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Latest DLL issue with this description is available at <http://www.bahnhof.se/wb758135/>

### **Description of the DLL functions supported in Double Dummy Problem Solver 2.8.3**

#### **Callable functions**

The callable functions are all preceded with `extern "C" __declspec(dllimport) int __stdcall`. The prototypes are available in `dll.h` in the "include" directory.

[Return codes](#) are given at the end.

Not all functions are present in all versions of the DLL. For historical reasons, the function names are not entirely consistent with respect to the input format. Functions accepting binary deals will end on Bin, and those accepting PBN deals will end on PBN in the future. At some point existing function names may be changed as well, so use the new names!

#### *The Basic Functions*

The basic functions `SolveBoard` and `SolveBoardPBN` each solve a single hand and are thread-safe, making it possible to use them for solving several hands in parallel. The other callable functions use the `SolveBoard` functions either directly or indirectly.

#### *The Multi-Thread Double Dummy Solver Functions*

The double dummy trick values for all  $5 \cdot 4 = 20$  possible combinations of a hand's trump strain and declarer hand alternatives are solved by a single call to one of the functions `CalcDDtable` and `CalcDDtablePBN`. Threads are allocated per strain in order to save computations.

To obtain better utilization of available threads, the double dummy (DD) tables can be grouped using one of the functions `CalcAllTables` and `CalcAllTablesPBN`.

Solving hands can be done much more quickly using one of the multi-thread alternatives for calling `SolveBoard`. Then a number of hands are grouped for a single call to one of the functions `SolveAllBoards`, `SolveAllChunksBin` and `SolveAllChunksPBN`. The hands are then solved in parallel using the available threads.

The number of threads is automatically configured by DDS on Windows, taking into account the number of processor cores and available memory. The number of threads can be influenced by calling `SetMaxThreads`. This function should probably always be called on Linux/Mac, with a zero argument for auto-configuration.

Calling `FreeMemory` causes DDS to give up its dynamically allocated memory.

### *The PAR Calculation Functions*

The PAR calculation functions find the optimal contract(s) assuming open cards and optimal bidding from both sides. In very rare cases it matters which side or hand that starts the bidding, i.e. which side or hand that is first to bid its optimal contract.

Two alternatives are given:

1. The PAR scores / contracts are calculated separately for each side. In almost all cases the results will be identical for both sides, but in rare cases the result is dependent on which side that “starts the bidding”, i.e. that first finds the bid that is most beneficial for the own side. One example is when both sides can make 1 NT.
2. The dealer hand is assumed to “start the bidding”.

The presentation of the par score and contracts are given in alternative formats.

The functions Par, SidesPar and DealerPar do the par calculation; their call must be preceded by a function call calculating the double dummy table values.

The functions SidesParBin and DealerParBin provide binary output of the par results, making it easy to tailor-make the output text format. Two such functions, ConvertToSidesTextFormat and ConvertToDealerTextFormat, are included as examples.

It is possible as an option to perform par calculation in CalcAllTables and CalcAllTablesPBN.

The par calculation is executed using a single thread. But the calculation is very fast and its duration is negligible compared to the double dummy calculation duration.

### *Double Dummy Value Analyser Functions*

The functions AnalysePlayBin, AnalysePlayPBN, AnalyseAllPlaysBin and AnalyseAllPlaysPBN take the played cards in a game or games and calculate and present their double dummy values.

Function	Arguments	Format	Comment
<a href="#">SolveBoard</a>	struct <a href="#">deal</a> dl, int target, int solutions, int mode, struct <a href="#">futureTricks</a> *futp, int threadIndex	Binary	The most basic function, solves a single hand from the beginning or from later play
<a href="#">SolveBoardPBN</a>	struct <a href="#">dealPBN</a> dlPBN, int target, int solutions, int mode, struct <a href="#">futureTricks</a> *futp, int threadIndex	PBN	As SolveBoard, but with PBN deal format.
<a href="#">CalcDDtable</a>	struct <a href="#">ddTableDeal</a> tableDeal, struct <a href="#">ddTableResults</a> * tablep	Binary	Solves an initial hand for all possible declarers and denominations (up to 20 combinations)
<a href="#">CalcDDtablePBN</a>	struct <a href="#">ddTableDealPBN</a> tableDealPBN, struct <a href="#">ddTableResults</a> * tablep	PBN	As CalcDDtable, but with PBN deal format.
<a href="#">CalcAllTables</a>	struct <a href="#">ddTableDeals</a> * dealsp, int mode, int trumpFilter[5], struct <a href="#">ddTablesRes</a> *resp, struct <a href="#">allParResults</a> * presp	Binary	Solves a number of hands in parallel. Multi-threaded.
<a href="#">CalcAllTablesPBN</a>	struct <a href="#">ddTableDealsPBN</a> *dealsp, int mode, int trumpFilter[5], struct <a href="#">ddTablesRes</a> *resp, struct <a href="#">allParResults</a> * presp	PBN	As CalcAllTables, but with PBN deal format.
<a href="#">SolveAllBoards</a>	struct <a href="#">boardsPBN</a> *bop, struct <a href="#">solvedBoards</a> * solvedp	PBN	Consider using this instead of the next 3 “Chunk” functions”!
<a href="#">SolveAllChunksBin</a>	struct <a href="#">boards</a> *bop, struct <a href="#">solvedBoards</a> *solvedp, int chunkSize	Binary	Solves a number of hands in parallel. Multi-threaded.
<a href="#">SolveAllChunks</a>	struct <a href="#">boardsPBN</a> *bop, struct <a href="#">solvedBoards</a> * solvedp, int chunkSize	PBN	Alias for SolveAllChunksPBN; don’t use!
<a href="#">SolveAllChunksPBN</a>	struct <a href="#">boardsPBN</a> *bop, struct <a href="#">solvedBoards</a> * solvedp, int chunkSize	PBN	Solves a number of hands in parallel. Multi-threaded.

<a href="#">Par</a>	struct <a href="#">ddTableResults</a> * tablep, struct <a href="#">parResults</a> *presp, int vulnerable	No format	Solves for the par contracts given a DD result table.
<a href="#">DealerPar</a>	struct <a href="#">ddTableResults</a> * tablep, struct <a href="#">parResultsDealer</a> * presp, int dealer, int vulnerable	No format	Similar to Par(), but requires and uses knowledge of the dealer.
<a href="#">DealerParBin</a>	struct <a href="#">ddTableResults</a> * tablep, struct <a href="#">parResultsMaster</a> * presp, int dealer, int vulnerable	Binary	Similar to DealerPar, but with binary output.
<a href="#">ConvertToDealerTextFormat</a>	struct <a href="#">parResultsMaster</a> * pres, char *resp	Text	Example of text output from DealerParBin.
<a href="#">SidesPar</a>	struct <a href="#">ddTableResults</a> *tablep, struct <a href="#">parResultsDealer</a> * presp, int vulnerable	No format	Par results are given for sides with the DealerPar output format.
<a href="#">SidesParBin</a>	struct <a href="#">ddTableResults</a> * tablep, struct <a href="#">parResultsMaster</a> sidesRes[2], int vulnerable	Binary	Similar to SidesPar, but with binary output.
<a href="#">ConvertToSidesTextFormat</a>	struct <a href="#">parResultsMaster</a> * pres, struct <a href="#">parTextResults</a> * resp	Text	Example of text output from SidesParBin.
<a href="#">CalcPar</a>	struct <a href="#">ddTableDeal</a> tableDeal, int vulnerable, struct <a href="#">ddTableResults</a> * tablep, struct <a href="#">parResults</a> * presp	Binary	Solves for both the DD result table and the par contracts. Is deprecated, use a CalcDDtable function plus Par() instead!
<a href="#">CalcParPBN</a>	struct <a href="#">ddTableDealPBN</a> tableDealPBN, struct <a href="#">ddTableResults</a> * tablep, int vulnerable, struct <a href="#">parResults</a> * presp	PBN	As CalcPar, but with PBN input format. Is deprecated, use a CalcDDtable function plus Par() instead!

<a href="#">AnalysePlayBin</a>	struct <a href="#">deal</a> dl, struct <a href="#">playTraceBin</a> play, struct <a href="#">solvedPlay</a> * solvedp, int thrId	Binary	Returns the par result after each card in a particular play sequence
<a href="#">AnalysePlayPBN</a>	struct <a href="#">dealPBN</a> dlPBN, struct <a href="#">playTracePBN</a> playPBN, struct <a href="#">solvedPlay</a> * solvedp, int thrId	PBN	As AnalysePlayBin, but with PBN deal format.
<a href="#">AnalyseAllPlaysBin</a>	struct <a href="#">boards</a> *bop, struct <a href="#">playTracesBin</a> *plp, struct <a href="#">solvedPlays</a> * solvedp, int chunkSize	Binary	Solves a number of hands with play sequences in parallel. Multi-threaded.
<a href="#">AnalyseAllPlaysPBN</a>	struct <a href="#">boardsPBN</a> *bopPBN, struct <a href="#">playTracesPBN</a> * plpPBN, struct <a href="#">solvedPlays</a> * solvedp, int chunkSize	PBN	As AnalyseAllPlaysBin, but with PBN deal format.
<a href="#">SetMaxThreads</a>	int userThreads		Used at initial start and can also be called with a request for allocating memory for a specified number of threads. Is apparently mandatory on Linux and Mac (optional on Windows)
<a href="#">FreeMemory</a>	void		Frees all allocated dynamical memory.
<a href="#">GetDDSInfo</a>	<a href="#">DDSInfo</a> * info		
ErrorMessage	int code, char line[80]		Turns a return code into an error message string

## Data structures

Common encodings are as follows.

Encoding	Element	Value
Suit	Spades	0
	Hearts	1
	Diamonds	2
	Clubs	3
	NT	4
Hand	North	0
	East	1
	South	2
	West	3
Vulnerable	None	0
	Both	1
	NS only	2
	EW only	3
Side	N-S	0
	E-W	1
Card	Bit 2	Rank of deuce
	...	
	Bit 13	Rank of king
	Bit 14	Rank of ace
Holding	A value of 16388 = 16384 + 4 is the encoding for the holding "A2" (ace and deuce). The two lowest bits are always zero.	
PBN	Whole hand	Example: W:T5.K4.652.A98542 K6.QJT976.QT7.Q6 432.A.AKJ93.JT73 AQJ987.8532.84.K

struct	Field	Comment
deal	int trump;	<a href="#">Suit</a> encoding
	int first;	The hand leading to the trick. <a href="#">Hand</a> encoding
	int currentTrickSuit[3];	Up to 3 cards may already have been played to the trick. <a href="#">Suit</a> encoding. Set to 0 if no card has been played.
	int currentTrickRank[3];	Up to 3 cards may already have been played to the trick. Value range 2-14. Set to 0 if no card has been played.
	unsigned int remainCards[4][4];	1st index is <a href="#">Hand</a> , 2nd index is <a href="#">Suit</a> . remainCards uses <a href="#">Holding</a> encoding.

struct	Field	Comment
dealPBN	int trump;	<a href="#">Suit</a> encoding
	int first;	The hand leading to the trick. <a href="#">Hand</a> encoding
	int currentTrickSuit[3];	Up to 3 cards may already have been played to the trick. <a href="#">Suit</a> encoding.
	int currentTrickRank[3];	Up to 3 cards may already have been played to the trick. Value range 2-14. Set to 0 if no card has been played.
	char remainCards[80];	Remaining cards. <a href="#">PBN</a> encoding.

struct	Field	Comment
ddTableDeal	unsigned int cards[4][4];	Encodes a deal. First index is hand. <a href="#">Hand</a> encoding. Second index is suit. <a href="#">Suit</a> encoding.

struct	Field	Comment
ddTableDealPBN	char cards[80];	Encodes a deal. <a href="#">PBN</a> encoding.

struct	Field	Comment
ddTableDeals	int noOfTables;	Number of DD table deals in structure, at most MAXNOOFTABLES
	struct <a href="#">ddTableDeal</a> deals[X];	$X = \text{MAXNOOFTABLES} * \text{DDS\_STRAINS}$

struct	Field	Comment
ddTableDealsPBN	int noOfTables;	Number of DD table deals in structure
	struct <a href="#">ddTableDealPBN</a> deals[X];	$X = \text{MAXNOOFTABLES} * \text{DDS\_STRAINS}$

struct	Field	Comment
boards	int noOfBoards;	Number of boards
	struct <a href="#">deal</a> [MAXNOOFBOARDS];	
	int target [MAXNOOFBOARDS];	See <a href="#">SolveBoard</a>
	int solutions [MAXNOOFBOARDS];	See <a href="#">SolveBoard</a>
	int mode [MAXNOOFBOARDS];	See <a href="#">SolveBoard</a>

struct	Field	Comment
boardsPBN	int noOfBoards;	Number of boards
	struct <a href="#">dealPBN</a> [MAXNOOFBOARDS];	
	int target [MAXNOOFBOARDS];	See <a href="#">SolveBoard</a>
	int solutions [MAXNOOFBOARDS];	See <a href="#">SolveBoard</a>
	int mode [MAXNOOFBOARDS];	See <a href="#">SolveBoard</a>

struct	Field	Comment
futureTricks	int nodes;	Number of nodes searched by the DD solver
	int cards;	Number of cards for which a result is returned. May be all the cards, but equivalent ranks are omitted, so for a holding of KQ76 only the cards K and 7 would be returned, and the “equals” field below would be 2048 (Q) for the king and 54 (6) for the 7.
	int suit[13];	Suit of the each returned card. <a href="#">Suit</a> encoding
	int rank[13];	Rank of the returned card. Value range 2-14.
	int equals[13];	Lower-ranked equals. <a href="#">Holding</a> encoding.
	int score[13];	-1: target not reached. Otherwise: Target of maximum number of tricks.

struct	Field	Comment
solvedBoards	int noOfBoards;	
	struct <a href="#">futureTricks</a> solvedBoard [MAXNOOFBOARDS];	

Struct	Field	Comment
ddTableResults	int resTable[5][4];	Encodes the solution of a deal for combinations of denomination and declarer. First index is denomination. <a href="#">Suit</a> encoding. Second index is declarer. <a href="#">Hand</a> encoding. Each entry is a number of tricks.

Struct	Field	Comment
ddTablesRes	int noOfBoards;	Number of DD table deals in structure, at most MAXNOOFTABLES
	struct <a href="#">ddTableResults</a> results[X];	X = MAXNOOFTABLES * DDS_STRAINS



struct	Field	Comment
parResults	char parScore[2][16];	First index is NS/EW. <a href="#">Side</a> encoding.
	char parContractsString[2][128];	First index is NS/EW. <a href="#">Side</a> encoding.

struct	Field	Comment
allParResults	struct parResults [MAXNOOFTABLES];	There are up to 20 declarer/strain combinations per DD table

struct	Field	Comment
parResultsDealer	int number;	
	int score;	
	char contracts[10][10];	

struct	Field	Comment
parResultsMaster	int score;	
	int number;	
	struct <a href="#">contractType</a> contracts[10];	

struct	Field	Comment
contractType	int underTricks;	
	int overTricks;	
	int level;	
	int denom;	
	int seats;	

struct	Field	Comment
parTextResults	char parText[2][128];	
	int equal;	

struct	Field	Comment
DDSInfo	int major, minor patch;	
	char versionString[10];	Printable version string
	int system;	0 unknown, 1 Windows, 2 Cygwin, 3 Linux, 4 Apple
	int compiler;	0 unknown, 1 Microsoft Visual C++, 2 mingw, 3 GNU g++, 4 clang
	int constructor;	0 none, 1 DLLMain, 2 Unix-style
	int threading;	0 none, 1 Windows, 2 OpenMP, 3 GCD
	int noOfThreads;	
	char systemString[512];	Printable summary string

struct	Field	Comment
playTraceBin	int number;	Number of cards in the play trace, starting from the first card in the trace (so excluding any cards in deal in currentTrickSuit and currentTrickRank)
	int suit[52];	<a href="#">Suit</a> encoding.
	int rank[52];	Encoding 2 .. 14 (not <a href="#">Card</a> encoding).

struct	Field	Comment
playTracePBN	int number;	Number of cards in the play trace, starting as in playTraceBin
	char cards[106];	String of cards with no space in between, also not between tricks. Each card consists of a suit (C/D/H/S) and then a rank (2 .. A). The string must be null-terminated.

struct	Field	Comment
playTracesBin	int noOfBoards;	
	struct <a href="#">playTraceBin</a> plays[MAXNOOFBOARDS];	

struct	Field	Comment
playTracesPBN	int noOfBoards;	
	Struct <a href="#">playTracePBN</a> plays[MAXNOOFBOARDS];	

struct	Field	Comment
solvedPlay	int number;	
	int tricks[53];	Starting position and up to 52 cards

struct	Field	Comment
solvedPlays	int noOfBoards;	
	struct <a href="#">solvedPlay</a> solved[MAXNOOFBOARDS];	

## Functions

### SolveBoard

```
struct deal dl,  
int target,  
int solutions,  
int mode,  
struct futureTricks *futp,  
int threadIndex
```

### SolveBoardPBN

```
struct dealPBN dl,  
int target,  
int solutions,  
int mode,  
struct futureTricks *futp,  
int threadIndex
```

SolveBoardPBN is just like SolveBoard, except for the input format. Historically it was one of the first functions, and it exposes the thread index directly to the user. Later functions generally don't do that, and they also hide the implementation details such as transposition tables, see below.

SolveBoard solves a single deal “**dl**” and returns the result in “**\*futp**” which must be declared before calling SolveBoard.

If you have multiple hands to solve, it is always better to group them together into a single function call than to use SolveBoard.

SolveBoard is thread-safe, so several threads can call SolveBoard in parallel. Thus the user of DDS can create threads and call SolveBoard in parallel over them. The maximum number of threads is fixed in the DLL at compile time and is currently 16. So “**threadIndex**” must be between 0 and 15 inclusive; see also the function SetMaxThreads. Together with the PlayAnalyse functions, this is the only function that exposes the thread number to the user.

There is a “transposition table” memory associated with each thread. Each node in the table is effectively a position after certain cards have been played and other certain cards remain. The table is not deleted automatically after each call to SolveBoard, so it can be reused from call to call. However, it only really makes sense to reuse the table when the hand is very similar in the two calls. The function will still run if this is not the case, but it won't be as efficient. The reuse of the transposition table can be controlled by the “**mode**” parameter, but normally this is not needed and should not be done.

The three parameters “**target**”, “**solutions**” and “**mode**” together control the function. Generally speaking, the target is the number of tricks to be won (at least) by the side to play; solutions controls how many solutions should be returned; and mode controls the search behavior. See next page for definitions.

For equivalent cards, only the highest is returned, and lower equivalent cards are encoded in the [futureTricks](#) structure (see “equals”).

target	solutions	Comment
-1	1	Find the maximum number of tricks for the side to play. Return only one of the optimum cards and its score.
-1	2	Find the maximum number of tricks for the side to play. Return all optimum cards and their scores.
0	1	Return only one of the cards legal to play, with score set to 0.
0	2	Return all cards that legal to play, with score set to 0.
1 .. 13	1	If score is -1: Target cannot be reached. If score is 0: In fact no tricks at all can be won. If score is > 0: score will always equal target, even if more tricks can be won. One of the cards achieving the target is returned.
1 .. 13	2	Return all cards meeting (at least) the target. If the target cannot be achieved, only one card is returned with the score set as above.
any	3	Return all cards that can be legally played, with their scores in descending order.

mode	Reuse TT?	Comment
0	Automatic if same trump suit and the same or nearly the same cards distribution,	Do not search to find the score if the hand to play has only one card, including its equivalents, to play. Score is set to -2 for this card, indicating that there are no alternative cards. If there are multiple choices for cards to play, search is done to find the score. This mode is very fast but you don't always search to find the score.  Always search to find the score. Even when the hand to play has only one card, with possible equivalents, to play.
1	deal.first can be different.	
2	Always	

**Note:** mode no longer always has this effect internally in DDS. We think mode is no longer useful, and we may use it for something else in the future. If you think you need it, let us know!

“Reuse” means “reuse the transposition table from the previous run with the same thread number”. For mode = 2 it is the responsibility of the programmer using the DLL to ensure that reusing the table is safe in the actual situation. Example: Deal is the same, except for deal.first. The trump suit is the same.

```

1st call, East leads:  SolveBoard(deal, -1, 1, 1, &fut, 0), deal.first=1
2nd call, South leads: SolveBoard(deal, -1, 1, 2, &fut, 0), deal.first=2
3rd call, West leads:  SolveBoard(deal, -1, 1, 2, &fut, 0), deal.first=3
4th call, North leads: SolveBoard(deal, -1, 1, 2, &fut, 0), deal.first=0

```

### CalcDDtable

```
struct ddTableDeal tableDeal,  
struct ddTableResults * tablep
```

### CalcDDtablePBN

```
struct ddTableDealPBN tableDealPBN,  
struct ddTableResults * tablep
```

CalcDDtablePBN is just like CalcDDtable, except for the input format.

CalcDDtable solves a single deal “**tableDeal**” and returns the double-dummy values for the initial 52 cards for all the 20 combinations of denomination and declarer in “**\*tablep**”, which must be declared before calling CalcDDtable.

### CalcAllTables

```
struct ddTableDeals *dealsp,  
int mode,  
int trumpFilter[5],  
struct ddTablesRes *resp,  
struct allParResults *presp
```

### CalcAllTablesPBN

```
struct ddTableDealsPBN *dealsp,  
int mode,  
int trumpFilter[5],  
struct ddTablesRes *resp,  
struct allParResults *presp
```

CalcAllTablesPBN is just like CalcAllTables, except for the input format.

CallAllTables calculates the double dummy values of the denomination/declarer hand combinations in “**\*dealsp**” for a number of DD tables in parallel. This increases the speed compared to calculating these values using a CalcDDtable call for each DD table. The results are returned in “**\*resp**” which must be defined before CalcAllTables is called.

The “**mode**” parameter contains the vulnerability ([Vulnerable](#) encoding; not to be confused with the SolveBoard **mode**) for use in the par calculation. It is set to -1 if no par calculation is to be performed.

There are 5 possible denominations or strains (the four trump suits and no trump). The parameter “**trumpFilter**” describes which, if any, of the 5 possibilities that will be *excluded* from the calculations. They are defined in [Suit](#) encoding order, so setting trumpFilter to {FALSE, FALSE, TRUE, TRUE, TRUE} means that values will only be calculated for the trump suits spades and hearts.

The maximum number of DD tables in a CallAllTables call depends on the number of strains required, see the following table:

Number of strains	Maximum number of DD tables
5	32
4	40
3	53
2	80
1	160

### SolveAllBoards

```
struct boards *bop,  
struct solvedBoards  
    * solvedp
```

### SolveAllChunksBin

```
struct boards *bop,  
struct solvedBoards *solvedp,  
int chunkSize
```

### SolveAllChunksPBN

```
struct boardsPBN *bop,  
struct solvedBoards *solvedp,  
int chunkSize
```

**SolveAllChunks** is an alias for SolveAllChunksPBN; don't use it.

**SolveAllBoards** used to be an alias for SolveAllChunksPBN with a chunkSize of 1; however this has been changed in v2.8, and we now recommend only to use SolveAllBoards and not the chunk functions any more; explanation follows.

The SolveAll\* functions invoke SolveBoard several times in parallel in multiple threads, rather than sequentially in a single thread. This increases execution speed. Up to 200 boards are permitted per call.

It is important to understand the parallelism and the concept of a chunk.

If the chunk size is 1, then each of the threads starts out with a single board. If there are four threads, then boards 0, 1, 2 and 3 are initially solved. If thread 2 is finished first, it gets the next available board, in this case board 4. Perhaps this is a particularly easy board, so thread 2 also finishes this board before any other thread completes. Thread 2 then also gets board 5, and so on. This continues until all boards have been solved. In the end, three of the threads will be waiting for the last thread to finish, which causes a bit of inefficiency.

The transposition table in a given thread (see [SolveBoard](#)) is generally not reused between board 2, 4 and 5 in thread 2. This only happens if SolveBoard itself determines that the boards are suspiciously similar.

If the chunk size is 2, then initially thread 0 gets boards 0 and 1, thread 1 gets boards 2 and 3, thread 2 gets boards 4 and 5, and thread 3 gets boards 6 and 7. When a thread is finished, it gets two new boards in one go, for instance boards 8 and 9. The transposition table in a given thread is reused within a chunk.

No matter what the chunk size is, the boards are solved in parallel. If the user knows that boards are grouped in chunks of 2 or 10, it is possible to force the DD solver to use this knowledge. However, this is rather limiting on the user, as the alignment must remain perfect throughout the batch.

SolveAllBoards now detects repetitions automatically within a batch, whether or not the hands are evenly arranged and whether or not the duplicates are next to each other. This is more flexible and transparent to the user, and the overhead is negligible. Therefore, use SolveAllBoards!

### Par

```
struct ddTableResults *tablep,  
struct parResults *presp,  
int vulnerable
```

### DealerPar

```
struct ddTableResults *tablep,  
struct parResultsDealer *presp,  
int dealer,  
int vulnerable
```

### SidesPar

```
struct ddTableResults *tablep,  
struct parResultsDealer *sidesRes[2],  
int vulnerable
```

### DealerParBin

```
struct ddTableResults *tablep,  
struct parResultsMaster * presp,  
int vulnerable
```

### SidesParBin

```
struct ddTableResults *tablep,  
struct parResultsMaster * presp,  
int dealer,  
int vulnerable
```

### ConvertToDealerTextFormat

```
struct parResultsMaster *pres,  
char *resp
```

### ConvertToSidesTextFormat

```
struct parResultsMaster *pres,  
struct parTextResults *resp
```

The functions Par, DealerPar, SidesPar, DealerParBin and SidesParBin calculate the par score and par contracts of a given double-dummy solution matrix “**\*tablep**” which would often be the solution of a call to [CalcDDtable](#). Since the input is a table, there is no PBN and non-PBN version of these functions.

Before the functions can be called, a structure of the type “**parResults**”, “**parResultsDealer**” or “**parResultsMaster**” must already have been defined.

The “**vulnerable**” parameter is given using [Vulnerable](#) encoding.

The Par() function uses knowledge of the vulnerability, but not of the dealer. It attempts to return results for both declaring sides. These results can be different in some rare cases, for instance when both sides can make 1NT due to the opening lead.

The DealerPar() function also uses knowledge of the “**dealer**” using [Hand](#) encoding. The argument is that in all practical cases, the dealer is known when the vulnerability is known. Therefore all results returned will be for the same side.

The SidesPar() function is similar to the Par() function, the only difference is that the par results are given in the same format as for DealerPar().

In Par() and SidesPar() there may be more than one par score; in DealerPar() that is not the case. Par() returns the scores as a text string, for instance “NS -460”, while DealerPar() and SidesPar() use an integer, -460.

There may be several par contracts, for instance 3NT just making and 5C just making. Each par contract is returned as a text string. The formats are a bit different between the two output

format alternatives.

Par() returns the par contracts separated by commas. Possible different trick levels of par score contracts are enumerated in the contract description, e.g the possible trick levels 3, 4 and 5 in no trump are given as 345N. Pass is also a possible (though very rare) par contract. Examples:

- “NS:NS 23S,NS 23H”. North and South as declarer make 2 or 3 spades and hearts contracts, 2 spades and 2 hearts with an overtrick. This is from the NS view, shown by “NS:” meaning that NS made the first bid. Note that this information is actually not enough, as it may be that N and S can make a given contract and that either E or W can bid this same contract (for instance 1NT) before N but not before S. So in the rare cases where the NS and EW sides are not the same, the results will take some manual inspection.
- “NS:NS 23S,N 23H”: Only North makes 3 hearts.
- “EW:NS 23S,N 23H”: This time the result is the same when EW open the bidding.

DealerPar() and SidesPar() give each par contract as a separate text string:

- “4S\*-EW-1” means that E and W can both sacrifice in four spades doubled, going down one trick.
- “3N-EW” means that E and W can both make exactly 3NT.
- “4N-W+1” means that only West can make 4NT+1. In the last example, 5NT just making can also be considered a par contract, but North-South don’t have a profitable sacrifice against 4NT, so the par contract is shown in this way. If North-South did indeed have a profitable sacrifice, perhaps 5C\*\_NS-2, then par contract would have been shown as “5N-W”. Par() would show “4N-W+1” as “W 45N”.
- SidesPar() give the par contract text strings as described above for each side.

DealerParBin and SidesParBin are similar to DealerPar and SidesPar, respectively, except that both functions give the output results in binary using the “[parResultsMaster](#)” structure. This simplifies the writing of a conversion program to get an own result output format. Examples of such programs are ConvertToDealerTextFormat and ConvertToSidesTextFormat.

After DealerParBin or SidesParBin is called, the results in parResultsMaster are used when calling ConvertToDealerTextFormat resp. ConvertToSidesTextFormat.

Output example from ConvertToDealerTextFormat:

“Par 110: NS 2S NS 2H”

Output examples from ConvertToSidesTextFormat:

“NS Par 130: NS 2D+2 NS 2C+2” when it does not matter who starts the bidding.

”NS Par -120: W 2NT

EW Par 120: W 1NT+1” when it matters who starts the bidding.



**CalcPar**

```
struct ddTableDeal dl  
int vulnerable,  
struct ddTableResults * tp,  
struct parResults *presp
```

**CalcParPBN**

```
struct ddTableDealPBN dl,  
struct ddTableResults * tp,  
int vulnerable,  
struct parResults *presp
```

CalcParPBN is just like CalcPar, except for the input format.

Each of these functions calculates both the double-dummy table solution and the par solution to a given deal.

Both functions are deprecated. Instead use one of the CalcDDtable functions followed by Par().

### AnalysePlayBin

```
struct deal dl,  
struct playTraceBin play,  
struct solvedPlay *solvedp,  
int thrId
```

### AnalysePlayPBN

```
struct dealPBN dlPBN,  
struct playTracePBN playPBN,  
struct solvedPlay *solvedp,  
int thrId
```

AnalysePlayPBN is just like AnalysePlayBin, except for the input format.

The function returns a list of double-dummy values after each specific played card in a hand. Since the function uses [SolveBoard](#), the same comments apply concerning the thread number “thrId” and the transposition tables.

As an example, let us say the DD result in a given contract is 9 tricks for declarer. The play consists of the first trick, two cards from the second trick, and then declarer claims. The lead and declarer’s play to the second trick (he wins the first trick) are sub-optimal. Then the trace would look like this, assuming each sub-optimal costs 1 trick:

9 10 10 10 10 9 9

The number of tricks are always seen from declarer’s viewpoint (he is the one to the right of the opening leader). There is one more result in the trace than there are cards played, because there is a DD value before any card is played, and one DD value after each card played.

As of v2.8.3, the functions can be invoked not just from the beginning of a 13-trick hand, but from any position. Cards in dl.currentTrickSuit and dl.currentTrickRank are respected.

### AnalyseAllPlaysBin

```
struct boards *bop,  
struct playTracesBin *plp,  
struct solvedPlays *solvedp,  
int chunkSize
```

### AnalyseAllPlaysPBN

```
struct boardsPBN *bopPBN,  
struct playTracesPBN *plpPBN,  
struct solvedPlays *solvedp,  
int chunkSize
```

AnalyseAllPlaysPBN is just like AnalyseAllPlaysBin, except for the input format.

The AnalyseAllPlays\* functions invoke SolveBoard several times in parallel in multiple threads, rather than sequentially in a single thread. This increases execution speed. Up to 20 boards are permitted per call.

Concerning chunkSize, exactly the same remarks apply as with [SolveAllChunksBin](#).

## **SetMaxThreads**

`int userThreads`

## **FreeMemory**

`void`

**SetMaxThreads** returns the actual number of threads.

DDS has a preferred memory size per thread, currently about 95 MB, and a maximum memory size per thread, currently about 160 MB. It will also not use more than 70% of the available memory. It will not create more threads than there are processor cores, as this will only require more memory and will not improve performance. Within these constraints, DDS auto-configures the number of threads.

DDS first detects the number of cores and the available memory. If this doesn't work for some reason, it defaults to 1 thread which is allowed to use the maximum memory size per thread.

DDS then checks whether a number of threads equal to the number of cores will fit within the available memory when each thread may use the maximum memory per thread. If there is not enough memory for this, DDS scales back its ambition. If there is enough memory for the preferred memory size, then DDS still creates a number of threads equal to the number of cores. If there is not even enough memory for this, DDS scales back the number of threads to fit within the memory.

The user can suggest to DDS a number of threads by calling **SetMaxThreads**. DDS will never create more threads than requested, but it may create fewer if there is not enough memory, calculated as above. Calling **SetMaxThreads** is optional, not mandatory. DDS will always select a suitable number of threads on its own.

It may be possible, especially on non-Windows systems, to call **SetMaxThreads()** actively, even though the user does not want to influence the default values. In this case, use a 0 argument.

**SetMaxThreads** can be called multiple times even within the same session. So it is theoretically possible to change the number of threads dynamically.

It is possible to ask DDS to give up its dynamically allocated memory by calling **FreeMemory**. This could be useful for instance if there is a long pause where DDS is not used within a session. DDS will free its memory when the DLL detaches from the user program, so there is no need for the user to call this function before detaching.

## **GetDDSInfo**

`DDSInfo * info`

This function returns various system and version information.

## Return codes

Value	Code	Comment
1	RETURN_NO_FAULT	
-1	RETURN_UNKNOWN_FAULT	Currently happens when fopen() returns an error or when AnalyseAllPlaysBin() gets a different number of boards in its first two arguments.
-2	RETURN_ZERO_CARDS	SolveBoard(), self-explanatory.
-3	RETURN_TARGET_TOO_HIGH	SolveBoard(), target is higher than the number of tricks remaining.
-4	RETURN_DUPLICATE_CARDS	SolveBoard(), self-explanatory.
-5	RETURN_TARGET_WRONG_LO	SolveBoard(), target is less than -1.
-7	RETURN_TARGET_WRONG_HI	SolveBoard(), target is higher than 13.
-8	RETURN_SOLNS_WRONG_LO	SolveBoard(), solutions is less than 1.
-9	RETURN_SOLNS_WRONG_HI	SolveBoard(), solutions is higher than 3.
-10	RETURN_TOO_MANY_CARDS	SolveBoard(), self-explanatory.
-12	RETURN_SUIT_OR_RANK	SolveBoard(), either currentTrickSuit or currentTrickRank have wrong data.
-13	RETURN_PLAYED_CARD	SolveBoard(), card already played is also a card still remaining to play.
-14	RETURN_CARD_COUNT	SolveBoard(), wrong number of remaining cards for a hand.
-15	RETURN_THREAD_INDEX	SolveBoard(), thread number is less than 0 or higher than the maximum permitted.
-16	RETURN_MODE_WRONG_LO	SolveBoard(), mode is less than 0.
-17	RETURN_MODE_WRONG_HI	SolveBoard(), mode is greater than 2.
-18	RETURN_TRUMP_WRONG	SolveBoard(), trump is not one or 0, 1, 2, 3, 4
-19	RETURN_FIRST_WRONG	SolveBoard(), first is not one or 0, 1, 2
-98	RETURN_PLAY_FAULT	AnalysePlay*() family of functions. (a) Less than 0 or more than 52 cards supplied. (b) Invalid suit or rank supplied. (c) A played card is not held by the right player.
-99	RETURN_PBN_FAULT	Returned from a number of places if a PBN string is faulty.
-101	RETURN_TOO_MANY_THREADS	Currently never returned.
-102	RETURN_THREAD_CREATE	Returned from multi-threading functions.
-103	RETURN_THREAD_WAIT	Returned from multi-threading functions when something went wrong while waiting for all threads to complete.
-201	RETURN_NO_SUIT	CalcAllTables*(), returned when the denomination filter vector has no entries
-202	RETURN_TOO_MANY_TABLES	CalcAllTables*(), returned when too many tables are requested.
-301	RETURN_CHUNK_SIZE	SolveAllChunks*(), returned when the chunk size is < 1.

## Revision History

Rev A, 2006-02-25.	First issue.
Rev B, 2006-03-20	Updated issue.
Rev C, 2006-03-28	Updated issue. Addition of the SolveBoard parameter "mode".
Rev D, 2006-04-05	Updated issue. Usage of target=0 to list all cards that are legal to play.
Rev E, 2006-05-29	Updated issue. New error code –10 for number of cards > 52.
Rev F, 2006-08-09	Updated issue. New mode parameter value = 2. New error code – 11 for calling SolveBoard with mode = 2 and forbidden values of other parameters.
Rev F1, 2006-08-14	Clarifications on conditions for returning scores for the different combinations of the values for target and solutions.
Rev F2, 2006-08-26	New error code –12 for wrongly set values of deal.currentTrickSuit and deal.currentTrickRank.
Rev G, 2007-01-04	New DDS release 1.1, otherwise no change compared to issue F2.
Rev H, 2007-04-23	DDS release 1.4, changes for parameter mode=2.
Rev I, 2010-04-10	DDS release 2.0, multi-thread support.
Rev J, 2010-05-29	DDS release 2.1, OpenMP support, reuse of previous DD transposition table results of similar deals.
Rev K, 2010-10-27	Correction of fault in the description: 2nd index in resTable of the structure ddTableResults is declarer hand.
Rev L, 2011-10-14	Added SolveBoardPBN and CalcDDtablePBN.
Rev M, 2012-07-06	Added SolveAllBoards.
Rev N, 2012-07-16	Max number of threads is 8.
Rev O, 2012-10-21	Max number of threads is configured at initial start-up, but never exceeds 16.

Rev P, 2013-03-16	Added functions CalcPar and CalcParPBN.
Rev Q, 2014-01-09	Added functions CalcAllTables/CalcAllTablesPBN.
Rev R, 2014-01-13	Updated functions CalcAllTables/CalcAllTablesPBN.
Rev S, 2014-01-13	Updated functions CalcAllTables/CalcAllTablesPBN.
Rev T, 2014-03-01	Added function SolveAllChunks.
Rev U, 2014-09-15	Added functions DealerPar, SidesPar, AnalysePlayBin, AnalysePlayPBN, AnalyseAllPlaysBin, AnalyseAllPlaysPBN.
Rev V, 2014-10-14	Added functions SetMaxThreads, FreeMemory, DealerParBin, SidesParBin, ConvertToDealerTextFormat, ConvertToSidesTextFormat.
Rev X, 2014-11-16	Extended maximum number of tables when calling CalcAllTables.
Rev Y, 2016-01-01	Update to v2.8.3.