Environment (TIDE). The latter is a standard VM implementation on a Windows platform, with configuration options that enable it to simulate a wide variety of potential target terminals. A developer may use this platform to test token modules, regardless of the language in which they were written. Token compilers are available for Forth and C. The ADK also includes an optimizer, which performs a variety of post-processing functions on token modules, that can reduce a module’s size by on the order of 50%. The result is a module that runs with no performance penalty; indeed, it is usually significantly faster, since there are fewer tokens to process.

Testing and validation tools

VM test suite development has progressed in parallel with VM development, and test suites are presently delivered with all KDKs. The VM test suite consists of a set of modules that exercise individual tokens, checking each token’s behavior against expected results and producing a report summarizing tests passed and failed (if any). The main test platform for token modules is TIDE, although tools are also in development to provide additional test facilities.

Background:

Payment Systems in Europe

Banking-based payment systems in Europe are organized nationally for domestic banking products, and internationally to facilitate international consumer payments. Looking at a typical payment transaction, the parties involved are the merchant, the acquiring bank, the payment system, and the issuer. Each of these is a distinct role, although it need not be played by a different physical or corporate entity.

• Issuers provide consumers with banking products, in this context as debit, credit, or stored-value cards. These cards can still be embossed only (for paper-based transactions), with magnetic stripe (today’s state-of-the-art) or with an IC. IC cards are currently used widely only in France, although pilot projects are under way in several other countries.

• Acquirers hold the commercial relationship with the merchant. They acquire the transactions, meaning they pay the merchant for the goods and route the transactions to whoever the consumer’s account is.

• Merchants accept cards, and provide goods to the cardholder. Merchants are more and more convinced of the necessity to migrate toward electronic payment services (e.g., magstripe or ICC).

• Payment systems such as Europay have two primary roles: to provide specifications (and associated certification) for international payment products, and to arbitrate member conflicts. In addition, payment systems also typically provide network and security services.

An IC card (or ICC) is an active device that stores data in such a way that it can prove their authenticity. It is also capable of generating authenticity certificates for transactions. This means that a point-of-sale terminal now has to deal with an active device that performs complex operations. The terminal software must behave correctly, whichever ICC is used.

Current ICCs carry about 200 times the amount of information that can be present on the magstripe cards. This amount is expected to increase as ICCs get loaded with more services. The drawback is that terminal programs become more complex and bigger. Terminals typically download their software from a server via a 1200-baud communication link. The cost of this management and download is becoming prohibitive, especially in Europe.

Many existing ICC-based payment systems are “closed” (proprietary) systems. This means it is very hard to introduce new applications without getting the consent of all the parties involved. Even then, extensive changes to the software on every terminal are required, and the terminals must be recertified. With OTA, Europay is attempting to provide an open system, capable of handling multiple ICC products, card types, and systems on a single terminal with minimal changes.

—P. Johannes, Europay International
A Simple Implementation of the Kermit Protocol in Pygmy Forth

Kermit in Pygmy

file KERMIT.SCR

Contains a simple implementation of the Kermit file transfer protocol.

copyright 1997 Frank Sergeant
pygmy@pobox.com
809 W. San Antonio St.
San Marcos, TX 78666

This source code is not Public Domain or Shareware.
You may use it freely for any private or commercial purpose provided you do so at your own risk.

For the algorithm, see pp 98-113 of
_C Programmer's Guide to Serial Communications_,
by Joe Campbell, Howard W. Sams & Company, 1987,
ISBN 0-672-22584-0.

Note, there are some errors in Campbell's examples.

GET-Y/N Wait for the user to press a y, n, Y, or N key.
Return true if y or Y. Return false if n or N.

TRY-AGAIN?
Display a message and ask whether the user wants to try again. E.g.
" Drive not ready" TRY-AGAIN? IF ... THEN

.MSG clears the top 2 lines of the screen and displays a message, leaving the cursor positioned just past the message. E.g. " Starting the transfer ..." .MSG

MYMAXL maximum "len" we are willing to handle.
The transmitted LEN field includes SEQ, TYPE, DATA, CKSUM fields. 94 maximum allowed under basic Kermit. Our buffers must be 1 byte longer to hold the LEN field also.
OUT-BUF & IN-BUF buffers for building outgoing or receiving
incoming frames. We store LEN, SEQ, TYPE, DATA, CKSUM fields, but not the SOH nor the ending CR.

MAXL holds agreed-upon maximum "len" value, which is the MIN of receiver's and sender's preferences.

a "character-ized" number is produced by adding a "space." The result must be $\leq 7E$, thus the original number must be $\leq 5E$ (ie 94 decimal).

scr # 13004
(KERMIT)

MAXL, QCTL, etc are the agreed-upon protocol parameters for the session. INIT-LIMITS initializes these to the values we would prefer to use. The sender and receiver exchange an S-frame and an ACK-frame listing their preferences. We then compromise by taking the MIN between them.

We make $\gg$LEN, $\gg$TYPE, etc relative to the start of the buffer so we can use the same definitions for both the receiving and sending buffers. $\gg$CKSUM assumes the LEN byte has been initialized.

scr # 13005
(KERMIT)

COMPROMISE assumes we have an S frame in one buffer and its ACK frame in the other buffer. We don't care whether we are the sender or receiver. The compromise takes the more conservative setting from each buffer as the actual protocol parameter to use.

For now, we will ignore all the settings except for MAXL and TIMEOUT, taking the MIN of MAXL and the MAX of TIMEOUT.
MODEM! sends a character to the modem. We defer it to make testing easy.

DATA! builds an entire data field, stopping either when out of source characters or out of room in OUT-BUF.

KSER-IN gets a serial character and tests whether it is SOH, all the while checking for a time-out. Returns character and SOH-flag (true if character is SOH). In case of time out, return up an extra level, putting a 'V on the stack as the dummy frame type indicating a time out followed by a true flag indicating a 'good' checksum.

Note, KSER-IN is only called by GETFRAME and so is always called with the correct stack depth. To test it standalone, nest it once in a test word, as shown in TEST-IN.

CKSUM? calculates a checksum on a buffer by adding the bytes of source characters or out of room in OUT-BUF.

CKSUM? says whether there is room in the buffer for another character. We require 2 bytes available in case the next character needs to be escaped. If we allowed high-bit escaping we would require 3 bytes instead.

CK%% converts the raw checksum of all the bytes after SOH into a checksum character by wrapping and character-izing it according to the KERMIT algorithm.

CKSUM calculates a checksum on a buffer by adding the bytes in the LEN SEQ TYPE & DATA fields and applying CK%. The LEN field must include the cksum byte.

CKSUM? Calculate the checksum character for the input frame and compare it to the transmitted checksum character. Return true if the checksum is good.
BUILD-FRAME  Given the address and length of data to be
transferred and the type of the frame, put as much of
the data as will fit into a frame and return the address
and length of the remaining (i.e. unsent) data.

scr # 13011
( KERMIT - debugging aids)

.FRAME .INB .OUTB  are used for testing to dump the contents
U.R
of the buffers to the screen.

TEST1 TEST2  provide some test data

.FRAME THEN ;

scr # 13012
( KERMIT)

SENDFRAME sends an entire header, from SOH through 1-byte
UNCHAR 1+
checksum and ending carriage return, to the "modem." It
sends SOH, sends LEN+1 characters in the OUT-BUF, and
then sends a carriage return.

scr # 13013
( KERMIT)

LIMITS  provides data for use in building either an S-frame
or its ACK frame for purposes of negotiating
the protocol as to maximum frame length, etc.

work)
Note that PADC is controlfied, but seems not to
be "escaped" -- after all, we haven't agreed upon
the escape character at the time of sending the
S-frame. We build this frame directly into OUT-BUF
to prevent DATA! from escaping any characters.
We say we'll use (~) as the repeat character, but we
will_not_use repeat counts when we transmit, but we
_will_handle them when we receive. If the sender does
not escape actual tildes, then we will have a problem.

scr # 12011
( KERMIT - debugging aids)

: BUILD-FRAME ( a # type - a' '# ) OUTLEN OFF
  0 ( ie dummy len ) CHAR ( KEMIT SEQ @ CHAR ( KEMIT ( a # ) DATA! ( a' ' ') )
  OUTLEN @ CHAR OUT-BUF >LEN C! ( a # )
  OUT-BUF CKSUM OUT-BUF >CKSUM C! ( a # )

scr # 12012
( KERMIT)

: SENDFRAME ( - ) SOH MODEM! OUT-BUF >LEN DUP C8+
  FOR ( a ) C8+ MODEM! NEXT DROP ( ) 50D MODEM! ;

scr # 12013
( KERMIT)

: LIMITS ( type - )
  SEQ OFF PUSH
  '1 ( the repeat char)
  '1 ( 1-byte chksum, either '1 or 1 CHAR seems to
  'N ( no hi-bit prefix)
  QCTL @
  EOLC @ CHAR PADC @ CTRL
  NPAD @ CHAR TIMEOUT @ CHAR MAXL @ CHAR POP
  SEQ @ CHAR 12 ( len ) CHAR
  OUT-BUF 12 FOR DUP PUSH C! POP 1+ NEXT DROP ( )
  OUT-BUF CKSUM OUT-BUF >CKSUM C! ;
scr # 13014
(KERMIT)
KINIT sends the 'send-init' frame. It must have sequence zero.
This is the 'S' frame sent by sender in response to the
receiver's initial NAK.
KINITACK sends a reply to a 'send-init' frame. Before sending
KINITACK (if we are receiving) or after receiving
KINITACK (if we are sending), we must adjust our settings
to the minimum of the sender's and the receiver's requests.
Note complex handling of COMPROMISE.
FILEHEADER sends the file name of the file to be transmitted.
EOF is sent at the end of each file we send. EOT is sent after
we finish sending all the files. Receiver sends ACK or NAK
after each frame is received, depending on whether checksum is
ok. ERROR is sent to abandon the session. I think we will
ignore an ATTRIB frame.

scr # 13015
(KERMIT)
EXPECTED holds the count of bytes we expect to receive
following the length byte.
SETLENGTH handles the length count for an incoming frame,
initializing EXPECTED and INLEN and putting the
length byte into the input buffer.
PUT-IN-BUFFER puts input bytes into the buffer and returns
a flag that is true when all the expected bytes
have arrived.

scr # 13016
(KERMIT)
GETFRAME is closely tied to KSER-IN and is the only word that
should ever call KSER-IN, as KSER-IN returns upward an extra
level in case of a timeout, supplying the type and cksum flag
(i.e. 'V -1'). So, GETFRAME always succeeds, returning a type
and flag. It watches for an SOH in the middle of a frame and
starts over. What makes GETFRAME tricky is it needs to handle
the usual case as well as a timeout at any time as well as an
unexpected SOH at any time. What makes it simpler is pushing
some of the logic down to the word KSER-IN and letting KSER-IN
terminate not only itself but also GETFRAME in the case of a
timeout, thus producing a dummy V-frame. After that we no
longer have a timeout as a special case, we simply have an
additional "frame" type (i.e. a timeout frame).

scr # 12014
(KERMIT)
: BUILD/SEND ( a # type - ) BUILD-FRAME SENDFRAME 2DROP ;
: KINIT ( - ) 'S LIMITS SENDFRAME ;
: KINITACK ( - ) 'Y LIMITS COMPROMISE 'Y LIMITS SENDFRAME ;
: FILEHEADER ( a - ) " sending file " .MSG 2DUP TYPE
            ( a @ ) 'F BUILD/SEND ;
: EMPTY-FRAME ( type - ) ( ) CREATE C,
            DOES> C9 0 0 ROT BUILD/SEND ;

    'Y EMPTY-FRAME {ACK}
    'N EMPTY-FRAME (NAK
    'Z EMPTY-FRAME EOF
    'B EMPTY-FRAME EOT
    'A EMPTY-FRAME ATTRIB
    'E EMPTY-FRAME ERROR

: ACK ( seq# - ) SEQ @ SWAP SEQ ! (ACK SEQ ! ) ;
: NAK ( seq# - ) SEQ @ SWAP SEQ ! (NAK SEQ ! ) ;

scr # 12015
(KERMIT)
VARIABLE EXPECTED

: INBUF! ( c - ) IN-BUF INLEN @ + C! 1 INLEN +! ;
: SETLENGTH ( c-length - )
    INLEN OFF DUP INBUF! ( c ) UNCHAR EXPECTED ! ;
: PUT-IN-BUFFER ( c - f ) INBUF! INLEN @ EXPECTED @ > ;

scr # 12016
(KERMIT)

: GETFRAME ( - type f )
BEGIN KSER-IN MIP UNTIL ( ) ( ie await SOH)
BEGIN
BEGIN KSER-IN WHILE DROP REPEAT ( c ) SETLENGTH ( )
BEGIN KSER-IN NOT WHILE ( c ) PUT-IN-BUFFER ( f )
IF IN-BUF >TYPE C8 CKSUM?
OVER 'E = OVER AND ABORT" Fatal Error in Kermit"
EXIT THEN ( )
REPEAT ( c ) DROP
AGAIN ( type f ) ;

Forth Dimensions XIX/2
GET-GOOD-FRAME continues to try to get a frame until one arrives with a good checksum. It will try forever unless the user aborts the transfer. (See KSER-IN for test for user abort.)

GOOD-SEQ? true if the input frame's sequence number is the expected sequence number.

GET-GOOD-FRAME (- type)
BEGIN GETFRAME (type cksumflag) NOT WHILE "." bad cksum " DROP REPEAT ;

GET-FIRST-NAK ignores timeouts and sequence numbers and waits for a NAK from the receiver.

SEND wait for the prompting NAK frame from receiver
send S-frame (ie KINIT)
reset serial in to throw away any extra prompting NAKs
get S-frame ACK for SEQ 0
send the entire file, one D-frame at a time
close the file
send end of file and end of transmission

IN-DATA is a buffer for holding the UNCTRL'd data field. Make it big in case lots of repeat counts are present.

C!+ stores a character and bumps the address (similar to C@+).
C8+-- gets a character from the 'from' address, increments
the 'from' address and decrements the count of remaining
characters.

UNCTRL'd if the current character is the QCTL escape character,
get another character and unescape it.

scr # 13021
REPEAT'd The most recent character was the tilde (~), indicating
the beginning of a 3 or 4 character repeat sequence.
Get the next character as the count and then the next 1
or 2 (if escaped) to find the value to be repeated, &
expand that repeated character into destination buffer.

UNCTRL copy the escaped and repeated source buffer,
unescaping and expanding as appropriate, to the
destination buffer.

>IN-DATA copies IN-BUF's data field, which may contain
escaped characters, to IN-DATA with escaped characters
converted to their actual values (and repeated counts
expanded).

scr # 13022
( KERMIT)

BUILDNAME extracts name of file to be received from an
input F frame and stores it in our KFNAME buffer
as a counted string (and an asciz string suitable
for passing to DOS for creating the file).

RCVNAME this is what we do in response to an F-frame:
save the file name in the KFNAME buffer as
a counted, asciz string, then create the file and
save the handle.

scr # 13023
( KERMIT)

GET-NEXT Get the next frame we are expecting, ACKing or NAKing
as appropriate.
Always ack with the seq number we received, even if
it wasn't the seq number we expected, thus allowing
sender to continue. But, throw away frames that

: UNCTRL'd ( from # c - from # c)
DUP QCTL @ - IF EXIT THEN DROP C8+- CTRL ;

scr # 12021
( KERMIT)

: REPEAT'd ( to from # - to from #) ROT PUSH ( 'fr #)
C8+- UNCHAR PUSH C8+- ( fr # c) UNCTRL'd ( fr # c)
POP POP ( le rpt# to) 2DUP + PUSH ( fr # c rpt# to)
SWAP ROT FILL ( fr #) POP ROT ROT ( to fr #) ;

: UNCTRL ( from to # - a #)
ROT PUSH DUP POP POP POP SWAP ( to from #)
BEGIN DUP WHILE ( to to fr #)
C8+- DUP '-' - IF ( to to fr # c) DROP REPEAT'd
ELSE UNCTRL'd PUSH ROT POP SWAP C1+ ROT ROT THEN
REPEAT ( to to fr 0) 2DROP OVER - ( a #) ;

: >IN-DATA ( - a #) IN-BUF >DATA IN-DATA ( from to)
IN-BUF C@ UNCHAR 3 - ( from to #) UNCTRL ;

scr # 12022
( KERMIT)

VARIABLE KHANDLE
CREATE KFNAME 50 ALLOT

: BUILDNAME ( -)
>IN-DATA ( a #) DUP PUSH KFNAME l+ SWAP MOVE ( )
0 KFNAME R9 + l+ C! ( make name into an asciz string)
POP KFNAME C! ;

: RCVNAME ( -)
BUILDNAME KFNAME FMAKE ( h f)
ABORT" cannot open output file" ( h) KHANDLE !
" receiving file " .MSG KFNAME COUNT TYPE SPACE ;

scr # 12023
( KERMIT)

: GETNEXT ( - type)
BEGIN GETFRAME ( type f)
IF ( type) DUP 'V =
   IF ( type) SEQ @ NAK -1 ( type f)
ELSE ( type) IN-SEQ DUP ACK ( type seq) SEQ @ -
THEN
Win32Forth 3.5 has been released to the community, and is available on the Forth Interest Group compilers page at:

The Forth Interest Group's home page is located at:
http://www.forth.org/fig.html

The primary changes to Win32Forth include enhancements to the WinView editor that allow editing multiple files at the same time, and a more intelligent screen-refresh algorithm. The class library has been generalized, and now supports more control classes.

Be sure to get the latest update file numbered like 32UPDTxx.EXE, where xx is a number 01, 02, etc. Intermediate update files will not be needed, each successive update will include all the previous updates.

3.5 will be the last public-domain release of Win32Forth, making this the basis for future user work. Bug fixes and minor revisions will be released periodically, in the form of an update to the base system.

I would like to give special thanks to all the industrious Forthers who have contributed bug reports, fixes, and examples to this project.
—Tom Zimmer

Pygmy 1.5 is now on my web site for your downloading convenience.
Get the file pygmy15.zip on my Forth page at:
http://www.eskimo.com/~pygmy

Version 1.5 has minor typo and documentation clean-ups, plus
multitasking and the ability to be embedded in a C wrapper in order to
access C library routines, give C access to Forth routines, an implementa-
tion of the Kermit file-transfer protocol, etc.

I have updated the bonus disk, too, available only via uuencoded e-
mail. Previous bonus disk customers, please e-mail me your preferred
e-mail address, and I'll send the updated bonus disk file. (Potential bonus
disk customers, see details in the pygmy15.zip file.) The bonus disk now includes the updated 68HC11 (cross) assembler and updated serial port routines, both interrupt-driven and multitasked polling.

If anyone does not have web access to get pygmy15.zip, e-mail me and I will be glad to send it as uuencoded e-mail.

My "3-instruction Forth" for the 68HC11 is now on my Forth web page. It includes the original article from the 1991 FORML Conference Proceedings, with variants of the code customized for several different versions of the 68HC11 (i.e., 'E1', 'A1', 'D0').

The article describes how to use a single-board computer with Forth on a host computer. Examples include code for Pygmy on the PC and a minimal "3-instruction Forth" monitor downloaded to the 68HC11's RAM. For development, this gives nearly the full convenience of a full Forth on the target, but using somewhere between 32 bytes (the smallest I have used) to 66 bytes of RAM on the 68HC11.

This may be of use even to those who do not use Forth to develop for the HC11, as it provides a convenient wrapper for writing, running, and testing assembly language routines on the 'HC11. The package is freely distributable and usable, under the condition that I bear no responsibility for any damages due to its use or misuse.

The Bare Bones EPROM Programmer materials are also on my web site. This includes the executable file, the schematic and printed circuit board artwork (as .bmp files), and instructions for building and using the programmer. It doesn't include source. The programmer uses the MC68HC11D0 and the 4049 or 74HC4049, and is controlled from a PC serial link. The programmer only programs 2kx8, 8kx8, 16kx8, and 32kx8 EPROMs (and probably EEPROMs). I am making this old project available for "historical" interest.

—Frank Sergeant • pygmy@pobox.com
A linked list is a list (i.e., sequence) of cells, called nodes, such that each node somehow contains the address of the next node. The address of the first node of the list is contained in a cell, the head of the list. The last node contains a programmer-chosen value to indicate the end of the list. This value is usually zero, and that's what we'll use here.

When the list is empty, the head contains the zero. The nodes themselves don't contain any information. Information is associated by a programmer-chosen convention to be physically near its node.

The information could be anything: a number, an execution token, a string, a node or head of another list, or whatever. More than one item of information may be associated with a node.

In the applications that interest us now, the primary information will be kept just after the node, and will be a counted string. Use CELL+ to go from a node to its information.

To get the address of the next node from a node, use node@. To set the contents of a node, use node!

These can be defined:

: node@ @ ;
: node! ! ;

We use node@ and node! so we can change the definition if we want.

To create a new list, we define its head.

: LIST: ("<spaces>name" -- )
CREATE 0 , ;
(name Execution: -- node)

To create a new node, which will be put in a list:

: New-Node ( -- node )
ALIGN HERE 0 , ;

Information should go into dataspace just after the new node.

To put a node, new or old, into a list [see Figure One]. This puts the node at the beginning of the list. To put a node at the end of the list [see Figure Two]. Any node in a list can be considered to be the head of a list. So to put a node after a node in a list, also use link-node.

All nodes in a list should be unique. We'll ensure this by only putting newly created nodes in a list, or moving a node from one list to another.

Information doesn't have to be unique, but generally will be.

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---

Figure One

: link-node (node list -- )
OVER 0=
ABORT" link-node: Mustn't link NIL node."
2DUP node@ SWAP node! node! ;

Figure Two

: append-node (node list -- )
BEGIN DUP node@ WHILE node@ REPEAT node! ;

Figure Three

( Create a list )
LIST: A-List
(A-List -- > 0 )
(Put "Larry" on the list.)
New-Node A-List link-node ," Larry"
(A-List -- > Larry -- > 0 )
New-Node A-List link-node ," Curly"
(A-List -- > Curly -- > Larry -- > 0 )
A-List node@ New-Node SWAP link-node ," Moe"
( A-List -- > Curly -- > Moe -- > Larry -- > 0 )

Figure Four

: PLACE ( caddr len addr -- )
2DUP 2>R CHAR+ SWAP CHARS MOVE 2R> C! ;
: STRING ( char "ccc<char>" -- )
WORD COUNT HERE OVER 1+ ALLOT PLACE ;
: ," [CHAR] " STRING ;
Figure Five
( cull-nodes  Remove nodes that are within a range. )
:cull-nodes 3 needed
( lower upper list -- )
 ROT ROT 2>R
 ( node)( R: lower upper )
 ( node)
BEGIN
DUP node@ ?DUP
WHILE
DUP 2R@ WITHIN IF
 node@ OVER node!
ELSE
NIP
THEN
REPEAT DROP
2R> 2DROP
;

Figure Six
: .text ( caddr len -- ) TYPE SPACE ;
: ?text ( addr -- ) ?DUP IF COUNT .text THEN ;
: BEGINS-WITH ( a1 ul a2 u2 -- a1 ul flag ) DUP >R 2OVER R> MIN
COMPARE 0= ;

Figure Seven
: items ( list -- ) ITEM> ( item) ?text ( ) ITERATE ;

Figure Eight
: #items ( list -- n ) 0 SWAP ITEM> DROP 1+ ITERATE ;

Figure Nine
:: Some-List ITEM>
  COUNT S" ANS" BEGINS-WITH IF .text ELSE 2DROP THEN
ITERATE ;;

Figure Ten
( item-search )

: ?node? ( flag node -- node 0 | node' node' | 0 0 )
 SWAP IF
  FALSE ( node 0)
 ELSE
 node@ DUP ( node' node' | 0 0 )
 THEN
 ;

MACRO ITEM> " >R FALSE BEGIN R> ?node? WHILE DUP >R CELL+ "
MACRO ITERATE " FALSE REPEAT DROP "
The Search Paradigm

Standard Forth provides a basic pattern for the general problem of searching. [Figure One]
When components are empty, \( O = \) WHILE REPEAT can be replaced by UNTIL, and ELSE THEN by THEN.
By writing test-for-more and test-for-match appropriately, the Search Paradigm can be written. [Figure Two]
This can be made strictly structured. [Figure Three]
Now make a simple definition and macro. [Figure Four]
See “Tool Belt #2” in this issue for MACRO.
This special instance of the Search Paradigm can now be written:
SPECIAL-SEARCH test-for-match? REPEAT IF what-to-do-if-found. ELSE what-to-do-if-not-found. THEN

If you don’t do anything special for found/notfound, you can write:
SPECIAL-SEARCH test-for-match? REPEAT DROP
If test-for-match is not really a test but an action, you want to do on every element:
SPECIAL-SEARCH do-it. FALSE REPEAT DROP

This is so common, another macro is appropriate.
MACRO ITERATE " FALSE REPEAT DROP " SPECIAL-SEARCH do-it. ITERATE
Example. Searching a file. [Figure Five]
Now we can write:
: LISTING ( -- ) LINES> TYPE CR ITERATE ;
Or use nonce words:
( List the file. )
:: LINES> TYPE CR ITERATE ;;

MACRO FAILURE " FALSE EXIT "
MACRO SUCCESS " TRUE EXIT "

In a long printout, you may want to pause, or terminate prematurely.

It’s used in ?ITERATE, an alternative to ITERATE:
MACRO ?ITERATE " QUIT? REPEAT DROP "

MACRO ?? " IF \ THEN "

( Simple FGREP )
:: LINES>
S" pattern" SEARCH ?DUP AND ?DUP ?? .LINE ITERATE ;

( That just prints the rest of the line. For the whole line: )
:: LINES> 2DUP S" pattern" SEARCH NIP NIP ?DUP AND ?DUP ?? .LINE ITERATE ;

Let’s capture that in another definition.
:: ?MATCH ( a1 u1 a2 u2 -- )
2>R 2DUP 2R> SEARCH NIP NIP ?DUP AND ?DUP ?? .LINE 

MACRO ?ITERATE
QUIT? REPEAT DROP

( Useful definitions. )
:: .LINE TYPE CR ;

Helpful definitions.

: LISTING ( -- ) LINES> .line ?ITERATE ;

If you haven’t hit a key, )
( return FALSE immediately. )
KEY? 0= ?? FAILURE
( If you hit a key other than )
( the space bar, return TRUE. )
KEY BL = NOT ?? SUCCESS
( Otherwise, pause and return )
( FALSE when you hit any key. )
KEY DROP
FAILURE

It’s used in ?ITERATE, an alternative to ITERATE:
MACRO ?ITERATE " QUIT? REPEAT DROP "

MACRO 'LISTING' redefined. )
:: LISTING LINES> .line ?ITERATE ;
FORTH INTEREST GROUP

MAIL ORDER FORM

HOW TO ORDER: Complete form on back page and send with payment to the Forth Interest Group. All items have one price. Enter price on order form and calculate shipping & handling based on location and total.

FORTH DIMENSIONS BACK VOLUMES

A volume consists of the six issues from the volume year (May–April).

  - Introduction to FIG, threaded code, TO variables, fig-Forth.
  - Interactive editors, anonymous variables, list handling, integer solutions, control structures, debugging techniques, recursion, semaphores, simple I/O words, Quick sort, high-level packet communications, China FORML.
  - Generic sort, FORTH spreadsheet, control structures, pseudo-interrupts, number editing, Atari Forth, pretty printing, code modules, universal stack word, polynomial evaluation, F83 strings.
Volume 8  FORTH Dimensions (1986–87) 108 – $35
  - Interrupt-driven serial input, data-base functions, TI 99/4A, XMODEM, on-line documentation, dual CFAs, random numbers, arrays, file query, Batcher’s sort, screenless Forth, classes in Forth, Bresenham line-drawing algorithm, unsigned division, DOS file IO.
  - Fractal landscapes, stack error checking, perpetual date routines, headless compiler, execution security, ANS-Forth meeting, computer-aided instruction, local variables, transcendental functions, education, relocatable Forth for 68000.
  - dBase file access, string handling, local variables, data structures, object-oriented Forth, linear automata, stand-alone applications, 8250 drivers, serial data compression.
  - Local variables, graphic filling algorithms, 80286 extended memory, expert systems, quaternion rotation calculation, multiprocessor Forth, double-entry bookkeeping, binary table search, phase-angle differential analyzer, sort context.
Volume 12 FORTH Dimensions (1990–91) 112 – $35
  - Floored division, stack variables, embedded control, Atari Forth, optimizing compiler, dynamic memory allocation, smart RAM, extended-precision math, interrupt handling, neural nets, Soviet Forth, arrays, metacompiler.

FORML CONFERENCE PROCEEDINGS

FORML (Forth Modification Laboratory) is an educational forum for sharing and discussing new or unproven proposals intended to benefit Forth, and is an educational forum for discussion of the technical aspects of applications in Forth. Proceedings are a compilation of the papers and abstracts presented at the annual conference. FORML is part of the Forth Interest Group.

1981 FORML PROCEEDINGS 311 – $45
  - CODE-less Forth machine, quadruple-precision arithmetic, overlays, executable vocabulary stack, data typing in Forth, vectored data structures, using Forth in a classroom, pyramid files, BASIC, LOGO, automatic cueing language for multimedia, NEXOS—a ROM-based multitasking operating system. 653 pp.
1982 FORML PROCEEDINGS 312 – $30
  - Rockwell Forth processor, virtual execution, 32-bit Forth, ONLY for vocabularies, non-IMMEDIATE loop words, number-input wordset, I/O vectoring, recursive data structures, programmable-logic compiler. 295 pp.
1983 FORML PROCEEDINGS 313 – $30
1984 FORML PROCEEDINGS 314 – $30
  - Forth expert systems, consequent-reasoning inference engine, Zen floating point, portable graphics wordset, 32-bit Forth, HP71B Forth, NEON—object-oriented programming, decompiler design, arrays and stack variables. 376 pp.
1986 FORML PROCEEDINGS 316 – $30
1988 FORML PROCEEDINGS 318 – $40
  - Includes 1988 Australian FORML, Human interfaces, simple robotics kernel, MODUL Forth, parallel processing, programmable controllers, Prolog, simulations, language topics, hardware, Wil’s workings & Ting’s philosophy, Forth hardware applications, ANS Forth session, future of Forth in AI applications. 310 pp.
1989 FORML PROCEEDINGS 319 – $40
  - Includes papers from '89 euroFORML. Pascal to Forth, extensible optimizer for compiling, 3D measurement with object-oriented Forth, CRC-polynomials, F-PC, Harris Ccross-compiler, modular approach to robotic control, RTX recompiler for online maintenance, modules, trainable neural nets. 433 pp.
1992 FORML PROCEEDINGS 322 – $40
  - Object oriented Forth bases on classes rather than prototypes, color vision sizing processor, virtual file systems, transparent target development, Signal processing pattern classification, optimization in low level Forth, local variables, embedded Forth, auto display of digital images, graphics package for F-PC, B-tree in Forth 260 pp.
1993 FORML PROCEEDINGS 323 – $45
  - Includes papers from '92 euroForth and '93 euroForth Conferences. Forth in 32-Bit protected mode, HDTV format converter, graphing functions, MIFS eForth, umbilical compilation, portable Forth engine, formal specifications of Forth, writing better Forth, Holon—A new way of Forth, POSM, a Forth string matcher, Logo in Forth, programming productivity. 509 pp.

New
BOOKS ABOUT FORTH

ALL ABOUT FORTH, 3rd ed., June 1990, Glen B. Haydon  201 – $90
Annotated glossary of most Forth words in common usage, including Forth-79, Forth-83, F-PC, MVP-Forth. Implementation examples in high-level Forth and/or 8086/88 assembler. Useful commentary given for each entry. 504 pp.

eFORTH IMPLEMENTATION GUIDE, C.H. Ting  215 – $25
eForth is the name of a Forth model designed to be portable to a large number of the newer, more powerful processors available now and becoming available in the near future. 54 pp. (w/disk)

Embedded Controller FORTH, 8051, William H. Payne  216 – $76
Describes the implementation of an 8051 version of Forth. More than half of this book contains source listings (with disk) 511 pp.

F83 SOURCE, Henry Laxen & Michael Perry  217 – $20
A complete listing of F83, including source and shadow screens. Includes introduction on getting started. 208 pp.

THE FIRST COURSE, C.H. Ting  223 – $25
This tutorial's goal is to expose you to the very minimum set of Forth instructions you need to use Forth to solve practical problems in the shortest possible time. "...This tutorial was developed to complement The Forth Course which skims too fast on the elementary Forth instructions and dives too quickly in the advanced topics in a upper level college microcomputer laboratory ..." A running F-PC Forth system would be very useful. 44 pp.

THE FORTH COURSE, Richard E. Haskell  225 – $25
This set of 11 lessons, called The Forth Course, is designed to make it easy for you to learn Forth. The material was developed over several years of teaching Forth as part of a senior/graduate course in design of embedded software computer systems at Oakland University in Rochester, Michigan. 156 pp. (w/disk)

FORTH NOTEBOOK, Dr. C.H. Ting  232 – $25
Good examples and applications. Great learning aid. poly-FORTH is the dialect used. Some conversion advice is included. Code is well documented. 286 pp.

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**XIX-2**
## Figure One

BEGIN test-for-more? \ More?
WHILE test-for-match? \ Found?
0= WHILE advance-to-next-element. \ Next.
REPEAT what-to-do-when-found. \ Found.
ELSE what-to-do-when-not-found. \ Not found.
THEN

## Figure Two

BEGIN test-for-more? \ More?
WHILE test-for-match? \ Found?
UNTIL what-to-do-when-found. \ Found.
ELSE what-to-do-when-not-found. \ Not found.
THEN

## Figure Three

FALSE BEGIN
   ?DUP IF FALSE
   ELSE test-for-more? DUP
   THEN
   WHILE test-for-match?
   REPEAT
   IF what-to-do-when-found.
   ELSE what-to-do-when-not-found.
   THEN

## Figure Four

: ?test-for-more?
   ?DUP IF FALSE ELSE
   test-for-more? DUP
   THEN
   ;

MACRO SPECIAL-SEARCH " FALSE BEGIN ?test-for-more? WHILE "

## Figure Five

: ?lines>?   ( flag -- caddr len true | flag false )
   ?DUP IF FALSE ELSE
   Line-Buffer DUP MAXLINE THE-FILE ` 
   READ-LINE checked ?DUP 0= IF
   2DROP FALSE DUP THE-FILE REWIND
   THEN
   THEN
   ;

MACRO LINES> " FALSE BEGIN ?lines>? WHILE "
Simple Macros

In "Tool Belt #1," a couple of definitions have the form:

: name " blahdy-blahdy-blah " EVALUATE ; IMMEDIATE

This is a way to provide simple macros for Forth. Typing or writing name is the same as typing or writing blahdy-blahdy-blah.

There are many places where simple macros would be useful. So let's abstract the defining process.

Using STRING from Starting Forth, MACRO can be defined:

: MACRO CREATE IMMEDIATE CHAR STRING DOES> COUNT EVALUATE ;

On systems where WORD's buffer happens to be at HERE, STRING can be defined:

: STRING ( char -- ) WORD C@ 1+ ALLOT ;

In Forth, Inc.'s Power MacForth, MACRO can be defined:

: MACRO CREATE IMMEDIATE CHAR ?PARSE CS, DOES> COUNT EVALUATE ;

Here is a definition using PLACE from F83.

: PLACE
  2DUP >R >R
  CHAR+ SWAP CHARs MOVE
  R> R> C! ;

: STRING
  WORD COUNT HERE OVER 1+
  CHARs ALLOT PLACE ;

The stack effects are:

PLACE caddr u addr --
STRING char "ccc<char>" --
MACRO " name<spaces><char>ccc<char>" --

The definition can be written using required words only—no Core Extension words or other optional word sets—and will work in any Standard Forth. No transient area, other than that used serially by WORD, and no temporary storage are used.

Because the text for macros is acquired by WORD, macro definitions must be on one source line. You can have more than one macro definition on a line, though. The need for long macros can be satisfied by using macros within macros.

Available in any Standard Forth

For portability, stick to one line.

Some examples of macro definitions are given in Figure One. Comment out definitions that don't interest you.

ANEW can be defined:

: ANEW
  >IN @ BL WORD FIND
  IF EXECUTE ELSE DROP THEN
  >IN ! MARKER ;

How about a parameter?

Much can be done with macros without parameters. But it would be nice to have a parameter when you need one. So here is a redefinition of MACRO that allows parameters occurring once in the macro. It also gives you a hook to compile long macros—up to 255 characters.

A parameter must be a single word, and it follows the use of the macro. \, which is otherwise useless in a macro, is used in the macro as the placeholder for a parameter. In a macro, the parameter cannot be quoted or be the name of a word being defined, because of parsing restrictions in EVALUATED strings. Placeholders are replaced by parameters, in the order in which they occur.

Think of a macro with parameters as a stencil with slots to be filled.

You can use \ as a parameter to leave a slot empty. [Figure Two]

If you don't already have /STRING from the String-Handling word set, it can be defined:

: /STRING ( a n k -- a+k n-k )
  2>R R@ CHARs + 2R> - ;

Some examples of simple macros using parameters are shown in Figure Three.

When should I use a macro?

1. Re-writing the examples without using EVALUATE will show you one reason.

   For instance, define ?? without EVALUATE. Be sure you can do everything the macro will do.

   Even something as simple as MACRO AGAIN " 0 UNTIL " is an advanced topic without MACRO.

   Many definitions are much easier using macros, rather than considering how to use LITERAL and POSTPONE on each word.

2. A second reason is when you want to eliminate the overhead of subroutine nesting. You want to trade space for time.

   Be selective. BOUNDS defined as MACRO BOUNDS " OVER + SWAP " in general won't do noticeably better than :

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24 Forth Dimensions XIX/2
Figure One

MACRO :: " ANEW NONCE : NONCE-DEF "
MACRO ;; " ; NONCE-DEF NONCE "
MACRO S= " COMPARE 0= "
MACRO TH " CELLS + "
MACRO ANDIF " DUP IF DROP " MACRO ORIF " ?DUP 0= IF "
MACRO =IF " OVER = IF DROP "
MACRO S IF " 2OVER S= IF 2DROP "
MACRO SUCCESS " TRUE EXIT " MACRO FAILURE " FALSE EXIT "
MACRO NOT " 0= "
MACRO 2>R " SWAP >R >R "
MACRO 2R> " R> R> SWAP "
MACRO 2R8 " R> R8 SWAP DUP >R "
MACRO ENDIF " THEN "
MACRO UNLESS " 0= IF "
MACRO AGAIN " 0 UNTIL "
MACRO FOR " BEGIN ?DUP WHILE 1- >R " MACRO NEXT " R> REPEAT "
MACRO #DO " 0 ?DO "
MACRO ?REPEAT " [ 0 CS-PICK ] UNTIL "
MACRO LINES> " FALSE BEGIN ?lines>? WHILE "
MACRO ITEM> " >R FALSE BEGIN R> ?node? WHILE DUP >R CELL+ "
MACRO ITERATE " FALSE REPEAT DROP "

Figure Two

: split-at-char ( a n char -- a+k n-k a k )
  >R 2DUP ( a n a+k n-k ) ( R: char)
  BEGIN DUP WHILE OVER C@ R8 =
  0= WHILE 1 /STRING REPEAT THEN
  R> DROP ( R: )
  DUP >R 2SWAP >R - ( a+k n-k a k )

: DOES>MACRO DOES>
  COUNT BEGIN ( caddr u)
  [ CHAR ] \ split-at-char 2SWAP 2>R ( caddr u)
  EVALUATE ( )
  R8 WHILE
  BL WORD COUNT EVALUATE
  2R> 1 /STRING ( caddr u)
  REPEAT ( )
  2R> 2DROP ( )

: MACRO CREATE IMMEDIATE CHAR STRING DOES>MACRO ;

Figure Three

MACRO ?? " IF \ THEN "
MACRO ?LEAVE " ?? LEAVE "
MACRO H: " <hex> \ </hex> "
MACRO 'TH " CELLS \ + "
MACRO TIMES " #DO \ LOOP "
MACRO TIME " :: N 0 COUNTER >R DO \ LOOP R> TIMER CR ;; "
MACRO THE " [ ALSO \ ] \ [ PREVIOUS ] "
MACRO CLEAR " DEPTH TIMES DROP "

Forth Dimensions XIX/2
BOUNDS OVER + SWAP ;. That's because it appears outside a loop, not inside.

Sometimes the system you're working with has a different word that does the same thing as the word you'd like to use. For example, <ROT instead of -ROT, or UP CASE instead of what you like for conversion to uppercase, or something that does the same as a standard word. So define MACRO -ROT "<ROT ", etc. The run-time overhead of your definition is eliminated.

3. Use a macro for short definitions when the compiler might give better results for in-line code.

1024 CONSTANT 1K
MACRO K "1K" "

I expect 401 K to be a literal, and most other ways of using K to become an in-line shift.

4. In a target compiler, macros that work just for source
code can be used to provide the convenience of a definition without having the overhead in the target. Thus, if the target doesn't have NIP, define MACRO NIP "SWAP DROP ".

Never define : -ROT ROT ROT ;. A high-level definition of -ROT destroys any advantage -ROT might have—it adds the overhead of nesting to the two ROTs. If you want to use -ROT, define it as MACRO -ROT " ROT ROT ". A friendly compiler should do the right thing for ROT ROT, even when it doesn't have -ROT.

Appendix
MACRO " ANEW NONCE : NONCE-DEF "
Start compiling a nonce word. Used extensively for data initialization and testing. Use ;; to complete the definition, execute it, and forget it.

Nonce words let you execute loops from the keyboard. They also allow you to initialize data structures programmatically.

Nonce words wouldn't be needed with self-compiling IF, BEGIN, DO, ?DO.

From The Random House Dictionary of the English Language: nonce word, a word coined and used only for the particular occasion.

MACRO ;; " ; NONCE-DEF NONCE "
Finish syntax compiling a nonce word, execute it, and forget it. If a syntax error occurs in compilation, just start over. If other corrections are needed, type NONCE to recover, make the corrections, and start over.

MACRO ?? " IF \ THEN "
For the frequent situation of IF being used with a single word.

?? a-word becomes IF a-word THEN.

Examples: ?? LEAVE, ?? NEGATE, DEPTH 0= ?? 0, /MOD SWAP ?? 1+, @ ?DUP ?? EXECUTE.

The single word may be a macro, which will expand.

MACRO 2>R " SWAP >R >R "
MACRO 2R> " R> R> SWAP "
MACRO 2R@ " R> R@ SWAP DUP >R "
MACRO R+! " R> + >R "
MACRO R! " R> DROP >R "

Words manipulating the return stack are easier to define with macros. Such definitions would only be used if they were not already defined directly.

MACRO ENDF " THEN "
MACRO AGAIN " 0 UNTIL "
MACRO UNLESS " 0= IF "
MACRO DO " 0 ?DO "

Words involving the control-flow words are easier to write and understand with macros.

MACRO FOR " BEGIN ?DUP WHILE 1- >R "
MACRO NEXT " R> REPEAT "

That implements the FOR ... NEXT loop used in some Forth systems.

MACRO ANDIF " DUP IF DROP "
MACRO ORIF " ?DUP 0= IF "

Short circuit conditionals.

!DUP IF DROP "
A common sequence. Like a CASE statement.

MACRO S=IF " 2OVER S= IF 2DROP "
A CASE statement for strings.

MACRO NOT " 0= "
MACRO TH " CELLS + "
MACRO S= " COMPARE 0= "

The above definitions were made with macros to make it easier for the compiler to optimize, and to avoid the overhead of nesting functions.

MACRO TIMES " #DO \ LOOP "
Execute the next word n times. For very short DO loops. Note the use of macro #DO.

[See Figure Four] A rare, simple macro with two parameters. COUNTER and TIMER are the words used for timing in the system I'm using. You should do what works with your system. The second parameter is there to clean up or complete the work done by the first parameter.

For example, TIME RANDOM DROP.

You will have to define n before using TIME. I generally define it as a value word, so I can experiment with the number of iterations.

To time an empty loop: TIME \ \
MACRO THE " [ ALSO \ ] \ [ PREVIOUS ] "

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Forth Dimensions XIX/2
Another simple macro with two parameters. For the Search-Order Extension word set.

The is used like THE EDITOR I or THE FORTH I, where the first parameter is a vocabulary, and the second is a word in that vocabulary.

MACRO H: " <hex> \ </hex> "

Figure Four

MACRO TIME " :: N 0 COUNTER >R DO \ \ LOOP R> TIMER CR ;; "

Figure Five

VARIABLE Temp

: <hex> ( -- ) BASE @ Temp ! HEX ;

: </hex> ( -- ) Temp @ BASE ! ;

MACRO LINES> " FALSE BEGIN ?lines>? WHILE "

MACRO ITEM> " >R FALSE BEGIN R> ?node@? WHILE DUP >R CELL+ "

MACRO ITERATE " FALSE REPEAT DROP "

To understand the next set of definitions, here are some examples of its use.

First some useful preliminary definitions. [See Figure Six.]

?text is to .text as? is to ...

Given a list, we will want to "list" its items. So we go through the list, displaying every item. [Figure Seven]

Count the number of items in a list. [Figure Eight]

List items in Some-List that begin with "ANS" using a nonce word. [Figure Nine]

The definitions of ITEM> "item-search" and ITERATE are given in Figure Ten.

ITEM> and ITERATE are macros and expand to the code shown in Figure Eleven.

This gives us a wrapper for doing things with the items of a list. [Figure Twelve]

To search a list, see Figure Thirteen.

The ... represents what you do with an item, leaving a flag on the stack—true to quit or false to continue.

After REPEAT there will be zero on the stack, if you went all the way through the list. If you quit before the end of the list, the address of the node where you quit will be on the stack.

The simplest use is to see whether a string is an item in a list [Figure Fourteen].

Used to change the BASE to hex at run time for the next word only. It needs supporting definitions like the ones in Figure Five, which will be explained in later articles.

(Next article: "Ordered Lists.")

For nonce word and macro see Tool Belt #1 and #2.
End of definition

At the end of the definition, the final word, the semi-colon, or end-code will not be indented, and will be at the left-hand end of the line. This ensures that the ends of definitions can be found. It also helps when code is added to the end of a word, by avoiding the possibility of having several semi-colons at or near the end of the word.

: WORD1 \ n1 n2 - n3 ; function to ...
  ...
  ...
;
CODE WORD2 \ n1 n2 - n3 ; function to ...
  ...
  ...
END-CODE

Immediate Declaration

If a word is to be made IMMEDIATE, the word to make it so should appear just after the semi-colon or END-CODE:

: WORD1 \ n1 n2 - n3 ; function to ...
  ...
  ...
  \ IMMEDIATE

If the word were to be placed on the line following the end of the definition, though legal, there would be a possibility of another word being inserted between the two, and the first word then losing its immediate or public status.

Comments

The function of a comment is to explain why, not what: Comments are written for people, not just the original programmer. Sometimes it hurts to come back to code you wrote a few years ago. From observation, code that was commented when it was written is more reliable than code that was commented afterwards.

The comments can even be written first using a PDL (program description language). Algol was first designed as a language for writing algorithms before it was implemented as a computer language. The move to literate programming and including the design within the code will lead to increasing use of tools that can process source files to produce a formatted output of the design and code using different fonts and layout rules.

MPE house rule

Comment as you write.

Definitions should be commented as well as possible. In a text file, there is no excuse for not having enough room to write comments, so comments should be used liberally. In a word, avoiding the possibility of having several semi-colons at or near the end of the word, the final word, the semi-colon, or end-code will not be indented, and will be at the left-hand end of the line. This ensures that the ends of definitions can be found. It also helps when code is added to the end of a word, by avoiding the possibility of having several semi-colons at or near the end of the word.

: WORD1 \ n1 n2 - n3 ; function to ...
  ...
  ...
  \ IMMEDIATE

Note that comments in a word body should be vertically aligned. Assuming that the paper is 80 columns wide, comments can often start at column 41, a convenient tab stop. Line comments are best started with the \ word—comment to end of line. This is in preference to the ( word, which must be terminated with a )). This last is easily forgotten. These comments should not be on the stack-detail level, though this may be appropriate in certain cases. They should, however, give descriptive information on the state of the system at that point—describing the overall action of the line of code, of the phrase. Needless to say, comments should also be correct.

On a point of style, it is better if the editor inserts tabs between the code and the comment than a series of spaces. This leaves less tidying-up to do after small changes to a line of code. It also makes the source file more compact on disc and faster to load.

Defining Words

Defining words present a special case of definition. This is because, as the word breaks down into two parts, more care should be given to the indentation:

: WORDN \ n1 n2 - n3 ; function to ...
  ...
  ...
  \ CREATE
  \ defining portion
  ...
  \ lay down data
  \ DOES>> \ execution portion
  ...
  \ get the data ...
  ;

Microprocessor Engineering, Ltd.
Southampton, England
The CREATE and DOES> words should be indented to below the name of the word. The code in the CREATE and DOES> portions should then be indented by further spaces. The layout of DOES> and ; also applies to ;CODE and END-CODE. It is also often found useful to document the stack action of the relevant portion of the word on the line with the CREATE and DOES> words:

```
: WORDN  \ n1 ; ; n3 ; function class to ... 
CREATE \ n1 ; ; defining portion 
 ... \ lay down data 
DOES> \ ; n3 ; execution portion 
 ... \ get the data ... 

Control Structure Layout
Control structures should be laid out for ease of understanding, and to easily spot overlapping or incomplete structures. To this end, indenting and the use of many lines makes the layout easy. Again, there is no lack of space on a page, and this should be used to advantage.

Flags and Limits
As Forth uses a postfix notation, the flag used to control program flow is specified before the structure or test which uses it. The flag should be identified on the line immediately preceding the test which will use it, as should loop limits:

```
VAR @ \ get flag 
IF \ if set ... 
... ENDIF

VAR @ 0 \ make loop limits 
DO \ for each ... 
... LOOP

VAR1 @ VAR2 @ AND \ we need these because ... 
VAR3 @ OR \ or this because ... 
IF 
... ENDIF

Indenting
For ease of reading, the start and end of a control structure should be placed on lines by themselves. This makes them easy to spot—for presence or absence. Modern editors with automatic colouring such as Ed4Windows, WinEdit, and CodeWright can do this automatically for Forth. The code within the structure should then be indented by a uniform amount, normally two spaces:

```
DO I .LOOP

The contrary view is that most bugs in code appear at structure and procedure boundaries.

At the end of a control structure, the structure termination word will be without indentation and back below the start of the structure, ensuring that starts and ends of structures are vertically aligned, so that it is easy to see an unbalanced structure or piece of code. See above for examples.

The multiple exit control structures introduced by ANS Forth are deprecated at MPE because their intention is to allow the user to associate several exit conditions with exit actions. However, the ANS format separates these visually, leaving a horrible job for program maintenance. A simple extension to CASE ... ENDCASE provides the visual match.

```
CASE \ description needed 
xx OF ... ENDOF \ case 1 
yy OF ... ENDOF \ case 2 
zz OF ... \ big case 3 
... \ consider factoring 
ENDOF 
... \ default 
ENDCASE

Short Control Structures
If the code within a control structure is very short, then it is good practice to leave the start and end of the structure on one line, with the body of the structure. However, what constitutes a short structure is very subjective.

```
DO I .LOOP

Note that there is more than one space between the DO and the I . and again to the LOOP. This helps the code to retain phrasing.

The contrary view is that most bugs in code appear at structure and procedure boundaries. These boundaries need to be made more visible, even if costs a few more lines on the screen.
Layout of Code Definitions

The layout of code definitions will be slightly different from the layout of high-level definitions. For a start, the layout will be more vertical than the corresponding high-level code. If a word is being defined, the top line of the definition will reflect that of any other word—i.e., it will have a stack comment and a brief description. If a label is being defined, then there may not be a stack effect, but there will still be a brief description of the function of the procedure or sub-routine. The code that then follows may be very vertical, or may be phrased more:

```forth
CODE WORD1 \ n1 - n2 ; word to ...
  MOV AX, BX
  ADD BX, # 03
  XCHG BP, SP BP INC XCHG BP, SP ...
END-CODE
```

Of course, there will still be plenty of in-line comments. Where code is being converted from a conventional assembler, it may be useful to retain the common tabbed layout of many assembler programmers. This also makes it easier for assembler programmers to read the Forth assembler. In most cases, ease of reading or writing code leads to reliability.

```forth
CODE WORD1 \ n1 - n2 ; word to ...
  MOV AX, BX \ BX=TOS, so get n1 from TOS
  ADD BX, # 03 \ this is the increment to...
  XCHG BP, SP \ swap stacks in order to
  PUSH AX \ hold this out of the way
  XCHG BP, SP \ for later ...
END-CODE
```

Data Structure Layout

Data structures should be laid out in a consistent fashion, not unlike the layout of definitions. However, there will be certain differences.

Where several similar items are being defined in one go, only one stack comment is required for the block. This should be at the start of the line above the items:

```forth
\ - addr ; the variables for input data
VARIABLE BILL \ contains ...
VARIABLE BEN \ defines the ...
```

Constants

Constants require a value as part of their definition. This value should appear at the left-hand end of the line. If several constants are being defined at one time, the words CONSTANT should line up vertically.

```forth
\ - n ; constants for destinations
3 CONSTANT BILL \ constant for ...
23 CONSTANT BEN \ constant for ...
```

It is good practice to define all constants in one place in the file, or in one file in the set. See the earlier section on the layout of a file.

Variables

Variables should be defined at the left-hand end of the line, and should be followed by an appropriate comment. A general stack comment may precede the whole block of variables:

```forth
\ - addr ; variables
VARIABLE BILL \ contains ...
VARIABLE BEN \ defines the ...
```

If the variables are to be pre-initialised to anything other than zero, the initialisation value should follow the definition of the variable:

```forth
DECIMAL
VARIABLE BILL 25 BILL ! \ contains ...
VARIABLE BEN \ contains ...
34 BEN ! \ default to 34 because ...
```

The use of program initialisation procedures has much to recommend it. It is surprising how often an application works after first being compiled, but not when run a second time. This situation is usually caused by the program not defining its required state within the initialisation code.

Buffers

A buffer may be defined and require more than one or two bytes of dictionary space. This space may be pre-initialised, or it may be a scratch area, or otherwise filled by the application. The buffer should be defined and any pre-initialisation should immediately follow its definition:

```forth
CREATE BILL \ the ...
10 ALLOT \ for a PC Forth
"" this" BILL $MOVE \ preset to 'this'
```

```forth
VARIABLE BILL
10 ALLOT-RAM \ for a ROM/RAM target
```

Tables

A table may be predefined—such as a look-up table. This will usually be created in the dictionary, and will include its data. The important point is consistency and ease of reading:

```forth
CREATE TABLE \ - addr ; bit-pattern table
  1 C, 2 C, 4 C, 8 C, \ b0..b3
  16 C, 32 C, 64 C, 128 C, \ b4..b7
```

Note that the numbers and the commas line up. This makes reading easy.

To be continued in the next issue...
Adaptive Digital Filters

Introduction

This month, we turn to the topic of adaptive digital filters. Just as we improved our ability to apply controls to external processes by introducing a closed loop, we will improve our filtering by closing the loop and using the filter output to modify the filter in real-time.

Adaptive filters can either be IIR (Infinite Impulse Response) or FIR (Finite Impulse Response). There are also non-linear filter types, but we will not consider them here. Generally, the form of the filter remains fixed as it runs, but a special output channel of the filter (usually called the error output) is fed into a process which recalculates the filter coefficients in order to produce an output that is closer to the desired form (see Figure One). If it is properly designed, the result of such a filter is an output that enhances the desired component over a wide range of conditions.

As with ordinary digital filters, a vast amount of written material is available on the topic of adaptive filters. We will only give a limited introduction to the topic here. You should also be aware that a proper treatment of adaptive filters requires a good deal of calculus and linear algebra; I will mostly spare you all the math, in order to provide an introduction to the types of adaptive filters and their applications.

What Can Go Wrong

When you think about it, adaptive filters are a little scary. They process a signal and then decide to adjust themselves in order to alter the signal's characteristics. How can you be sure the filter makes the right decision and doesn’t make things worse? Mathematically, what we are concerned with here is the stability of the filter. The question of the filter’s stability arises because of two related properties of adaptive filters. First, the feedback of an error term makes the filter behave as a differential equation. It is perfectly valid for a differential equation to have an unstable solution. If we have happened to design an adaptive filter whose underlying differential equation has an unstable solution, we are in trouble. Second, since we are implementing our filter in the discrete time domain, the filter implementation becomes a finite difference approximation to the differential equation. Finite difference equations have their own stability constraints, such that it is possible to have numerically unstable solutions even when the analytic solution is stable.

Analyzing the stability of an adaptive filter tends to be a deep exercise in mathematics (involving such things as Laplace transforms and numerical analysis). Having a mathematical software package such as Mathematica or Macsyma helps a great deal, but often, in the real world, such filters are just empirically tested. Hopefully, a proper analysis is used for filters that will be installed into safety-critical systems.

General Principles

Unlike nonadaptive filters, which just pass their input data through the filtering mechanism, adaptive filters also apply a system model. The estimate of the system is compared against the filter output to create an error signal; this error signal is then used in a cost function of some kind, which indicates how well (or badly) we are doing with the current parameters of the filter.

The Kalman Filter

The simplest error signal we can generate is just the difference between what we are getting out of the filter, \( \hat{x}_t \), and what we expect to see, \( x_t \).

\[ e_t = x_t - \hat{x}_t \tag{1} \]

For many problems, an overshoot is just as bad as an undershoot, so we can use the mean square error as a cost function. There are lots of other cost functions we could use, but this one is particularly convenient mathematically. The earliest adaptive filter derived from this error and cost function is the Wiener filter. Unfortunately, it is in FIR form and has coefficients that extend infinitely back in time. Except for certain periodic systems, this filter is not very practical. The filter can be re-derived in IIR form—this is known as the Kalman filter. The discrete time, linear, form of this equation looks like,

\[ \dot{\hat{x}}_t = bKy_t + K_3z_t \tag{2} \]

\( b \) is a model of how the system goes from one time interval to the next. It is our best understanding of how the ideal system goes from a value at time \( t - 1 \) to a value at time \( t \). \( K_3 \) is the Kalman gain. It is not controlled by the measurements directly, but instead is determined by how good you think the model \( b \) is, compared to the quality of the observations.

\( z_t \) is called the innovation. It is an estimate of what you think the error will be at time \( t \), given a measurement at time \( t \), \( y_t \), and a prediction of \( x \) at time \( t \) based upon the best estimate of \( x \) at \( t - 1 \) extrapolated to time \( t \) by applying our model function, \( b \). The simplest example of how to calculate the innovation is,

\[ z_t = y_t - b\hat{x}_{t-1} \tag{3} \]

where \( H \) is a function that may be necessary to convert the components of \( x \) to the components of \( y \). (An example is the meteorological case of estimating the humidity—the \( x \)—based upon wet-bulb and dry-bulb temperature measurements—the \( y \). The \( H \) function would have one component that converts humidity to wet-bulb temperature, and one for the conversion to dry-bulb). In an application, the innovation is a known

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For more information, please visit www.taygeta.com.
function, like above, and the function $b$ is known. What is not known is the gain, $K$; this must be calculated in parallel with the model estimation. The time varying gain is where the adaptive nature of the Kalman filter expresses itself.

In order to determine the equation that gives us the gain function, we have to spend some time with optimal estimation theory. I will not spend the time on this here, but just show the result. In the scalar case, the gain function is:

$$K_t = \frac{Hb^2p_{t-1} + \sigma_y^2}{\sigma_v^2 + H^2\sigma_b^2 + H^2b^2p_{t-1}} \quad (4)$$

Two of the new quantities, $\sigma_y^2$ and $\sigma_b^2$, are the noise or error variances for the model, $b$, and the measurements, respectively. The first is a statement about how good you believe the model of the system is. The second quantifies how good you think your measurements are. Both of these quantities are presumed to be known. The third quantity, $p_{t-1}$, is the error covariance of the filter; it gives effectively the error bars of the current model output. This can be calculated given the gain,

$$p_t = \frac{1}{H}\sigma_y^2K_t \quad (5)$$

To use the filter, each time a new observation ($y$) becomes available, we calculate (3) and (4), and then use that information in (2) and (5).

The Kalman filter is frequently applied to systems where $x$ and $y$ are multi-channel or vector systems. In this case, the equations (2) through (5) are rewritten as matrix equations.

**The LMS Adaptive Filter**

An important general form for adaptive filters is the Least Mean Squares (LMS) filter. This type of adaptive filter is easy to implement and is widely used because of this. The filter uses a gradient search technique in order to determine how to improve the filter coefficients. This gradient search is also the reason for the basic weakness of the filter: it has a relatively slow convergence rate.

Suppose we consider the $N$th-order FIR filter,

$$y_n = h(1)x_{n-1} + h(2)x_{n-2} + \ldots + h(N)x_{n-N} \quad (6)$$

the filter error is,

$$e_n = y_n - y \quad (7)$$

With the LMS filter, we adjust the values of the coefficients, $h$, proportional to the error, $e$,

$$h(n) = h(n-1) + 2\mu e_n \quad (8)$$

where $\mu$ is a “learning factor” which controls how strongly the error is weighted. This equation is the consequence of the requirement to minimize the mean square value of $e$, hence the name of the filter.

**The RLS Filter**

The Recursive Least Squares (RLS) filter is, in theory, a better filter than the LMS filter, but it is not used as often as it could be because it requires more computational resources. (The LMS filter requires $2N+1$ operations per filter update, whereas the RLS filter requires $2.5N^2+4N$). It has been successfully used in system identification problems and in time series analysis, where its real-time performance is not an issue.

There are several forms of the RLS filter, but all of them are similar to the Kalman filter, in that a covariance is calculated along with the regular filter output. This covariance is then used to calculate a new filter gain.

Listing One shows a Forth implementation of the square-root form of the filter. This form of the filter calculates the square root of the covariance, instead of the covariance directly, in order to improve the numerical stability of the filter. The filter has two tunable parameters: $\sigma_v$ is the square root of the variance of the input data, and $\lambda$ is a weighting coefficient that controls how strongly to perturb the coefficients for a given filter error. These two coefficients need to be carefully considered in order to ensure that the resulting filter is stable. Note that, in this example, the filter error is just the straight difference between the input sample and the convolution of the filter weights and the previous inputs; this could be made to be different for different types of problems.

**Application Example—Echo Cancellation**

As example of how to apply an adaptive filter to a real-world problem, let’s consider the problem of echo cancellation. In this problem, there is a signal we want to recover, $x$, that we measure—but it is contaminated with multiple copies of itself. These extra copies overlap with unknown delay times and amplitudes. Mathematically, the measurements consist of the series, $y$, which is the convolution of the clean signal $x$ and the unknown reflection coefficient series $h$,

$$y = h \ast x \quad (9)$$

The goal of the filter is to estimate the unknown reflection coefficients $h$.

This type of problem is sometimes solved by direct mathematical inversion of the known quantities $x$ and $y$. In the engineering literature, this is sometimes called the system identification problem; in geophysics, it’s known as deconvolution. An adaptive filter can be used to solve this problem in real-time, but it takes some amount of time for it to converge (particularly if the signal power is low). The adaptive filter approach will also work when $h$ is slowly varying with time; this is something standard deconvolution does not work well with.

We can use any adaptive filter for this; if we use an LMS filter, the coefficients will get adapted by the application of equation (8). If we do this for the echo cancellation problem, we have to replace $e_n$ in that equation with the difference between the convolution of the reference signal, $x$ with the coefficients $h$ and the actual filter input data $s$:

$$e_n \leftarrow s - y \quad (10)$$

**Conclusion**

Take a look at where we have been in this series; we have considered how to generate signals that can be used to manipulate the outside world, how to measure how the outside world is responding to our signals, and how to create a closed-loop controller to make the external system behave in the particular manner we desire. In recent columns, we have looked at how to handle signals that are time varying and how to modify those signals with filters. This time, we enhanced our filtering ability to be able to adaptively modify a signal.

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Next time, I am going to shift gears a bit and spend some time considering the software development process itself. Please don’t hesitate to contact me through Forth Dimensions or via e-mail if you have any comments or suggestions about this or any other Forthware column.

References

Listing One.

\ rls.fth  An implementation of the square root form of an RLS adaptive filter
\ This is an ANS Forth program requiring:
\  1. The Floating point word set
\  2. The Forth Scientific Library Array words
\  There is an environmental dependency in that it is assumed
\  that the float stack is separate from the parameter stack
\ This code is released to the public domain September 1996 Taygeta Scientific Inc.
\ $Author: skip $
\ $Workfile: rls.fth $
\ $Revision: 1.1 $
\ $Date: 16 Jul 1997 23:19:58 $
\ %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
\ the Array words from the Forth Scientific Library
\ $" /usr/local/lib/forth/fsl-util.fth" INCLUDED
\ %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

8 CONSTANT N  \ the filter order
FVARIABLE sigma \ square root of the initial data variance
FVARIABLE lambda \ weighting coefficient
FVARIABLE Err  \ filter error output
FVARIABLE Gain  \ filter gain
N Float Array K{ \ filter gain components
N Float Array Phi{ \ filter data
N Float Array H{ \ filter coefficients
\ internal filter coefficient data
FVARIABLE y_old
N Float Array F{  \ and D{ are actually diagonal matrices such that the
N Float Array V{ \ filter covariance is U * D * Transpose( U )
N Float Array U{  
N Float Array D{
: F+! ( addr -- , F: x -- ) \ increment a Float variable
  DUP F@ F+ F! 
};
: initialize ( -- , F: sigma lambda -- ) \ one time initialization
lambda F!
N 0 DO
  0.0E0 Phi{ I } F!
  0.0E0 H{ I } F!
  1.0E0 U{ I } F!
  FDUP D{ I } F!
LOOP
sigma F!
;
: )shuffle ( x{ -- } \ slide all the data values down by one
  1 N 1- DO
    DUP I 1- } F@ DUP I } F!
  -1 +LOOP
DROP
;
: do_filter ( -- , F: yn -- ) \ apply the RLS filter on the current data
  0.0E0
N 0 DO
  Phi{ I } F@ H{ N 1- I - } F@ F* F+
LOOP
FNEGATE FOVER F+ \ err
Err F!
y_old F!
;
: preset ( -- ) \ initial filter setup for each step
  N 0 DO
    U{ I } F@ Phi{ I } F@ F*
    F{ I } F!
    D{ I } F@ F{ I } F@ F* V{ I } F!
LOOP
V{ 0 } F@ K{ 0 } F!
V{ 0 } F@ F{ 0 } F@ F* lambda F@ F+ ( -- , F: alpha )
D{ 0 } F@ FOVER F/ D{ 0 } F! \ d(0) = d(0)/alpha
Alpha{ 0 } F!
;
: adjust_gain ( -- ) \ apply RLS adaptive scheme to adjust the gain
  preset
  N 1 DO
  \ d[i] = d[i]*alpha/lambda
    D{ I } F@ Alpha{ I 1- } F@ F* lambda F@ F/ D{ I } F!
  \ calculate new alpha
    V{ I } F@ F{ I } F@ F* Alpha{ I 1- } F@ F+
    FDUP Alpha{ I } F!
  \ finish update of D, d[i] = d[i] / new alpha
    D{ I } F@ FSWAP F/ D{ I } F!
  \ update U keeping a copy of the old value
    F{ I } F@ Alpha{ I 1- } F@ F/ FNEGATE
    K{ I 1- } F@ F* U{ I } F@
    FSWAP FOVER F+ U{ I } F! ( -- , F: uold )
  \ update the gain
    V{ I } F@ F* K{ I 1- } F@ F+
    K{ I } F!
LOOP
\ compete the Gain update
N 0 DO
  K( I ) F@ Alpha( I ) F/ F K( I ) F!
LOOP
;

: adjust_coefficients ( -- )
  Err F@
  N 0 DO
    FDUP K( I ) F@ F*
    H I } F+!
  LOOP
FDROP
Phi{ } shuffle
y_old F@ Phi{ 0 } F!

: rls_filter ( -- , F: y -- yf ) \ do RLS filter for one data point
  do_filter
  adjust_gain
  adjust_coefficients
  Err F@

\ ==...An implementation an LMS adaptive filter
\ This is an ANS Forth program requiring:
\  1. The Floating point word set
\  2. The Forth Scientific Library Array words
\ There is an environmental dependency in that it is assumed
\  that the float stack is separate from the parameter stack
\ This code is released to the public domain September 1996 Taygeta Scientific Inc.
\ $Author: skip$
\ $Workfile: lms.fth$
\ $Revision: 1.0$
\ $Date: 17 Jul 1997 02:57:08$
\ \ ALIGN
\ \ the Array words from the Forth Scientific Library
S" /usr/local/lib/forth/fsl-util.fth" INCLUDED
\ \ ALIGN
8 CONSTANT N \ the filter order
8 CONSTANT M \ the running mean block size
FVARIABLE beta \ weighting coefficient

M N MAX CONSTANT Ny
M Float Array Err{ \ filter error output
Ny Float Array Y{ \ filtered data
N Float Array A{ \ filter coefficients
N Float Array X{ \ input data

: F+! ( addr -- , F: x -- ) \ increment a Float variable
  DUP F@ F+ F!

;
initialize ( -- , F: beta -- ) \ one time initialization
2.0E0 F* beta F!
M 0 DO
 0.0E0 Err( I ) F!
LOOP
N 0 DO
 0.0E0 A( I ) F!
 0.0E0 X( I ) F!
LOOP
Ny 0 DO
 0.0E0 Y( I ) F!
LOOP

; ) shuffle ( n x( -- ) \ slide all the data values down by one
1 ROT 1- DO
  DUP I 1- } F@ DUP I } F!
-1 +LOOP
DROP

; do_filter ( -- , F: x -- ) \ apply the LMS filter on the current data
N X( } shuffle
FDUP X( 0 } F!
0.0E0
N 0 DO
  A( N 1- I - ) F@ X( I ) F@ F* F+
LOOP
Ny Y( } shuffle
FDUP Y( 0 } F!
FNEGATE F+ \ err
N Err( } shuffle
Err( 0 } F!

; get_adjustment ( k -- , F: -- x ) \ calculate adjustment
NEGATE
0.0E0
M 0 DO
  Err( OVER I + ) F@ X( OVER I + ) F@ F* F+
LOOP
DROP
Beta F@ F* M S>D D>F F/

; lms_adapt ( -- ) \ apply LMS adaptive scheme
N 0 DO
  I get_adjustment
  A( I ) F+!
LOOP

; lms_filter ( -- , F: y -- yf ) \ do LMS filter for one data point
do_filter
lms_adapt
Y( 0 } F@ Err( 0 } F@ F-

\ ---------------------------------------------------------------------
0.85E0 initialize
\ ---------------------------------------------------------------------
Yet another Forth objects package

After criticizing the Neon model in the last issue, here I present (and expose to criticism) a model that I find better, and its implementation. Its properties (most are advantages, in my opinion) are:

• It is straightforward to pass objects on the stack. Passing selectors on the stack is a little less convenient, but possible.
• Objects are just data structures in memory, and are referenced by their address. You can create words for objects with normal defining words like constant. Likewise, there is no difference between instance variables that contain objects and those that contain other data.
• Late binding is efficient and easy to use.
• It avoids parsing, and thus avoids problems with state-smartness and reduced extensibility; for convenience, there are a few parsing words, but they have non-parsing counterparts. There are also a few defining words that parse. This is hard to avoid, because all standard defining words parse (except :name); however, such words are not as bad as many other parsing words, because they are not state-smart.
• It does not try to incorporate everything. It does a few things and does them well (in my opinion). In particular, I did not intend to support information hiding with this model (although it has features that may help); you can use a separate package for achieving this.
• It is layered; you don’t have to learn and use all features to use this model. In particular, the features discussed after the section “Programming Style” are optional and independent of each other.
• An implementation in ANS Forth is available.

I have used the technique on which this model is based to implement Gray [ertl89] [ertl97]; we have also used this technique in Gforth.

This paper assumes (in some places) that you have read the paper on structures. [Editor’s note: due to space constraints, the Structures paper will appear in the subsequent issue.]

Why Object-Oriented Programming?

Often we have to deal with several data structures (objects), that have to be treated similarly in some respects, but differ in others. Graphical objects are the textbook example: circles, triangles, dinosaurs, icons, and others, and we may want to add more during program development. We want to apply some operations to any graphical object, e.g., draw for displaying it on the screen. However, draw has to do something different for every kind of object.

We could implement draw as a big CASE control structure that executes the appropriate code depending on the kind of object to be drawn. This would be not be very elegant, and, moreover, we would have to change draw every time we add a new kind of graphical object (say, a spaceship).

What we would rather do is: When defining spaceships, we would tell the system: “Here’s how you draw a spaceship; you figure out the rest.”

This is the problem all systems solve that (rightfully) call themselves object-oriented, and the object-oriented package I present here also solves this problem (and not much else).

Terminology

This section is mainly for reference, so you don’t have to understand all of it right away. I (mostly) use the same Smalltalk-inspired terminology as [mckewan97]. In short:

class
A data structure definition with some extras.

object
An instance of the data structure described by the class definition.

instance variables
Fields of the data structure.

selector (or method selector)
A word (e.g., draw) for performing an operation on a variety of data structures (classes). A selector describes what operation to perform. In C++ terminology: a (pure) virtual function.

method
The concrete definition that performs the operation described by the selector for a specific class. A method specifies how the operation is performed for a specific class.

selector invocation
A call of a selector. One argument of the call (the top-of-stack) is used for determining which method is used. In Smalltalk terminology: a message (consisting of the selector and the other arguments) is sent to the object.

receiving object
The object used for determining the method executed by a selector invocation. In our model, it is the object that is on the TOS when the selector is invoked. (Receiving comes from Smalltalk’s message terminology.)

child class
A class that has (inherits) all properties (instance variables, selectors, methods) from a parent class. In Smalltalk termi-
Basic Usage

You can define a class for graphical objects like this:

```forth
object class
  "object" is the parent class
  selector draw ( x y graphical -- )
end-class graphical
```

This code defines a class graphical with an operation draw. We can perform the operation draw on any graphical object, e.g.:

```
100 100 t-rex draw
```

where t-rex is a word (say, a constant) that produces a graphical object.

How do we create a graphical object? With the present definitions, we cannot create a useful graphical object. The class graphical describes graphical objects in general, but not any concrete graphical object type (C++ users would call it an abstract class); e.g., there is no method for the selector draw in the class graphical.

For concrete graphical objects, we define child classes of the class graphical, e.g.:

```forth
graphical class
  "graphical" is the parent class
  cell% field circle-radius

:noname ( x y circle -- )
  circle-radius @ draw-circle ;
overrides draw

:noname ( n-radius circle -- )
  circle-radius ;
overrides construct

end-class circle
```

Here we define a class circle as a child of graphical, with a field circle-radius (which behaves just like a field in the structure package); it defines new methods for the selectors draw and construct (construct is defined in object, the parent class of graphical).

Now we can create a circle on the heap (i.e., allocated memory) with

```
50 circle heap-new constant my-circle
```

heap-new invokes construct, thus initializing the field circle-radius with 50. We can draw this new circle at (100,100) with

```
100 100 my-circle draw
```

Note: You can invoke a selector only if the object on the TOS (the receiving object) belongs to the class where the selector was defined or to one of its descendants; e.g., you can invoke draw only for objects belonging to graphical or its descendents (e.g., circle). Immediately before end-class, the search order has to be the same as immediately after class.

The Object Class

When you define a class, you have to specify a parent class. So how do you start defining classes? There is one class available from the start: object. You can use it as the ancestor for all classes. It is the only class that has no parent. It has two selectors: construct and print.

Creating Objects

You can create and initialize an object of a class on the heap with heap-new (... class -- object) and in the dictionary (allocation with allot) with dict-new (... class -- object). Both words invoke construct, which consumes the stack items indicated by "..." above.

If you want to allocate memory for an object yourself, you can get its alignment and size with class-inst-size 28 (class -- align size). Once you have memory for an object, you can initialize it with init-object (... class object --); construct does only a part of the necessary work.

Programming Style

This section is not exhaustive.

In general, it is a good idea to ensure that all methods for the same selector have the same stack effect: when you invoke a selector, you often have no idea which method will be invoked, so, unless all methods have the same stack effect, you will not know the stack effect of the selector invocation.

One exception to this rule is methods for the selector construct. We know which method is invoked, because we specify the class to be constructed at the same place. Actually, I defined construct as a selector only to give the users a convenient way to specify initialization. The way it is used, a mechanism different from selector invocation would be more natural (but probably would take more code and more space to explain).

Class Binding

Normal selector invocations determine the method at run time, depending on the class of the receiving object (late binding).

Sometimes we want to invoke a different method. E.g., assume you want to use the simple method for printing objects, instead of the possibly long-winded print method of the receiver class. You can achieve this by replacing the invocation of print with [bind] object print in compiled code, or bind object print in interpreted code. Alternatively, you can define the method with a name (e.g., print-object), and then invoke it through the name. Class binding is just a (often more convenient) way to achieve the same effect; it avoids name clutter and allows you to invoke methods directly without naming them first.
A frequent use of class binding is this: When we define a method for a selector, we often want the method to do what the selector does in the parent class, and a little more. There is a special word for this purpose: parent selector is equivalent to bind parent selector, where parent is the parent class of the current class. E.g., a method definition might look like:

```forth
dup [ parent ] foo
\ do parent's foo on the receiving object
... \ do some more
; overrides foo
```

[mckewan97] presents class binding as an optimization technique. I recommend not using it for this purpose unless you are in an emergency. Late binding is pretty fast with this model anyway, so the benefit of using class binding is small; the cost of using class binding where it is not appropriate is reduced maintainability.

While we are at programming style questions: You should bind selectors only to ancestor classes of the receiving object. E.g., say, you know the receiving object is of class foo or its descendents; then you should bind only to foo and its ancestors.

### Method Conveniences

In a method, you usually access the receiving object pretty often. If you define the method as a plain colon definition (e.g., with :name), you may have to do a lot of stack gymnastics. To avoid this, you can define the method with m: ... ;m. E.g., you could define the method for drawing a circle with:

```forth
m: ( x y circle -- )
( x y ) this circle-radius @ draw-circle ;m
```

When this method is executed, the receiver object is removed from the stack; you can access it with this (admittedly, in this example the use of m: ... ;m offers no advantage). Note that I specify the stack effect for the whole method (i.e., including the receive object), not just for the code between m: and ;m. You cannot use exit in m: ... ;m—instead, use exitm!

You will frequently use sequences of the form this field (in the example above: this circle-radius). If you use the field only in this way, you can define it with inst-var and eliminate the this before the field name. E.g., the circle class above could also be defined with:

```forth
graphical class
  cell% inst-var radius
m: ( x y circle -- )
  radius @ draw-circle ;m
overrides draw
m: ( n-radius circle -- )
  radius ! ;m
overrides construct
```

1. Moreover, for any word that calls catch and was defined before loading objects.fs, you have to redefine it like I redefined catch:

```forth
: catch this >x catch r> to-this ;
```

### Interfaces

In this model, you can only call selectors defined in the class of the receiving objects or in one of its ancestors. If you call a selector with a receiving object that is not in one of these classes, the result is undefined; if you are lucky, the program crashes immediately.

Now consider the case when you want to have a selector (or several) available in two classes: You would have to add the selector to a common ancestor class, in the worst case to object. You may not want to do this, e.g., because someone else is responsible for this ancestor class.

The solution for this problem is interfaces. An interface is a collection of selectors. If a class implements an interface, the selectors become available to the class and its descendents. A class can implement an unlimited number of interfaces. For the problem discussed above, we would define an

```forth
end-class circle
radius can only be used in circle and its descendents classes, and inside m: ... ;m.

You can also define fields with inst-value, which is to inst-var as value is to variable. You can change the value of such a field with [ to-inst]. E.g., we could also define the class circle like this:

```forth
graphical class
  inst-value radius
m: ( x y circle -- )
  radius draw-circle ;m
overrides draw
m: ( n-radius circle -- )
  [ to-inst] radius ;m
overrides construct
end-class circle
```
interface for the selector(s), and both classes would implement the interface.

As an example, consider an interface storage for writing objects to disk and getting them back, and a class `foo` that implements it. The code for this would look like:

```forth
2dup selector-interface @ (object selector-body object interface-offset )
swap object-map @ + @ (object selector-body map )
swap selector-offset @ + @ execute
```

parent, and a copy of the parent's method map. Defining new fields extends the size and alignment; likewise, defining new selectors extends the method map. `overrides` just stores a new XT in the method map at the offset given by the selector.

Class binding just gets the XT at the offset given by the selector from the class' method map and `compile`s it (in the case of `bind`).

I implemented this as a value. In an `m: ... ;m` method, the old `this` is stored to the return stack at the start and is restored at the end; and the object on the TOS is stored to this. This technique has one disadvantage: If the user does not leave the method via `;m`, but via `throw` or `exit`, this is not restored (and `exit` may crash). To deal with the throw problem, I have redefined `catch` to save and restore this; the same should be done with any word that can catch an exception. As for exit, I simply forbid it (as a replacement, there is `exitm`).

```forth
inst-var is just the same as field, with a different `does>` action:
@ this +
```

Similar for `inst-value`.

Each class also has a wordlist that contains the words defined with `inst-var` and `inst-value`, and its protected words. It also has a pointer to its parent. `class` pushes the wordlists of the class and all its ancestors on the search order, and `end-class` drops them.

An interface is like a class without fields, parent, and protected words; i.e., it just has a method map. If a class implements an interface, its method map contains a pointer to the method map of the interface. The positive offsets in the map are reserved for class methods; therefore, interface map pointers have negative offsets. Interfaces have offsets that are unique throughout the system, unlike class selectors, whose offsets are only unique for the classes where the selector is available (invocable).

This structure means that interface selectors have to perform one indirection more than class selectors to find their method. Their body contains the interface method pointer offset in the class method map, and the method offset in the interface method map. The `does>` action for an interface selector is, basically [as in Figure One] where `object-map` and `selector-offset` are first fields and generate no code.

As a concrete example, consider the following code:

```forth
interface
selector if1sel1
selector if1sel2
end-interface if1

object class
if1 implementation
selector cr1sel1
cell% inst-var cr1iv1
'ml overrides construct
```

2. This is Self [chambers&ungar89] terminology; in C++ terminology: virtual function table.
I end-class
assuming structure for object) is shown
create
last issue with the properties presented here.
compare the properties of the Neon model presented in the
ever, it is not really about object-oriented programming, be-
two systems that have the implementation using method
maps in common with the package discussed here.

extensions;
ject (like this in my model): The active object is not only
object of every selector invocation; you have to change the
changes more or less implicitly at m
ready; on the other hand, the explicit change is absolutely
necessary in that model because, otherwise, no one could ever
change the active object.
wordlists)
and overloading resolution (by keeping names in various
uses parsing and state-smart objects and classes for resolving
the selector and determines the method from this. If the se-
overloading and for early binding: the object or class parses
explicit changing (with

Fields are always accessed through the active object. The big
disadvantage of this model is the parsing and the state-smart-
ness, which reduces extensibility and increases the opportu-
nities for subtle bugs; essentially, you are only safe if you never
tick or postpone an object or class.

The model of [zs6ter96] makes heavy use of an active ob-
ject (like this in my model): The active object is not only
used for accessing all fields, but also specifies the receiving
object of every selector invocation; you have to change the
active object explicitly with {...}, whereas in my model it
changes more or less implicitly at m: ... ;m. Such a change at
the method entry point is unnecessary with the [zs6ter96]
model, because the receiving object is the active object al-
ready; on the other hand, the explicit change is absolutely
necessary in that model because, otherwise, no one could ever
change the active object.
The model of [paysan94] combines information hiding
and overloading resolution (by keeping names in various
wordlists) with object-oriented programming. It sets the ac-
tive object implicitly on method entry, but also allows ex-
licit changing (with >o ... oo or with with ... endwith). It
uses parsing and state-smart objects and classes for resolving
overloading and for early binding: the object or class parses
the selector and determines the method from this. If the se-
lector is not parsed by an object or class, it performs a call to
the selector for the active object (late binding), like [zs6ter96].
Fields are always accessed through the active object. The big
disadvantage of this model is the parsing and the state-smart-
ness, which reduces extensibility and increases the opportu-
nities for subtle bugs; essentially, you are only safe if you never
tick or postpone an object or class.

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References
[chambers&ungar89] Craig Chambers and David Ungar.
"Customization: Optimizing compiler technology for Self, a
dynamically-typed object-oriented programming language. In
SIGPLAN '89 Conference on Programming Language Design and

pers/ertl89.ps.Z "GRAY - ein Generator für rekursiv absteigende
Ybersetzer." Praktikum, Institut für Computersprachen,
Technische Universität Wien, 1989. In German.

pers/ertl97.ps.gz "GRAY - ein Generator für rekursiv absteigende

[mckewan97] Andrew McKewan. "Object-oriented programming

[paysan94] Bernd Paysan. "Object oriented bigFORTH." Vierte
Dimension, 10 no. 2, 1994. An implementation in ANS Forth
is available at http://www.informatik.tu-muenchen.de/
paysan/oof.zip.

[pountain87] Dick Pountain. Object-Oriented Forth. Academic

[rodriguez&poehlman96] Bradford J. Rodriguez and W. F. S.
Poehlman. "A survey of object-oriented Forths." SIGPLAN No-
tices, pages 39–42, April 1996.

[zs6ter96] András Zsótér. "Does late binding have to be slow?"
Forth Dimensions, 18 no. 2, 1996. An implementa-
tion in ANS Forth is available at http://www.forth.org/fig/
oof.html.

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Glossary

bind ( ... "class" "selector" -- ... )
Execute the method for selector in class.

<bind> ( class selector-xt -- xt )
xt is the method for the selector selector-xt in class.

bind' ( "class" "selector" -- xt )
xt is the method for selector in class.

[ bind] ( compile-time: "class" "selector" -- )
( run-time: ... -- ... )
Compile the method for selector in class.

class ( parent-class -- align offset )
Start a new class definition as a child of parent-class. align offset are for use by field, etc.

class->map ( class -- map )
map is the pointer to class's method map; it points to the place in the map to which the selector offsets refer (i.e., where object-maps point).

class-inst-size ( class -- addr )
Used as class-inst-size 28 ( class -- align size ), gives the size specification for an instance (i.e., an object) of class.

class-override! ( xt sel-xt class-map -- )
xt is the new method for the selector sel-xt in class-map.

construct ( ... object -- )
Initializes the data fields of object. The method for the class object just does nothing ( object -- ).

current' ( "selector" -- xt )
xt is the method for selector in the current class.

[ current] ( compile-time: "selector" -- )
( run-time: ... -- ... )
Compile the method for selector in the current class.

current-interface ( -- addr )
This variable contains the class or interface currently being defined.

dict-new ( ... class -- object )
allot and initialize an object of class class in the dictionary.

drop-order ( class -- )
Drops class's wordlists from the search order. No check is made whether class's wordlists are actually on the search order.

derend-class ( align offset "name" -- )
name execution: -- class
Ends a class definition. The resulting class is class.

derend-class-name ( align offset -- class )
Ends a class definition. The resulting class is class.

derend-interface ( "name" -- )
name execution: -- interface
Ends an interface definition. The resulting interface is interface.

derend-interface-name ( -- interface )
Ends an interface definition. The resulting interface is interface.
exitm ( -- )
exit from a method; restore old this.

heap-new ( ... class -- object )
allocate and initialize an object of class class.

implementation ( interface -- )
The current class implements interface. I.e., you can use all
selectors of the interface in the current class and its descendents.

init-object ( ... class object -- )
initializes a chunk of memory (object) to an object of class
class; then performs construct.

inst-value
( align1 offset1 "name" -- align2 offset2 )
nname execution: -- w
w is the value of the field name in this object.

inst-var
( align1 offset1 align size "name" -- align2 offset2 )
nname execution: -- addr
addr is the address of the field name in this object.

interface ( -- )
starts an interface definition.

;m ( colon-sys -- ) ( run-time: -- )
end a method definition; restore old this.

m: ( -- xt colon-sys ) ( run-time: object -- )
start a method definition; object becomes new this.

method ( xt "name" -- )
nname execution: ... object -- ...
creates selector name and makes xt its method in the cur-
rent class.

object ( -- class )
The ancestor of all classes.

overrides ( xt "selector" -- )
replace default method for selector in the current class
with xt. overrides must not be used during an interface
definition.

[parent] ( compile-time: "selector" -- )
( run-time: ... object -- ... )
compile the method for selector in the parent of the cur-
rent class.

print ( object -- )
print the object. the method for the class object prints the
address of the object and the address of its class.

protected ( -- )
set the compilation wordlist to the current class’s wordlist

public ( -- )
restore the compilation wordlist that was in effect before the
last protected that actually changed the compilation wordlist.

push-order ( class -- )
add class’s wordlists to the search-order (in front).

selector ( "name" -- )
nname execution: ... object -- ...
creates selector name for the current class and its descen-
dents; you can set a method for the selector in the current
class with overrides.

this ( -- object )
the receiving object of the current method (a.k.a. active object).

<to-inst> ( w xt -- )
store w into the field xt in this object.

[to-inst] ( compile-time: "name" -- )
( run-time: w -- )
store w into field name in this object.

to-this ( object -- )
set this (used internally, but useful when debugging).

xt-new ( ... class xt -- object )
makes a new object, using xt ( align size -- addr ) to
get memory.

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