Dealer Maintenance Notes by JGM

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Preamble

While the user documentation for dealer is sufficient there is a lack of documentation for those who want to maintain or modify the program.

The original author is Hans van Staveren, Amsterdam, Holland , (circa 1990), the latest maintainer is Henk Uijterwaal circa 1999. There have not been many changes made to dealer in the last 20 years.

Dealer is now used by BBO to deal practice hands for its users.

Dealer was originally intended to just generate deals of interest for study, bidding practice, perhaps to analyze a line of play and so on. It was not, (and is still not) intended to generate hands for play in tournaments and such like. However it was (and is) such a useful program that many people have added functionality to it over the years. I, JGM, wanted to use it to experiment with different methods of hand evaluation. In order to do that I had to learn a fair bit about Dealer's structure and workings. What you read here is my humble attempt to document my findings in case someone else wants to modify Dealer even further.

I should at this time also state that none of the original authors have been involved in my attempt. If there are any errors in my description herein, they are all my own.

Conventions Used in this Document

When you see text in `Courrier New` font, that means the text is either input to, or output from the computer. Possibly it is a filename, or directory name.

When you see a line of `Courrier New` text that ends with a backslash (\) that means that the line as printed on the screen was too long to fit on the page and is continued on the next line. It does not mean that the backslash needs to be typed in, or will appear in the output.

Sometimes the text, or program name is highlighted with like so.

Overview

Dealer defines a 'grammar' of user commands in typical BNF form. The user prepares an 'input file' consisting of the instructions written in that grammar as to what kind of bridge deals he wants.

Dealer uses the yacc/bison tools to generate a parser that can process instructions written in that grammar. yacc/bison relies on a 'lexer', in the case of Linux, flex, to parse the user's input into tokens.

So the structure of dealer is made up of:

1) A grammar definition file, called defs.y in the original distribution. JGM has renamed this dealyacc.y in his code.

2) A lexer definition file, called scan.l in the original distribution. JGM has renamed this dealflex.l in his code.

3) A main program and several subroutines, in a file called, `dealerv2.c`

4) Various header files and supporting routine header and code files

5) Makefiles

6) Examples and regression tests.

Workflow

YACC stands for, "Yet Another Compiler Compiler". The goal of yacc is to parse an input file according to the grammar for the target language.

The Dealer workflow is slightly different, from that of a compiler. The output of YACC/BISON is a routine called yyparse() and its supporting functions as defined in the dealyacc.y file. This routine is compiled into the dealer application along with the other C code. The user enters his 'input' file into dealer and the parser produces several in memory data structures that encode the user's instructions.

Maintenance 2022

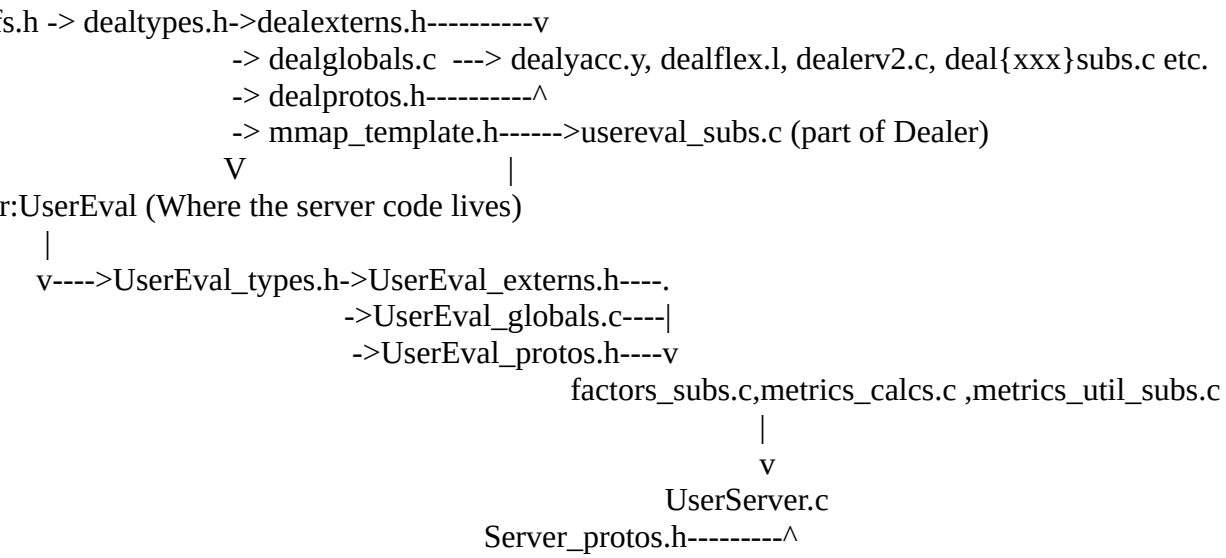
The early versions of dealer were developed on a 32 bit SUN workstation which by 2021 standards would not have qualified as a cell phone. Windows95 was not available. So there was considerable effort made to ensure that the code was portable to various flavors of Unix and even to a Unix like environment (Cygwin et. al.) on Windows 3.x. and even on DOS.

As of 2022, Linux has essentially taken over almost all of the Unix market (there is still some BSD, SUN and AIX but these are unlikely to be relevant to a bridge playing program). There is also MacOS which has a Unix pedigree, but is now completely closed and proprietary. The systems are almost all 64 bit and at least 1000 times faster than the original SUN workstation. Furthermore, Windows now includes WSL 2.0 which can run almost all Linux command line applications, and even many graphical (X window) applications, natively.

So it does not make a lot of sense to hobble the development of Dealer with 1990 era constraints. Accordingly JGM has decided to use any feature of Linux/Bison/Flex that seems useful, regardless of portability concerns such as POSIX compliance, or Windows tool chains.

Furthermore the (Standard ANSI) C language is much improved from 1990, allowing functions to return structures and unions, including some extra libraries for random number generation, firming up function prototype definitions and the like. These features too, are used whenever appropriate.

Hierarchy of Files



Dealer Heritage

This next bit is taken from the original dealer documentation; it gives a flavor of what the landscape was like back in 1989-ish when the program was first developed, and in the years immediately following.

<Quote>

Portability

The program has been developed under SunOS on Sun hardware. I (Hans) am a reasonably competent programmer though, and I expect the program to be highly portable. The most suspect part is in the initialization of the random number generator. The system call used here might need to be changed on other OSes.

There has been a DOS and OS/2 port by Pedl Rau. I tested the speed at about 9000 hands a second on my 486DX33. ***Note:*** *this has been superseded by the work from (a.o.) Paul Baxter, Alex Martelli and Danil Suits.*

Henk Uijterwaal has compiled his version under Linux (2.0.x and 2.2.x) without any problem, except that one needed to do:

```
ln -s /usr/bin/flex /usr/bin/lex
```

as flex has succeeded lex on Linux. On Ultrix, DEC Alpha(OSF), BSDI/3.x and SGI, the program compiled without any problem.

A. Martelli (alex@magenta.com) used to build and run Dealer on Win/NT and Win/98 with the free Cygwin GCC C/C++ compiler and Unix emulation environment. Main changes needed were byacc instead of yacc, as well as flex instead of lex, in the Makefile. A Makefile with all these changes is available in the MSDOS subdirectory.

Dealer's latest versions build and run fine using Microsoft Visual Studio 5 and 6 (still using byacc and flex if needed for syntax mods, but with no other known dependency on Cygwin); there is a current dependency on the Winsock2 DLL (for ntohs, ntohl functions) soon to be removed.

</end Quote>

Even in 1999, the last date I have for when work was done on this program by Henk Uijterwaal and others, the Linux kernel was still only in version 2.2.

It is now 2022, so I, JGM, have decided to use any Linux based tool that seemed appropriate without worrying too much about portability. I only started my modifications for my own learning and needs and never expected to release this code, and it is too late now to worry about portability.

Novice's Introduction to Bison/Yacc and Flex

Overview

This bit is a 50,000 foot view of Bison and Flex. Written by a novice, for novices. If you really want to understand the theory behind how Bison generates its parsers, you need to read up on Compiler Design and LALR(1) grammars and so forth.

YACC stands for Yet Another Compiler Compiler and is a tool to help people write compilers for new languages that they come up with. The original author of Dealer, Hans van Steveren (HvS) used YACC in a clever way to develop a parser for the dealer input file commands. It's not quite a compiler, but it is a very powerful parser.

So the overall process is this:

Define your 'language'. A language has a syntax and a grammar. Express your grammar in 'rules' that YACC understands. When you feed these rules into YACC it will produce a piece of magic C code that will parse your input for you. This piece of C code is a procedure called **yyparse().** The grammar definition is usually in a file with a .y extension.

You also define your rules for making tokens that you feed into the parser. You process these token making rules with Flex and it produces a piece of not quite so magic C code that will break your input stream up into tokens. The lexer definition rules are usually in a file with a .l extension.

You then write a main program which calls yyparse() to parse the input, and your main program then does whatever is called for with what yyparse produces. Usually there will be significant extra code required over and above just the parsing step, but not always. The GNU Bison examples have a main program that just calls yyparse and nothing else.

yyparse works by assembling 'tokens' into something more complicated; in the case of a parser that is say building sentences, the tokens are words. The bison examples on the GNU web site are various forms of calculators; the tokens are arithmetic operators, variable names, numbers, and so forth.

yyparse(), the parser, gets its tokens by calling a C procedure named **yylex(),** the lexer. (Lexing is short for 'lexical analysis' which is essentially breaking text up into its component parts.)

yylex's job is to read the input stream and break it up into tokens according to certain rules. In the case of sentences the tokens are groups of letters between whitespace and punctuation i.e. words. In the case of the calculators the tokens are numbers and symbols and so on.

You can run yyparse() as produced by bison, without involving flex to produce your lexer. If your lexer is simple enough you can code it by hand. In fact that is what the bison examples on the GNU web site do; they do not use flex at all.

You can also run your lexer without involving a parser if your grammar is simple enough; i.e. you can in effect write your parser by hand. That is what some of the examples in O'Reilley's lex and yacc book do.

But usually you use the two of them together as a pair. Bison to produce the parser, **yyparse**, and Flex to produce the lexer, **yylex.** Using these programs rather than hand coding, leads to fewer bugs, quicker development, and much easier maintenance. And the performance is on par with what you could write by hand.

The Lexing Process -- Flex

The lexer's job is to produce tokens for the parser to assemble into something more elaborate. Each token always has an 'ID' associated with it, this is the token type. For example a string of digits might have the token type INTNUM, a string of digits with a decimal point could have the token type FLTNUM. A word could have the token type NOUN or VERB or CONJUNCTION.

Typically in the code we write we express token types in all capitals; other symbols that are made up of several tokens put together are in lower case.

In addition to its type, most tokens also have 'semantic value'. For a VERB say the semantic value would be something like, "does", "is", "has" and so forth; a FLTNUM could have a semantic value of 3.14159 or 2.7182818 say. When the lexer is returning the token to the parser it returns the token type as the value in the return statement, and it puts the semantic value into a global variable that is shared between the lexer and the parser. In the case of bison, this global variable is called yylval, so flex puts the semantic value of the token type it is returning there.

Not all tokens have a semantic value attached; for example in a calculator one of the tokens might be a plus sign, '+' ; this plus sign has no semantic value, it's just a token.

These two pieces of information are the main ones; you can build your application with nothing more. However a compiler (which is what bison/yacc is helping you build) is expected to provide diagnostic error codes and messages, and so the location of the token in the input stream, line and column numbers say, could be very useful. Flex and Bison have a way of sharing the location of the various tokens between them to help with such issues.

The lexer can also process certain tokens on its own; if the token does not need to be assembled into a more complicated structure, then having the 'front end' lexer handle what it can, can simplify the grammar and speed up the parser.

An example is comments; if the parser is just going to ignore the comments anyway, then the lexer might as well just skip over them itself. Another example in the Dealer program is the token 'produce'. This token specifies the maximum number of hands that meet the criteria, the Dealer program output. When the parser sees this token it takes its semantic value and puts it into a global variable that the main procedure will refer to later. But there is no need to involve the parser in such a simple task, the lexer already knows the semantic value of the number associated with the 'produce' word, and can easily populate the global variable itself.

The Lexing Rules File (.l)

The input to the flex program, the dot ell file, is essentially a set of lines that follow the model:

- *Column 1:* Pattern aka Regular Expression
- *Whitespace*
- { C code between curly braces that says what action to take when the pattern is matched. }
  Here is an example of a Flex specification.

```
[0-9]+{ws} { yylval = atoi(yytext) ; return INTNUM ; }
```

This says that when you see one or more digits with some whitespace following them, use the C function "`atoi`()" to convert the text you just matched to an integer; put the integer value into the global value yylval and return the token type INTNUM to yyparse.

That is the essence of a lexer specification; of course users want the ability to do more than just this, and Flex has many features designed to allow writing powerful lexer specs easily and quickly.

Flex takes specifications such as the above and produces a Finite State Machine that matches the input patterns, breaks the input text up into tokens, takes the corresponding actions, and passes the token type and semantic value to the parser. The name of the C procedure that does this job is yylex(). As stated earlier while it is possible to generate a lexer by hand, it is quicker and easier to maintain, if you use a tool such as Flex to do it. It's the difference between writing declarative statements and procedural ones.

Generating The Parser with Bison

In order to build an application using a language, one needs to parse it. Many years ago, defining new languages was quite common; so someone at Bell Labs, where Unix, C, and many other software tools were invented, wrote the program Yacc, which stood for, "Yet Another Compiler Compiler'. This tool was designed to help people write compilers. The GNU re-implementation of Yacc, is Bison.

Bison, like Yacc before it, will take a series of declarative statements that define a language grammar, and it will produce an 'automaton' (State Machine) that can parse 'programs' written in that language.

The name of the C procedure that does the parsing is **yyparse().** yyparse calls a lexer, most often **yylex()** whenever it needs a token. Then using the context established by previous tokens, and the rules defined in the grammar, the parser can either process the user's input itself (see the various GNU calculator examples) or, in the case of our Dealer program, it creates some data structures (decision tree, and action list) that the main program uses to generate bridge hands of interest.

The parser's job is considerably more complex than that of the lexer. The author of the dealer program, Hans van Staveren, was very clever in his use of the lex and yacc tools to build this application.

The Parsing Rules File (.y)

The file that defines the grammar and the token types typically has a dot wye extension. There are several good examples of such files on the GNU web site in the Bison documentation section.

One of the things about grammar rules is that they are usually recursive; it is extremely common to see rules that read, "An expression is either a number, or an expression in parentheses, or an expression followed by the character '*' and another expression". You can see that the expression is defined in terms of itself, like recursive function calls in many programming languages.

To really understand how a parser automaton is generated and works you need to read up on compiler design, LALR(1) grammars, shift / reduce parsing and so on. That is well beyond what I can go into here, but the GNU Bison site is an excellent place to start.

We turn now to the dealer program itself.

Overview of the Operation of Dealer

The current production version of Dealer, has good documentation on how to use the program, what words and specifications you can put in the input file and so on. But the Dealer documentation is pretty sparse when it comes to describing how the program works, so that those who want to modify or extend it really have to study the code. As explained in the prologue, the following is what I have learned from extending Dealer's functionality.

The program can be thought of as consisting of 4 main parts:

1. Initialization and setup. This portion also processes any options entered on the command line. JGM in version 2.0 has almost doubled the number of parameters that can be passed into Dealer this way.

2. Calling **yyparse()**. This step processes the user's input file and builds several 'trees' and linked lists in memory that tell Dealer how to generate deals that are 'interesting' to the user.

3. Setting Context. This step is a sort of initialization part II. Some of the results produced by yyparse, are over-ridden by the parameters passed in on the command line.

4. The Main Loop. This bit consists of several parts.

    4.1 Use a random number generator to shuffle a deck of cards.

    4.2 For each deal generated in 4.1 walk the decision tree produced by the yyparse stage to see if the deal is 'interesting'. An 'interesting' deal is one that satisfies the condition as defined in the input file. This step is explained in more detail later in this document. If the deal is interesting, proceed to step 4.3. If the deal is not interesting discard it and return to step 4.1

    4.3 If the deal is interesting then run through the list of 'actions' defined by the user and perform them. Most actions involve producing some form of output, usually via a print statement. Many times there is only one action statement such as **printall** (the default action). Actions are of two types, those that produce output for every interesting deal, and those that produce output only at the end of the run. Examples of the first kind are the **printall**, or **printoneline** actions. Examples of the second kind are the **average** and **frequency** actions. It not usually useful to have more than one action that produces output for every deal as the output(s) from them would all be mixed together. But it is quite useful to have one action that produces output for every deal, and several other actions that wait till the end of the run to produce their output, such as several Averages, or Frequency counts.

    4.4 The Main Loop finishes when either the Generate or the Produce count is reached, whichever comes first.

5. The end of the run processing.

After finishing the main loop, Dealer outputs the results of the delayed actions, the Averages, the Frequency Counts, the Print Compass and the Evalcontract. If the user has left the verbose mode set to ON it also outputs the time taken and the total number of deals generated and produced, one of which will be less than the user asked for.

Evaluating the Condition Clause

Evaluating the condition clause is the most complex part of what Dealer does. For one thing there are very many aspects of a bridge hand, or deal, that the user may wish to use as a selection criteria. These aspects include such things as: suit lengths, high card points, controls, shape and many others. They can be combined into complex expressions with each other, using many of the standard arithmetic operators such as plus, minus, division and multiplication. The complex expressions can be further combined into logic clauses with standard logic predicates such as 'not', 'and', 'or', and 'if'. See the user's documentation for details.
The parser will assemble the various key words and functions in the input file into a series of 'clauses' known in this instance as 'rules'. Whenever the parser has assembled enough tokens from the lexer to make up a rule, it executes the C code that the programmer has specified for that rule. It is Yacc/Bison, the parser generator, that is responsible for generating the C code that manages to keep the rules coherent and in a logical sequence. The programmer does not need to know how it does this. So long as he has specified a grammar with no 'bugs' in it, Yacc/Bison will generate a correct parser.

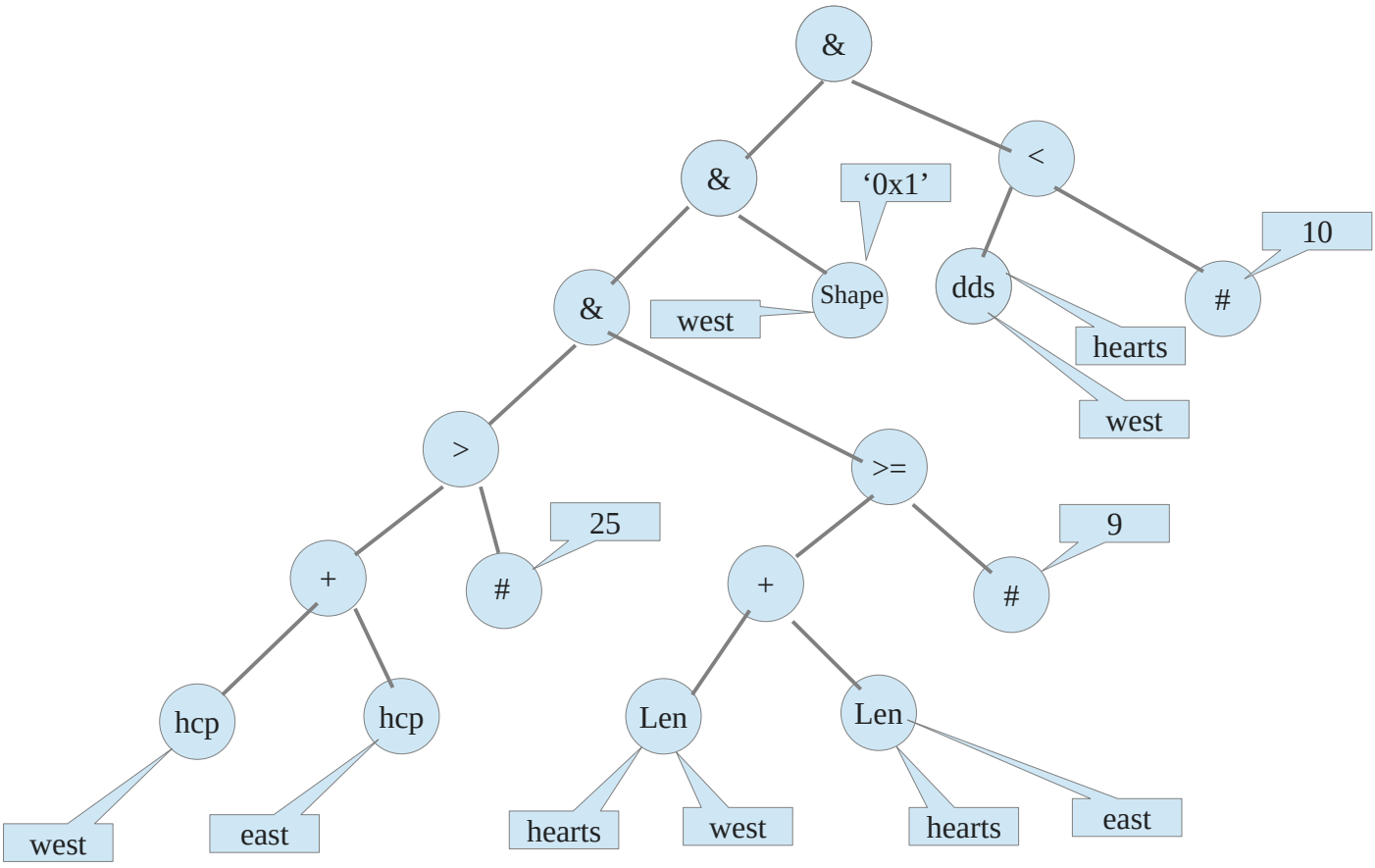
In Dealer the usual 'user action' that is taken when a condition 'rule' is recognized is to add a 'node' to the decision tree. A diagram of a simple decision tree is shown on the next page. The programmer does not have to try to ensure that the new node is added in the right place on the tree. That is the parser's job. The programmer just has to make sure that the node is the correct type and also that whatever values are needed at runtime are part of the data carried with the node.
In the following diagram, each node has: i) a type always present, ii) two integer values that are part of the node structure; one, none, or both of these may be used; and iii) two pointers again 0, 1, or both of these may be used to point to child nodes of the current one.

As an example, when the following condition expression:

```
condition ( ( hcp(west) + hcp(east) )     > 25 &&
            (hearts(west) + hearts(east)) >= 9 &&
          shape(west, any 7xxx ) &&  dds(west, hearts) < 10 )
```

is parsed by the yacc/bison generated yyparse() function a 'decision tree' is created in memory at run time. This is done once while the input file is being parsed, and is used for the rest of the run. On the next page is a diagram of what the decision tree looks like. In the diagram the type of node is shown inside the circle, the values attached to the node are shown in the rectangular boxes, and the links between the nodes by straight lines.
The evaluation function recursively calls itself; It starts at the top of the tree, but the top node in the tree needs the result from the next two nodes down. So the evaluation function calls itself on first the left node, and then the right node. And each call to those nodes, evaluates sub-nodes and so on. The effect is that the decision tree is evaluated left to right bottom to top. This is pretty much the same order as the clauses appear in the condition statement. This fact will have some practical value as will be explained later.
As soon as the evaluation function can make a decision, it does so and it does not continue to evaluate all the nodes if it is not necessary.
In this example there are many clauses joined by 'and' therefore as soon as one of the branches of an 'and' is false the whole expression must be false and the evaluation function can finish.

Example Decision Tree



Since the evaluation is done left to right, roughly in the same order as specified in the condition statement, it pays to put the quicker evaluations first; if these fail the evaluation routines may never have to execute the slower functions. In this example the DDS (Double Dummy Solver) function is the slowest, since it is more difficult to calculate the number of tricks a hand can take than to count its hcp or the number of cards in a suit. So we put it last in the condition statement; had we put it first, it would have been called on every deal. As shown it is called only for those deals which meet all other conditions.

Code Locations -- src Directory

JGM has (re)-organized the C code that makes up the Dealer application as follows: (all of the following are in the "src" directory. (following list circa 2023. More files added later)

dealflex.l - there is some C code here that implements Flex action statements and some functions that are called by these action statements. This file also contains the lexing rules for Flex. The .l file is much more complex than that for Dealer version 1. The reason is that Version 2 makes use of Flex's ability to redirect the input stream from the .l file itself to a string variable; in effect it calls itself recursively and pushes the current state on a stack. Version 2 uses this feature to implement the scripting variables, and the FD shapes.

dealyacc.y - there is some C code here that is run whenever the parser 'reduces' a rule; typically this C code adds a node to the decision tree or adds another item to the action list or the variable list. There is also C code that consists of functions that are called by the tree building statements in the rules. This file also contains the grammar definition for the Dealer application.

dealerv2.c - This file includes the "main" function, the initialization, and the main loop code.

mainsubs.c - this code is used by the main program to parse command line variables, initialize the random number generator and so forth.

dealparse_subs.c - These are more extensive routines that are run during the parser phase of Dealer. They do not implement evaluation or bridge oriented functionality; they do not form part of the main loop code. The are primarily called from code in the dealflex.l and dealyacc.y files.

dealeval_subs.c - These functions are run during the evaluation phase of the main loop. That is they are run for every random hand that Dealer generates. These functions make up the code that is run depending on which node of the decision tree is being traversed.

deal_knr.c - This code implements the Kaplan and Rubens Four C's hand evaluation method, as well as the Suit Quality measurements. The code is run during the evaluation phase but it is in its own file to make it easier to maintain.

dealdds_subs.c - This code implements the calls to the Double Dummy Solver library. It is run during the evaluation phase, but the functions have been given their own file to make them easier to maintain.

Dealer_DDS_IF.c - This code provides the interface between Dealer and the DDS library. It is in its own file to avoid name conflicts with code in the other dealer files.

dealaction_subs.c - These functions are run when the evaluation phase marks the deal as interesting. They implement the print, average, frequency and such like functionality.

dealdebug_subs.c - These are functions written by JGM to debug his code and to learn how Dealer works. Unless the symbol JGMDBG is defined at compile time, they should have no effect on the operation of Dealer.

dealServer_subs.c - These functions implement the usereval functionality in Dealer. They start and stop the external server program, create the IPC semaphores, and shared memory (mmap) area, and perform the asking of the query(s) and the reporting of the responses. They do not implement the code for the external server itself.

There is also a sub-directory called, UserEval. In this directory are the files that implement the server infrastructure, and the various metrics calculations. These next files are in this sub-directory.

UserServer.c - This file contains the code for the external server. It includes the functions to mmap the shared memory area, signal with the semaphores, retrieve the query from the mmap, and write the responses thereto. It also calls the 'userfunc' code that implements the measurements that the user wants.

metrics_calcs.c, factors_subs.c, metrics_util_subs.c- These files contain code that is called by DealerServer to actually perform the calculations. The idea is that the user can write his own code to calculate whatever he likes, and then compile and link it with UserServer.c, thus focussing on his own code and not having to worry about the infrastructure of how to share memory, or communicate via semaphores. There are many examples of how to use the usereval keyword to post the query and use the reply.

Code Locations -- include Directory

The header files are in the "include" directory (following list circa 2023. More files added later)

std_hdrs.h - this file contains include statements for all the standard headers needed, such as stdlib.h, stdio.h, assert.h etc. The first statement in this file is to define the macro _GNU_SOURCE. This has the effect of 'turning on' all the GNU extensions that are available in glibc, such as extra string functions and so on. If you want strictly POSIX or strictly ANSI C, you will need to define a different macro.

dealdefs.h - this file defines all the symbolic constants used. It is needed by all the other .h files as well as most of the .c files.

dealtypes.h - this file defines the various structures, arrays, typedefs and so on. It uses the definitions from dealdefs.h

dealglobals.c - This file defines and allocates space for the global variables used in Dealer. There are probably too many of these, but several are used to exchange information between Flex, Yacc, and the Dealer main program, as well as between functions compiled in different files. This file should only be included in the main program file, dealerv2.c, not in any of the other files.

dealexterns.h - This file is the counterpart to dealglobals.c. It contains extern statements for the global variables defined in dealglobals.c

dealprotos.h - This file contains prototype statements for most of the functions that are not defined in the same file where they are used.

The above files are usually all that is needed by most of the Dealer .c files. In addition there are a few files that are only needed by a small subset of the code:

deal_knr.h - header info used only by the c4.c file, and defining an interface to that code.

deal_dll.h - this file is an extract from the dll file provided with the DDS library. It imports the minimum amount of information to avoid potential naming conflicts.

deal_dds.h - this file makes available to the code that uses the DDS library the minimal amount of information from the Dealer program.

pointcount.h - included into dealtypes.h because it defines the max size of the pointcount array.

dealdebug_subs.h - some prototypes and definitions for the debugging routines.

mmap_template.h - The structs and other definitions used by the usereval_subs, and the user_eval server.

Code Locations -- Other Directories

The `Prod` directory contains the Makefile and the binary for the 'production' version of dealerv2.

The `Debug` directory contains the Makefile and the binary for the debug version of Dealer, dealdbg
There is also a DebugExamples directory for testing various mods to Dealer. In Debug/Makefile the symbol JGMDBG is defined, so that the debugging code in the Dealer source files is included in the resulting binary. The included debugging code is triggered by setting the -D switch on the cmd line to a value between 1 and 9. If the -D switch is set to 0 then all the debugging output is suppressed. Debugging output is sent to `stderr` so that it is possible to save the debugging output by redirecting `stderr`, and not have it interfere with the normal Dealer output.

The `docs` directory contains the User Guide, a README file, this Maintainer's guide, license and copyright files, and other useful background info.

The `lib` directory contains the pre-compiled DDS library. This is a static library, NOT a shared object. I hope that this means it will not be necessary to recompile it for different Linux kernels. While Dealer itself can be compiled with ordinary C compiler, DDS must be compiled with C++. Since this library was compiled with g++ the final dealerv2 binary link step must be done with g++. The Makefiles have been pre-built to do this.
`lib` also contains a tarball of the JGM's Perl code that implements the Optimal Point Count hand evaluation method. This code is needed if you intend to use the 'opc' functionality of Dealer.
There is no 'package' install of this, but Dealer has been pre-compiled to run the code from the `/usr/local/games/DOP` directory. You will need super-user privileges to install it in that location.
`lib` also contains François' Perl script that parses the enhanced shapes syntax.

The `Examples` directory contains many Dealer 'Input Files' demonstrating how to use the various features of Dealer. Many of these come from the original version. There are also files giving the output from these examples on my machine, and a Perl script to compare the latest output to the reference output. This has been copied from version 1.

The `DDS` directory contains a tarball of Bo Haglund's Double Dummy Solver.
If you intend to rebuild this library it is best to start with BH's distribution, but you might find some of the files in this directory helpful.

The `UserEval` directory contains the all the files, src, include, Makefile, etc. required to build the DealerServer binary that comes with this version of dealer. Starting with the file `UserServer.c`, and using the files `metrics_calcs.c` and `factors.c` as examples is a good way to begin if you want to create your own version of DealerServer.

Modification Examples

Adding a Title.

The objective is to be able to add a title string to some of the output, so as to describe, for example, what bidding practice is being generated. One can also put this title out as part of the PBN report.
The title will be a simple character array in a global variable. As such there is no real grammar associated with this; we can do it all in the Flex file.
1. Allocate space for the title string, and its length in the dealglobals.c file. Also add an extern definition for these global variables in the dealexterns.h file.
2. In the dealflex.l file define the pattern 'title' beginning in column 1. We could make a regex that matches 'title' followed by whitespace then followed by a quoted string. But we want the user to be able to put the title on a separate line. So we make use of Flex's "exclusive state" feature so that once 'title' is seen the only thing that Flex will recognize is a quoted string. The user action statement associated with the quoted string, copies the string to the global variable, and also sets the length. It then exits the exclusive state and resumes looking for a token that it can pass to yyparse.
Here is the code as it is in the dealflex.l file:

```
%x TITLE
ws [ \t]+
nl \n
qstring   \"[^\"\n]*[\"\n]
title({ws}|{nl}) { BEGIN(TITLE);  }
<TITLE>{nl}   ;               /* do nothing if {nl} found. */
<TITLE>{qstring}  {
                    strncpy(title, yytext+1, (yyleng-2) ) ;
                    title[yyleng-2] = '\0';
                    title_len = strlen(title) ;
                    BEGIN(INITIAL) ;
                  }
```

The first line defines a new exclusive state to Flex.
The next 3 lines just define some symbolic constants to make reading the rest of the code easier.
The line beginning with 'title' tells Flex to look for 'title' followed by whitespace, or newline. If it sees that, it enters the TITLE exclusive state, looking only for a quoted string.
When Flex finds a quoted string it copies the text it found (less the opening and closing quote marks) to the global variable and adds a null string terminator at the end.
Then for convenience it saves the length of the string in another global variable, and exits the TITLE state and returns to the default, INITIAL state.

Other parts of the program can test the title_len variable and if it is non-zero they know that there is a title that can be output along with the Dealer results. If the user does not want a title mixed in with his output he does not enter one.

This is all done without involving the grammar file, dealyacc.y.

Adding Losing Trick Count (ltc)

The next example adds a new feature to the Dealer vocabulary. I wanted to have a more 'modern' LTC

than just counting losers. For example AJT should be counted as 1.5 losers not 2; Qxx should be counted as 2.5 losers not 2. In the input file the user would be able to enter conditions such as:

`ltc(north)<5.5` or perhaps `ltc(north,spades)<2. && ltc(south, clubs)<1.`

You can see that this is very similar to the syntax of other aspects of hand evaluation such as HCP, or length in a suit. So the grammar would also be very similar to the HCP grammar.

The steps involved are as follows:

I - Grammar file (dealyacc.y)

1. Define a new token LTC with a `%token LTC` statement.

2. Write two new rules, the first to handle the case where the user enters only the 'compass' direction [e.g. `ltc(north)`] and the second where the user enters the compass direction and the suit.

3. In the action statement associated with reducing the first rule, create a new node of type TRT_LTCTOTAL and put the compass direction value (0..3) in the first integer of the node.

4. In the action statement associated with reducing the second rule, create a new node of type TRT_LTC, put the compass value in the first integer, and the suit value in the second integer.

5. Bison will assign an integer value to the new token LTC when it builds the parser from the grammar file. Flex will become aware of this value via the `#include dealyacc.tab.h` file which is generated from the grammar file along with the yyparse C code. In the dealflex.l file we tell Flex what to do when it sees an 'ltc' word: `ltc  return(LTC);`

6. The next step is to write the code that will calculate the LTC values for various suit combinations. The code for this is in the dealeval_subs.c file. The way Dealer is written, after the random deal is generated, but before the decision tree is scanned, there is a routine called 'analyze' which pre-calculates several aspects of hand evaluation, such as High Card Points, suit lengths, controls, in general any aspect of the hand which is likely to be needed on most deals, and which is relatively straightforward to derive. We add to the 'analyze' function a call to the function we write to calculate the new ltc.

7. There is one aspect of the above which is not mentioned here, and that is the use of numbers with decimal points (such as 2.5 in the above example). Version 1 of Dealer had no notion of any number that was not an integer; all the calculations and all the return values were all integers. In version 2, JGM extended the Dealer syntax to allow the user to input numbers of the form 99.99 but internally Dealer remains an integer only application. See the User Guide where the new 'Dotnum' feature of Dealer is described for the limitations of this feature.

Here is the code that has been added to the grammar file to implement the LTC feature. It is virtually identical to the code that defines HCP for example:

```
| LTC '(' compass ')'
          { $$ = newtree(TRT_LTCTOTAL, NIL, NIL, $3, 0 ); }
| LTC '(' compass ',' SUIT ')'
          { $$ = newtree(TRT_LTC,      NIL, NIL, $3, $5); }
```

"$3" in the above refers to the value that has been assigned to 'compass'. "$5" refers to the value that has been assigned to "SUIT". *Aside: $1 is LTC , $2 is the **(** left parens and $4 is the comma in the*

second rule.

Random Number Generation

The original author of Dealer, HvS, was quite conscious of the time taken to generate and analyze hundreds of thousands of deals in order to get few hundred that would meet the user's criteria. For example the original dealer code had a very clever way of avoiding modulo division when generating a random number. According to my tests HvS's method cut the time to generate a random number in half.

The system on which the following performance numbers were generated is as follows:

System: Linux Kernel: 5.4.0-96-generic x86_64 bits:
Machine: Type: Desktop Mobo: ASUSTeK model: P8Z68 DELUXE
CPU: Topology: Quad Core model: Intel Core i7-2600K bits: 64 type: MT MCP
L2 cache: 8192 KiB
Speed: 1605 MHz min/max: 1600/3800 MHz Core speeds (MHz): 4 CPUs, 8 Cores.

Dealer itself was compiled with GCC version 9, with optimization level -O3(Prod directory) or -Og(Debug directory).

Random Number Generation:
Avg Random Number (0..100) over 10 million deals using rand :
Average= 49.48, Std Dev= 28.87, Var= 833.37, Sample Size=10000000
10 Million Random Numbers
Generated 10000000 hands
Produced 10000000 hands
Initial random seed 138249490574914
Time needed 18.067 sec

Without the Debugging code and symbols, and using -O3 optimization the result is:
Avg Random Number (0..100):
Mean= 49.50, Std Dev= 28.87, Var= 833.23, Sample Size=10000000
Random Number Generator Test 10,000,000 No Conditions
Generated 10000000 hands
Produced 10000000 hands
Initial random seed 113
Time needed 12.773 sec

The original Version 1.4 code as distributed by Debian (and compiled on my machine with -O3) gives:
Avg Random Number (0..100) over 10 million deals using rand : 49.5036
Generated 10000000 hands
Produced 10000000 hands
Initial random seed 1643427436
Time needed 5.046 sec

The difference is that in the first two cases JGM has removed HvS's clever workaround which sped up

the RNG. The main reason being that I did not quite understand it; it seemed to me that this method (which is essentially 16 bit?) would result in a relatively short period for the RNG; my concerns were further amplified by HvS's statements that the RNG was the most dubious part of the program, and that the program was not suitable for generating deals for such things as tournament play. I wanted to use the current GNU 48 bit random number generator, (which was not available when Hans first wrote his program) and I wanted to be certain that the period of the RNG was sufficiently long for the simulation studies that I was doing. I figured I could afford a few extra micro-seconds to be certain.
If we assume that we will need 10,000 deals generated per simulation run, and each deal needs 52 random numbers for the shuffle, then we need $5.2*10^5$ random numbers per run. To avoid the 'birthday paradox' the period of the RNG should be greater than the square of this number or $27*2^{33}$. The period of the 2022 GNU RNG is said to be 2^{45}. In addition I have taken the precaution of seeding the RNG with values from the Linux Kernel's entropy pool to ensure as much randomness as possible. Of course the user still has the option of specifying an initial seed value as he could in previous versions.
For reference it is the modulo division required to map the number generated by the RNG into the range 0 .. 52 that takes the extra time. The GNU RNG is not the source of the time taken; a program that does nothing but return 50 Million random numbers takes the following amount of time:

```
CheckRandom:: Version=DOUBLES, Seed=234021249433746
Average over 50000000 loops = 0.500036
real    0m0.376s  user        0m0.375s    sys         0m0.001s

CheckRandom:: Version=LONGS, Seed=47779911134368,
Average over 50000000 loops = 1.07375e+09
real    0m0.295s  user        0m0.289s   sys         0m0.004s
```

The older GNU RNG gives these results:

```
CheckRandom:: Version=SHORTS, Seed=0,
Average over 50000000 loops = 1.07376e+09
real    0m0.423s  user        0m0.419s   sys         0m0.004s
```

For reference the GNU RNG has 3 different modes: 1) generate a double in the interval [0,1), generate a 32 bit integer in the interval $[0, 2^{31})$ and generate a signed integer in the interval $[-2^{31}, 2^{31})$.
They all take about the same amount of time and give about the same average and standard deviation.

Other Performance Figures

Simple Condition File

The next result is for the following condition clause:

```
condition   shape(north, any 4333 + any 4432 + any 5332) &&
            hcp(north)>=20 and hcp(north)<=22
```

Generated 1,550,673 hands
Produced 10,000 hands
Initial random seed 113
Time needed 2.777 sec
real 0m2.784s user 0m2.768s sys 0m0.022s
For a somewhat more complicated Stayman evaluation such as:

```
east_notrump = shape(east, any 4333 + any 4432 + any 5332) and
               hcp(east) >= 15 and hcp(east) <= 17
west_stayman = shape(west, 3451 + 4351) and hcp(west) <= 7

east_2d = shape(east, xxxx - 4xxx - x4xx - 5xxx - x5xx)
east_2h = shape(east, x4xx)
east_2s = shape(east, 4xxx - x4xx)
east_2n = shape(east, 5xxx + x5xx)

d = diamonds(east)+diamonds(west)
h = hearts(east)+hearts(west)
s = spades(east)+spades(west)

found_d_fit = east_2d and d>=8
found_h_fit = east_2h and h>=8
found_s_fit = east_2s and s>=8
found_M_fit = east_2n and (h>=9 or s>=9)

condition east_notrump and west_stayman

action
     average "fit" found_d_fit or found_h_fit or
                    found_s_fit or found_M_fit
fit: Mean=0.58, Std Dev=0.50, Var=0.25, Sample Size=220
```

Generated 1,000,000 hands
Produced 220 hands
Initial random seed 113
Time needed 2.249 sec
real 0m2.255s user 0m2.237s sys 0m0.025s

Double Dummy Analysis with GIB and DDS

Version 1.4 of Dealer (the version distributed by Debian) used GIB in double dummy mode, as a way of determining the number of tricks that South could take in a given strain for the deal being analyzed. Compared to the other metrics used to evaluate hands, using GIB in this way is quite slow. On order of a tenth of a second per call to GIB. (.085 secs). There are a couple of reasons for this, firstly actually solving a deal to see how many tricks can be taken is not a trivial exercise; it is much harder than just counting HCP. Secondly each call to GIB means creating a temporary file to hold the deal in, writing the deal to that file, starting up the shell program which in turn starts up the GIB program, waiting for the program to complete its analysis and write to its output file, opening and reading said file, and finally getting the number of tricks. Frankly I was surprised it was a quick as it was. However I was interested in seeing if I could improve on this for two reasons; the first of course is performance, the second it that the use of GIB in this way is a bit clumsy; not everyone may have a copy of GIB (which is no longer available on Ginsberg's web site), and GIB itself needs to be installed with certain files in certain directories. Changing directories can mean copying a couple of files from elsewhere.

I therefore added functionality to Dealer to give it the ability to use Bo Haglund's Double Dummy Solver (DDS). Since GIB was designed to be a bridge playing program with a DD mode added on, and DDS was designed to be a double dummy solver, you might expect that DDS is more efficient, and

offers more features than does GIB for this purpose. Such is indeed the case. To use DDS does not involve running any external program, you compile the DDS library right into Dealer. To solve one board, for one strain takes DDS only about one fifth the time it takes GIB. (0.0145 secs). But this is using DDS in the most inefficient way; DDS is optimized to obtain many results in parallel through multi-threading and re-using partial results from other calculations for the same deal. DDS can get all 20 possible results (4 declarers * 5 strains) in about the same time it would take GIB to get two results. And this is still not the best way to use DDS, but for Dealer's purposes it is more than sufficient. DDS also gives you the ability to calculate the PAR result on any given deal. However even for DDS the time taken is not trivial; doing a DDS calculation on thousands of deals will take some time.

In my implementation of DDS for Dealer I have borrowed a technique from the folks who did the GIB implementation and I have 'cached' the results as they are calculated.

At this point I should digress a bit and explain that Dealer does NOT store the results of previous calculations, but recomputes them each time they are called for.

For example if in the condition clause you ask for

```
hcp(north) >= 15 and hcp(north) <= 17
```

this will result in two calls to whatever function evaluates the HCP. Even if you specify a variable like `NorthHCP=hcp(north)` and then say `NorthHCP >=15 and NorthHCP <=17` this still results in two calls to the HCP evaluation function. In fact this is less efficient than the previous method since it involves first finding the variable NorthHCP in the variable list and from there calling the HCP function. Dealer does both the find and the function call twice, once for each time the variable is used. This is one reason why Dealer implements the 'analyze()' function described earlier; analyze() pre-computes many of the commonly used metrics and stores them in a structure so that whenever they are needed it is a simple matter of table lookup. Analyze however does NOT pre-compute the GIB (or DDS) results since a) they are not often needed, and b) they would slow down EVERY deal generated whether the deal satisfied the other conditions or not. The end result would make Dealer unbearably slow.

Therefore the GIB and DDS functions save the results of previous calls in a cache so that the second time the same result is needed on the same deal, it does not result in a second call to GIB (or DDS) but instead a simple array lookup.

End of Digression.

In my implementation of DDS for Dealer, there are two ways that DDS can be called: a) the way that returns a single result and b) the way that returns all 20 possible results. Method (a) is about 5 times as fast as method (b) so obviously if you only need one to four different results , such as comparing 4 of a major to 3NT, you are better off to use method (a). But if you want PAR calculations, or you are trying to build up a library of deals for future study and you want more than 4 different results per deal, you are better off to use method (b). See the User Guide for details.

DDS also gives the user the option of specifying how many threads to run while solving the deal(s). If you are using method (a) there is no advantage to specifying more than 1 thread. If you are using method (b) you can specify between 1 and 15 threads. On my machine with 8 cores, when using method (b) I saw a gradual improvement as I increased the number of threads from 3 to 9. After that there was no additional improvement in time taken. The code therefore ships with 9 threads as the

default when using method (b). The user can override this from the command line.

Experimental Results.

The following shows the results of running Dealer with different DD solver setups, and with the DD clause before or after the other clauses in the condition statement. (see the code in the next section.) The Total Calls figures are the calls to the cached results and the calls to populate the cache. The Solve Calls figures are the number of times the actual work of solving the deal was done. (Mode 1 is single solution, mode 2 is 20 solutions)

```
../dealer Descr.DDS_slow -M2 -s17 -D2
DDS with tricks clause at start of condition -- Mode 2
Generated 395 hands
Produced 20 hands
Initial random seed 17
Time needed  100.382 sec
Tot Calls to DDS =  7100, DDS Solve Calls=   396
Tot Calls to GIB =     0, GIB Solve Calls=     0
-----------------------------------------------------
../dealer Descr.DDS_slow -M1 -s17 -D2
DDS with tricks clause at start of condition -- Mode 1
Generated 395 hands
Produced 20 hands
Initial random seed 17
Time needed   51.637 sec
Tot Calls to DDS =  7100, DDS Solve Calls=  1980
Tot Calls to GIB =     0, GIB Solve Calls=     0
-----------------------------------------------------
../dealer Descr.DDS_quick -M2 -s17 -D2
DDS with tricks clause at end of condition -- Mode 2
Generated 395 hands
Produced 20 hands
Initial random seed 17
Time needed    6.198 sec
Tot Calls to DDS =   402, DDS Solve Calls=    22
Tot Calls to GIB =     0, GIB Solve Calls=     0
-------------------------------------------------------------
../dealer Descr.DDS_quick -M1 -s17 -D2
DDS with tricks clause at end of condition -- Mode 1
Generated 395 hands
Produced 20 hands
Initial random seed 17
Time needed    3.030 sec
Tot Calls to DDS =   402, DDS Solve Calls=   110
Tot Calls to GIB =     0, GIB Solve Calls=     0
-------------------------------------------------------------
../dealer Descr.GIB_quick  -s17 -D2 -p20
Tricks clause at end of condition statement; 5 calls to GIB when needed
Generated 395 hands
Produced 20 hands
Initial random seed 17
Time needed    8.109 sec
Tot Calls to DDS =     0, DDS Solve Calls=     0
```

Tot Calls to GIB = 402, GIB Solve Calls= 110

../dealer Descr.GIB_slower -s17 -D2 -p20
Tricks clause at Start of condition statement; 5 calls to GIB on each hand
Generated 395 hands
Produced 20 hands
Initial random seed 17
Time needed 152.405 sec
Tot Calls to DDS = 0, DDS Solve Calls= 0
Tot Calls to GIB = 7100, GIB Solve Calls= 1980

../dealer Descr.DDS1x_slow -M1 -s17 -D2
DDS with tricks clause at START of condition only 1 call per hand
Generated 362 hands
Produced 20 hands
Initial random seed 17
Time needed 8.016 sec
Tot Calls to DDS = 363, DDS Solve Calls= 363
Tot Calls to GIB = 0, GIB Solve Calls= 0

../dealer Descr.GIB1x_slower -s17 -D2 -p20
GIB with tricks clause at START of condition only 1 call per hand
Generated 362 hands
Produced 20 hands
Initial random seed 17
Time needed 30.054 sec
Tot Calls to DDS = 0, DDS Solve Calls= 0
Tot Calls to GIB = 363, GIB Solve Calls= 363
==========

The condition statement used in the 5x tests

```
# These next statements calculate the maximum number of tricks North can take in any strain.
# The five calls per deal that populate the cache
nNtrix = tricks(north, notrumps)
nStrix = tricks(north, spades)
nHtrix = tricks(north, hearts)
nDtrix = tricks(north, diamonds)
nCtrix = tricks(north, clubs)
# the IF statements that generate the extra calls to the DD solver.
ntrixM = nStrix > nHtrix ? nStrix : nHtrix
ntrixm = nDtrix > nCtrix ? nDtrix : nCtrix
ntrixT = ntrixM > ntrixm ? ntrixM : ntrixm
ntrix  = ntrixT > nNtrix ? ntrixT : nNtrix
condition    ( ntrix > 6  ) &&              /* ntrix > 6 clause goes here for the slow runs */
     shape(north, any 4333 + any 4432 + any 5332) and
     hcp(north)>=15 and hcp(north)<=18 and hcp(south) <= 12    /* && (ntrix > 6) goes here for quick runs*/
# The ntrix>6 clause is at the beginning of the condition statement for the 'slow' runs, and at the end for the 'quick' runs.
```

==========

Conclusion:

1. Avoid calling a double dummy solver on EACH hand, whether DDS or GIB
2. Caching makes a big difference especially when there are many calls using the same value of tricks.
3. DDS mode 1 is 3-4 times faster than GIB for 'ordinary' use. i.e. 1-5 double dummy calls per hand.

4. DDS mode 2 is quicker than GIB by about 30% when there are 5 calls to GIB per hand. When there are only one or two calls it is slower.
5. GIB consistently takes about 0.08 seconds per call. DDS mode 1 about 0.0017 seconds

Performance of the DealerServer

The usereval keyword also calls an external program; however this external program is only started once, not like GIB or OPC, and it uses very efficient shared memory between Dealer and DealerServer to communicate. Further it can return up to 64 numbers on each call, which are then cached. The overall effect is that it is the quickest of the set, {DDS, GIB, OPC, or DealerServer}.

A very simple UserEval function, which just returns a fixed set of numbers every time it is called, will take **178.7** secs, for 10 thousand calls, or about **0.018** secs per call.

Performance Summary of Various External Programs

Performance Summary:		Secs
DDS Mode 1. Per Call:		0.027
DDS Mode 2. Per Call:		0.26
GIB	Per Call:	0.08
OPC	Per Call:	0.037
UserEval	Per Call:	0.018

The Shape Functions -- H. van Staveren & F. Dellacherie

HvS shape(..)

The original shape function by HvS is called from the Input File with the keyword 'shape' and the arguments in parentheses **()**. The arguments are 4 character strings made up of the digits 0-9 and the letter 'x'. The arguments are called distributions. Several distributions can be joined together with a plus sign (+) meaning 'or'. The suits are given in the usual order of S, H, D, C. For example the distribution 5431 means 5 spades, 4 hearts, 3 diamonds, and 1 club, or as it is usually written in bridge columns 5=4=3=1. A distribution such as 54xx means 5=4 in the Majors and the 4 minor suit cards can be distributed in any way from 4=0 to 0=4.
Each distribution can be preceded by the keyword 'any', to indicate that the order of the suits does not matter. For example 4333 means a distribution with 4 spades; 'any 4333' means the 4 cards can be in any suit. A distribution such as 'any 54xx' would include 54xx, 5x4x, 5xx4, 45xx, 4x5x, 4xx5, and so on.
After all the included distributions have been listed, the user can exclude certain distributions by prefixing them with a minus (-) sign. So that 5332 + any 6xxx - 4xxx would exclude hands with exactly 4 spades. The list of distributions can be almost arbitrarily long. I have tested cases with 175 distributions in the list.

The shape() functionality itself is made up of three phases: the intialization phase, the parsing phase, and the evaluation phase.

shape() Initialization Phase

To store the distribution information about a hand, there is a 4D array called, distrbitmaps This array

has one cell for each possible length in a suit. Since there are 14 possible lengths for any suit (0 .. 13) a naive way of allocating this array would be distribitmaps[14][14][14][14]. This would result in an array of 38,416 cells requiring 153,664 bytes of storage. So that to get the information about a hand with 5=4=3=1 shape, we would say `shapebits = distribitmaps[1][2][4][5]`, where the first index is the number of clubs, and the last one is the number of spades. But a bit reflection will show that many of these cells will never contain any data. For example the sub-array *distribitmaps[13][x][x][x]* in the above scheme will consist of 2744 cells, only one of which will be used: *distribitmaps[13][0][0][0]*. Similarily if we have 12 clubs, only 3 of the 2744 cells in the distribitmaps[12] sub array can be used: distribitmaps[12][1][0][0], distribitmaps[12][0][1][0], distribitmaps[12][0][0][1]. The same is true for all of the other distributions; many of the cells will never be used. Hans therefore instead of this naive approach has generated 679 separate sub arrays, with a total size of only 14,840 bytes (plus a bit of overhead). A saving of over 90%. The programmer however can still refer to the distribitmaps array just like a real 4D array by issuing a C statement such as:
`shapebits= distribitmaps[club_len][diam_len][heart_len][spade_len].`
This array is created at run time before the parser is called so that it is available to the parsing routines to store information about shape requirements in.

shape() Parsing Phase

During the parsing phase two things occur: First when the parser sees the shape(....) statement it creates a new node in the decision tree (or a new expression tree in the var list). This node carries with it two pieces of information: the compass direction for which the shape constraint applies, and an integer referred to in the program as '`shapeno`'. The shape number referred to is a number identifying the shape statement as a whole, NOT any individual distribution in the statement. The 'shapeno' is used to create a bit mask that can test for the relevant shapes.
A compass direction can have several shape statements that refer to it; there is no requirement that a compass direction appear in only one shape statement. For example:

```
condition shape(north, xxx6 + xx6x ) && hcp(north) >=11 or
shape(north, 5xxx + x5xx ) && hcp(north)>=11
```

so that to open an 11 count in a minor needs a 6 card suit, is perfectly OK. Each of the shape statements in the above will create its own node in the decision tree, and will have its own `shapeno`.
The second thing that happens is that each distribution in the shape statement is evaluated and the 4D array created in the intialization phase is updated. The integer from distribitmap[c][d][h][s] is retrieved and the bit corresponding to the current shapeno is set. (or cleared if the distribution is preceded by a minus sign). There may be other bits in the same integer that have been set, and these are not disturbed by the new information. Thus each integer in the 4D array can carry information about 32 different shape statements. Since each shape statement can specify an almost unlimited number of distributions this gives the user the ability to control the overall shape as much as he wants.
The hard part is figuring out which lengths to use to set the bits in the 4D array. A distribution such as 5431 is straightforward, there is only one cell in the 4D array that is affected. It is a bit more difficult if the user specifies 'any 5431'. Now there are 24 cells in the 4D array that need to have the relevant shapeno bit set. It gets even harder if there are 'x's in the distribution; a distribution such as 'any 7xxx' can occur in 196 different ways. However it happens there is a routine called 'setshapebit' that will set bit number 'shapeno' in the 4D array for each distribution that qualifies. 'shapeno' is essentially incremented by one for each shape(compass, xxxx + xxxx + ...) statement. So the first call to shape will set shapno to zero, and the least significant bit in the affected cells in the 4D array will be set to 1 giving them a value of '1'. The third shape(compass, ...) statement will set shapeno to 2 and the

affected cells will have their '2' bit set, in effect incrementing them by '4'. (2**2).
A given distribution may occur in two different shape statements. For example it is possible to ask that either (or both) of north and west have 5=4=3=1 shape. In that case two bits will be set in the distribitmaps[1][3][4][5] cell giving it a value of say 3.

Evaluating shape()

To test if the compass direction meets the shape condition, the cell corresponding to that compass' distribution is retrieved and the relevant bit is tested by anding it with '1' shifted by 'shapeno'. For example suppose that the North hand is 6=4=2=1 and the North shapeno is 2. Suppose further that the shape condition for West is any 6421 and that for North is any 5332. Then to check if North (with 6=4=2=1) meets the condition, we use a statement such as the following:
`if ( distribitmaps[1][2][4][6] & (1<<2) ){ then true } else {false}.`
Now the integer in the [1][2][4][6] will be non zero because of the West condition; but it will not have it's '2' bit set, because only cells that match North's 5332 requirement will have that bit set, and this is not one of them. When we test West (perhaps with a 1=4=2=6 distribution) with a statement like that above we will use a different value from '2' to shift the '1' and we will get a match in that case.

François Dellacherie Shape{ .. }

The second kind of shape statement that Dealer Version 2.x allows is one where the arguments are enclosed in **braces {}**, not parentheses (). The braces versus parentheses is how we tell them apart. I call them FDshapes and FDdistributions because the code to implement them was written, back in 1997, by François Dellacherie. The complete syntax for specifying an FDdistribution is given in the User Guide. In brief it allows the user to specify in a very compact form shape contraints that would take dozens or in some cases over a hundred different HvS distributions. For example this FDdistribution: `shape{east, 4+m5-Mxx }` specifies at least a 4 card minor, at most a 5 card Major. It expands to 990 characters, and 142 distributions from 0409 to x5x7
See the Examples directory for more examples on how to use an FDshape statement.
The expansion of this compact distribution clause is done by an external Perl script. The Perl script is called `fdp` and it resides in the lib directory. There is also a version called `fdpi` which is an interactive version. The interactive version allows the user to enter an FDshape command from the keyboard, and see the results on his screen. It is a good way to test an FDshape statement that you intend to include into the Dealer Input file.
When the lexer, Flex, sees a **shape{ .. }** statement, it does not return said statement immediately to the parser. Instead it passes the statement to the ../lib/fdp Perl script via a Linux `popen` system call. The script (if it is working correctly) creates a valid HvS shape command from the FDshape command. Flex captures the results produced by the script, and then switches from lexing the Input File to lexing the script results, passing each term produced by the script to the parser just as if the user had entered them by hand. The parser never sees the shape{ .. } text, but only the text transformed by the FD Perl script. From that point on the shape requirement is handled exactly the same way as described above.

Installing Dealer V2 From the Github Repo.

Warning:

I am NOT an experienced package maintainer. This is the first time I have ever used Github.
There is no package (.deb or .rpm) that will automatically install Dealer for you.

I assume that one of these three things is true:

1) The binary in the Prod directory will run as is on a Linux system. This may or may not be true. While DealerV2 itself does not rely on any DLL's there are several references to standard GCC and Linux DLL's in the code. The binary was developed on Linux Mint, an Ubuntu derivative. If some other distro puts it's .so libraries in a different location this assumption may not be valid.

2a) Cloning the git hub repo and then building from source with a `make` command will work.
2b) Github also gives you the option of downloading a ZIP file of the code. I did not create this zip file it is done automatically by Github. I assume that if you download the ZIP and unpack it this will be the equivalent of cloning it.

3) You are an experienced developer that knows how to build stuff on your system.
If you are going to try to get this program to work on Windows that is your best option. As stated in the User Guide, Windows Subsystem For Linux can run this binary. But maybe not on your system. Maybe you have to rebuild for your WSL. If that is the case you are more or less on your own. I have no experience developing for Windows.

Installation From the Github Repository

Obviously you will need to have already installed `git` if you are going to do this.
First cd to the directory where you want the repo to reside e.g. `cd ~/BridgeStuff`
Second clone the github repo with the command:
`git clone https://github.com/dealerv2/Dealer-Version-2-`
Note the trailing dash.
You should wind up with a new directory under BridgeStuff called: `Dealer-Version-2-`
If you then type the command: `tree -L 1 Dealer-Version-2-` (note the space after the L)

The result will be:

```
.
├── DDS_Demo
├── dealerv2 -> Prod/dealerv2
├── Debug
├── DebugExamples
├── docs
├── DOP
├── DOP4DealerV2.tar.gz
├── Examples
├── include
├── install_dealer.bash
├── lib
├── LICENSE_GPLV3
├── Prod
├── README.md
├── src
├── stdlib
└── Un_install_dealer.bash
└── src/
```

The primary directories of interest are the Prod/ directory and the Examples/ directory.
The binary for Dealer is **dealerv2** in the **Prod** directory. There are many examples of Dealer input files with names beginning with "Descr." in the Examples directory.
To (re)-build the binary cd to the Prod directory and type `make`. Ignore the warnings about unused variables and the tmpname function and so forth.

If you have downloaded the zip file the process is similar. After un-zipping the zip file, you should be able to run the `tree -L` and `make` commands as above.

After Getting The Repository

There are README files in some of the various directories that explain what each one does.
For someone that just wants to use the program, the most important directories are the Prod directory (where the dealerv2 binary is; copy it to wherever you like and run it from there) and the Examples directory where there are several files beginning with "Descr.?????" These are examples of instructions to Dealer to generate various sorts of hands. The other files in this directory are typically outputs from the various Descr.???? files.
Most of the files in the repository are write protected; even for their owner. This is to prevent accidents.

The owner can always give himself write priviledges with: `chmod -R u+w *` if he wants to modify or delete anything.

In order to use OPC hand evaluation or François Dellacherie shapes, you need to install Dealer with s`udo install_dealer.bash` and it will copy the repository structure to `/usr/local/games/DealerV2_4` and `/usr/local/games/DOP`. It will also update your PATH setting in .bashrc. This step is necessary because the paths to the DOP and fdp Perl scripts are hard coded into the program.

FDP

fdp is a perl script consisting of two files. Both of these files are in the lib subdirectory of the DealerV2 distribution. The path to these files is hard coded into the Dealer source as:
`/usr/local/games/DealerV2_4/lib/fdp`

GIB

As explained in the user guide if you want to use the **tricks** function of Dealer you will need to install GIB. How to obtain and install GIB is not something covered here. Furthermore there is really no reason to use GIB once you have Version 2 working. The **dds** function does what the **tricks** function does and does it 5x faster. In the interests of completeness however I will repeat here what is in the User Guide: the name of the GIB program is has been changed for Version 2 from version One. In version One, the program name was 'bridge'. Linux already has a utility called 'bridge' and it refers to configuring LAN cards. So when the user asks for the **tricks** function, Dealer version 2 tries to run the binary `/usr/games/gibcli.` If you do install GIB make sure you either rename it or create a symlink to it accordingly.

DOP

There is one external program that you might want to install however and that is the DOP program that

implements the **opc** function. This is a Perl program. It is in the file: `DOP4DealerV2.tar.gz`
To install this you need to create the directory `/usr/local/games/DOP`. To do this you must have super user privileges. Then you unpack the tarball in that directory. if you type
`tree -L 1 /usr/local/games/DOP` you should see:

```
/usr/local/games/DOP
├── Copyright_Notice.txt
├── Doc
├── DOP -> dop
├── dop
├── DOP_Calculation_Subs_V21.pl
├── DOP_Competition_Subs_V21.pl
├── DOP_main_V21.pl
├── DOP_Requires_V21.pl
├── DOP_Subs2_V20.pl
├── DOP_Subs2_V21.pl
├── DOP_Subs_V21.pl
├── DOP_Util_Subs_V21.pl
├── DOP_Var_Defns_V21.pl
├── Examples
├── GPL_V3.pdf
└── subxref.txt
```

If you want to test that this has worked correctly you can say:
`/usr/local/games/DOP/dop </usr/local/games/DOP/Doc/1deal.dat`
and you will get a bunch of output that starts out looking like this:

```
{******* DOP Deal Detail  Report Deal: 391 ****** QK_Losers}
 Deal# O  HLF_NT NT-D NT-Tx %  LS HLDFl LS-Tx %  [S,NT] \
                                        <------------------- Hand ------------------>
[0391] W  34.50  0, 0 12  55    D 36.50  13  71   0,0   \
                                       [Ax/xxx/Kxxxx/AKx :: xx/AKQx/AQxx/Qxx       ]
[0391] HL[32.50] ADJ[-1] HF[1] FN[2] Misfit[ 0] Mirror[-1] Waste[0.0] noWASTE[  0]
   DFit_in: Sp[0], He[0], Di[2], Cl[0]  FNs=> S[ 0] H[ 0] D[ 2] C[ 0]
    Descr:      6 NT on x pts
```

The Repository Contents

As stated earlier the two directories Prod/ and Examples/ are the ones that are of primary interest to the ordinary user.
Prod/ contains the `dealerv2` binary and the `Makefile` that is used to build this binary.
Examples/ contains sample Dealer Input Files and the results of running some of these files.
It also contains some utilities to check that Dealer is operating correctly. These are of real interest only to those who are rebuilding Dealer from source.
DDS_Demo/ This directory is not related to Dealer directly. It is mainly of interest to developers who want an example of how to use the DDS libraries. See the README file in the directory.
Debug/ This directory is where to build debug versions of Dealer. The main difference is in the Makefile. One of the very first lines defines the symbol JGMDBG which causes the conditional compilation of Debugging statements to be turned on. The other difference is that the compilation is done with the gcc flag -Og (which is approximately equal to -O1 but with some debugging symbols left in) instead of -O3 which optimizes the binary for speed. The output file is called `dealdbg` and if you

run it with ./`dealdbg -D2 -Xjunkfile -0 "x5xx + 5xxx - 1xxx -0xxx" -V`

You should get as output:

```
Version info....
Revision: 102.5.0
Build Date:[2022/11/15]
$Authors: Hans, Henk, JGM $
JGMDBG is defined. Debugging printing to stderr is active
JGMDBG DEFINED= 1 in main
--------HELLO FROM VERSION 102.5.0 ----------
YYDEBUG NOT Defined.  BISON DBG IN_Active.
Showing Options with Verbosity = 1
       g:Maxgenerate=[100000]
       m:ProgressMeter=[0]
       p:Maxproduce=[40]
       q:Quiet=[0]
       s:Seed=[0]
       u:UpperCase=[1]
       v:Verbose=[1 ; 1]
       x:eXchange aka Swapping=[0]
       C:Fname=[] mode=[]
       D:Debug Verbosity=[2] set to 2
       M:DDS Mode=[1] set to 1
       O:Opener=[N, 1]
       P:Par Vuln=[-1]
       R:MaxThreads=[1]
       R:MaxRamMB=[160]
       T:Title=[],len=0
       N:PreDeal=[]
       S:PreDeal=[]
       E:PreDeal=[]
       W:PreDeal=[]
       X:Fname=[junkfile]
       U:Fname=[]
Showing Script Vars with Verbosity = 1
       [$0]=x5xx + 5xxx - 1xxx -0xxx
```

DebugExamples/ This directory contains many Dealer Input Files that were used at one time to test various features of Dealer. They might prove useful or not. Browse at leisure.
docs/ This directory contains the License file, the Copyright Notice, the User Guide and other explanatory documentation.
include/ The directory with the C header files that are included in most of the source files. There is also the dummy headerfile, "`allheaders.h`". If you update the timestamp on this file, usually with a `make allheaders` command, it will cause Dealer to be rebuilt from scratch.
lib/ The directory with some supporting files. The most important one being `libdds.a` the DDS library. it also includes the tarball for the DOP code written in Perl.
src/ The directory that includes all of the .C source files for the program. It also includes the grammar file used by Bison/Yacc, `dealyacc.y` and the lexer file used by Flex, `dealflex.l`

Because the paths to the DOP/OPC, and François shape scripts are hard coded into the Dealer source it is best if the installer runs: `sudo install_dealer.bash` from the repository directory. This will copy all of the repo files to `/usr/local/games/DealerV2_4` and `/usr/local/games/DOP`

and then Dealer can be run from any location without problems.
All of the files in the repository have been write protected to prevent accidents. But the user can easily reverse this with `chmod -R u+w *`

Regression/ This directory will be of interest to those who want to make further mods to dealerv2. It contains code (bash shell and perl scripts) that run the test (new) version of dealerv2 against a series of input files to produce outputs. These outputs are compared to the outputs produced by the current, production version of dealerv2, run against the same input files.

Appendix - Adding the CSV Report

The most extensive piece of functionality I added to Dealer was the CSV report. The DDS functionality had more C code, but did not touch quite as many pieces of Dealer as the CSV report functionality. The following can be used as a kind of checklist if you want to add functionality of your own. Not every step that I took here will be needed.

1. Define the grammar in dealyacc.y
    1.1 a new %token for: CSVRPT, DEAL, SIDE, and TRIX.
    1.2 a new type in the union structure, a pointer to a `struct. struct csvterm_st *y_csv`
    1.3 a new %type for csvlist, `%type <y_csv> csvlist`
    1.4 new rules for csvlist, allowing for expressions, strings, and collections of bridge hands, and trick taking.
    1.5 new rules for the csvrpt action, giving the code to build the new action node of type CSVRPT and add it to the list of actions.
    1.6 new rules for the various terms in the csvlist, to add a node to the list of expressions that are to by printed to the csv report. Populate the node with the type and semantic value.

2. Define the token patterns in dealflex.l
    2.1 when the pattern csvrpt is seen return the value of CSVRPT
    2.1 when the patterns for the csvlist bridge hands are seen set `yylval` accordingly and return the related tokens. (DEAL, TRIX, SIDE, STRING, etc.)

3. Header Files in include directory
    3.1 Define a new type in `dealdefs.h`: a struct that implements the various types of terms in the csvlist
    3.2 Define new variables to hold the output buffer of the report, and an array to hold the results of the trix calculation. Modify `dealglobals.c` and `dealexterns.h` accordingly.
    3.3 Modify the `dealtypes.h` file to reflect the new command line options structure.
    3.4 Modify the `dealprotos.h` file to provide an external link to the new functions in `dealdds_subs.c` and `dealaction_subs.c`
4. Action Subs Code
4.1 Modify the `dealaction_subs.c` file to contain the code to run when an action of type CSVRPT is found. Essentially modify the case statement in the **action()** function. Also add to the case statements in the **setup_action()** and **cleanup_action()** functions.
4.2 Add code to the `dealaction_subs.c` file to format the deal for printout;
5. Add code to `dealdds_subs.c` to call the double dummy solver routines, and to change the mode of the double dummy solver, if required.
6. Add code to the `mainsubs.c` file, and the `dealerv2.c` file to process the new command line switch that gives the filename and write mode of the CSV report file.
7. Write new page in users guide.
8. Conduct regression tests to ensure I did not break anything.
9. Since csvrpt did not require any new evaluation or decision making, no mods to `dealeval_subs.c` were needed.

Top

The DealerServer Infrastructure

The DealerServer functionality is implemented via three components.
1. The first component is the code added to the Dealer program itself. This code is also made up of three components:

1.1 mods to the grammar to parse and process the *usereval* keyword
1.2 mods to the setup portion of Dealer to create the DealerServer shared memory, the semaphores, and to start the execution of the DealerServer daemon.
1.3 mods to the evaluation functions in `dealeval_subs.c` to make use of the numbers returned by the DealerServer daemon.

2. The second component is the DealerServer infrastructure code. This code maps to the shared memory location created in section 1.2 above, and also sets up communication channels via the semaphores. It also looks after keeping the cache up to date. There are in effect two caches, one for each side. The cache is refreshed each time the deal changes, and also if the user asks for a different query aka metric to run. Having this basic code pre-written means the user need only code the third piece.

3. The third component is the code that implements whatever custom evaluation method the user needs to return meaningful numbers to Dealer. This user custom code is linked with the DealerServer infrastructure code and becomes part ofthe DealerServer daemon.

Coding DealerServer Metrics Functions

This repo has code, written in C, that implements many different evaluation metrics. The code is in the `UserEval` subdirectory of the `dealerv2` directory. The main files of interest are: `metrics_calcs.c` and `factors_subs.c` There is also a file, `metrics_util_subs.c` that provides some debug functions and some utility functions such as evaluating Quick Tricks, or Quick Losers, that are not specific to any one metric.
The `factors_subs.c` file contains code that implements parts of an overall metric, such as counting various flavors of HCP, various ways of correcting for short honors, or adding support points when a fit is found and so forth. There is nothing specific to the DealerServer infrastructure in any of them.
The starting point for the DealerServer program is the file, in the `include` directory, called `mmap_template.h` This file describes the layout of the shared memory area; where the DealerServer program can find its input and where it should place its output. The shared memory area is 4096 bytes, which on Linux represents one 'Virtual Page' of memory. It is the smallest unit of memory that Linux itself keeps track of.
The template file splits this 4096 bytes into three main areas:

- The header area, consisting of a description of the remaining areas, the information necessary to the infrastructure to establish communication, and the details of the current query.
- The input data area. This area contains a copy of the deal itself, and of the `handstat` which has been filled out by the `analyze` function. The metrics calculation routines are thus spared the trouble of duplicating work that has already been done by Dealer in `analyze`, such as

counting hcp, or determining suit lengths.

- The results output area. This area has room to hold 64 integer results for each of the NS and EW sides. The metrics calculation routines put their results in this area. The *usereval* function picks up the results from the slot that has been specified in the *usereval* statement.

The overall execution flow of DealerServer is:

- Startup. Use the argc and argv arguments passed to main, to extract the file descriptor that was used to create and map the shared memory area.
  - Use this fd to map to the shared memory. Consult the template file to find the offset of the data structure that describes the semaphores.
  - Open the query and response semaphores.
  - Do any other startup tasks, such as opening a log file, and filling a structure with a set of pointers to all the various areas of the shared memory region using the offsets in the template file.
- Main Loop.
  - Wait on the query semaphore. When a signal is retrieved, get the information about the query submitted, primarily its ID and which side it refers to, from the shared memory region.
  - Call a C function, `userfunc`, passing to that function, several of the pointers from the startup phase in case the user needs them.
  - `userfunc` then executes a switch statement which calls a generic 'reply' function. The reply function in turn calls one of the metrics_calcs functions.
  - When the metrics_calc function returns, post a reply to the Dealer client, and resume waiting on the semaphore for the next query.
  - All of the code to this point is in the `UserServer.c` file in the `UserEval/src/` directory.
- Metrics Calculation Functions.
  - These functions have names such as bergen_calc, dkp_calc, karpin_calc and reside in the `metrics_calcs.c` file. They generally take a single argument, the side for which the value is to be computed. The general intent is that the first time they are called they will calculate all of the values that the user has asked for in the input file; this is a requirement, since otherwise the caching algorithm which only checks the side-tag combination will not work.
  - These metrics calcs use the code in factors_subs.c to determine the degree of fit, deductions for short honors, extra points for intermediates and so forth. When they have completed their role of calculating all of the relevant values these are stored in the results area and the function returns to the generic 'reply' function mentioned earlier.

- Using The Results
  The results area for the side NS, and also for the side EW, each have room for 64 integers. The easiest way to have the metrics_calcs functions work is to just have them put the results in the slots 0 .. 63, and then from the Dealer input file access them with clauses such as: `usereval(10, NS, 16)` or `usereval(4, EW, 63)` The user will need to keep track of which result goes to which slot, but that is fairly straightforward. You can also treat the results area as being split into four 16 slot areas. The first 16 slots are reserved for clauses such as the above, that is just specifying the tag, the side, and the slot number. The next 16 (slots 16 to 31) are the ones used for the results from clauses such as

`usereval(10, NS, spades, 0)` or `usereval(4, NS, clubs,3)`. That is to say, there are 16 slots reserved for the side to report up to 4 values for each suit. But the user does not need to worry about that; it is transparent. The slots 32 to 47 are used when the user enters clauses with a compass direction. There is room for each compass direction to return up to 8 different results, numbered 0 to 7 in clauses such as `usereval(0,north,0)` or `usereval(9,south,7)`. The last set of 16 allows each compass direction to return two results, numbered 0 and 1, for each suit, with the syntax such as `usereval(5, south, spades, 1)` or `usereval(7,north,hearts,0)`.
The process is exactly the same if the user wants results for the EW side; just replace NS with EW, "north" with "east" and "south" with "west" in the above description.

Mixing The Results from Two Different Metrics.

The usereval functionality is fairly efficient since it uses shared memory and a daemon that does not need to be started up from scratch each time. However it pays to be aware that when you ask for several different queries for the same side in the input file, for example a query to evaluate the hands using the Bergen metric and then annother query to evaluate the hands using the Pavlicek metric for the same side, then you will cause the server to be accessed once for each query and the cache will be overwritten each time you do so. If you then try to use the results from the query more than once, you may very well cause several calls to the DealerServer to be made each time.
If you are concerned about the performance hit of doing this, you can take advantage of the fact that there is room for 64 results to be returned on each call, and a metric seldom needs more than five or six of them at most. Therefore you can code a 'mixed' query. In the case of our example of comparing Bergen (query-id 0) and Pavlicek (query-id 10), we can make a mixed query, and give it the id 88 for example. Then when your code sees query-id 88 it can first run the Bergen calcs and store those results in slots 0 to 7 say, and then run the Pavlicek calcs and store those results in slots 8 to 15.
As far as the caching mechanism is concerned you have run only one query, query 88, and those 16 results will be kept in the cache until the next deal. You then access these results with clauses such as `usereval(88, NS, 6)` (for Bergen) or `usereval(88, NS, 13)` (for Pavlicek).
If you further place your usereval clauses at the end of the condition statement as recommended for the other 'slower' functionallity of Dealer, such as DDS, GIB and OPC, your performance will be quite acceptable.