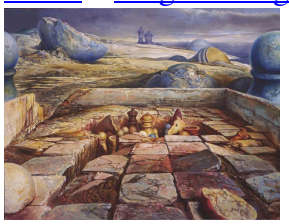
Home * Programming * Data * **Attack and Defend Maps**



Samuel Bak - Sheltering Myths, 1998 [1]

**Attack and Defend Maps**, also called **Attack Tables**, refer to data-structures, most often arrays, containing attack or defend information for every pawn or piece and/or the transposed information for each square, which pieces control, that is either attack or defend it. These Maps are useful for evaluation purposes such as safe mobility, SEE and of course move generation. While the piece centric attack information, a set of attacked squares per piece, is often encoded as bitboard, there are more alternatives for storing the square centric information, about attacking pieces.

# Table of Contents

# Maintaining Attacks

## Incremental Update

The piece centric and/or square centric information is often initialized at the root and updated incrementally during the search while making and unmaking moves. The idea is that a move has often only a local influence on the attack tables, and that it is usually cheaper to change only those squares which changed from- or to-attacks, rather than all squares from scratch. This is especially true during the opening or early middlegame phase, but does become more expensive in the late middlegame or endings with sliding pieces, especially queens.

## On the Fly

Programmers like Joël Rivat [2], Robert Hyatt [3], Ed Schröder and Gerd Isenberg avoid or have abandoned incrementally updated attack tables and rely on the paradigm to process information if needed. A lot of nodes don't need the attack information at all, or only a small part of it. With all the hash tables, incremental update tends to do some unnecessary work, considering the update costs in "worst case" positions, f.i. queen endings, where one move change the attack information of many squares.

On the other hand, if attack tables are available, one should utilize the information as much as possible for a smarter search and evaluation to gain exponentially. Anyway, one has to be careful with too complicated data structures and update code.

# Implementations

## Classical Approach

The square centric classical approach with bitboards was used in Chess 4.5 and descibed by Larry Atkin and David Slate [4] . The incrementally updated attack tables, from which most move generation is done, are called *ATKFR* and *ATKTO*. *ATKFR* is a set of 64 bitboards which give, for each square, all the squares attacked by the piece, if any, that resides on the square. *ATKTO* (Square Attacked By) is the transpose of *ATKFR*, giving for each square, the locations of all pieces that attack that square. For instance the square E4 (T) is attacked by a black rook at E8, a black knight at F6, and defended by a white rook at E1 and a white pawn at D3 [5] :

```
attacks_to[E4]
 . . . . 1 . . .
 . . . . . . . .
 . . . . . 1 . .
 . . . . . . . .
 . . . . T . . .
 . . . 1 . . . .
 . . . . . . . .
 . . . . 1 . . .
```

## Alternatives

There are several alternatives for keeping the square centric information what pieces attack each particular square.

### Piece-Sets

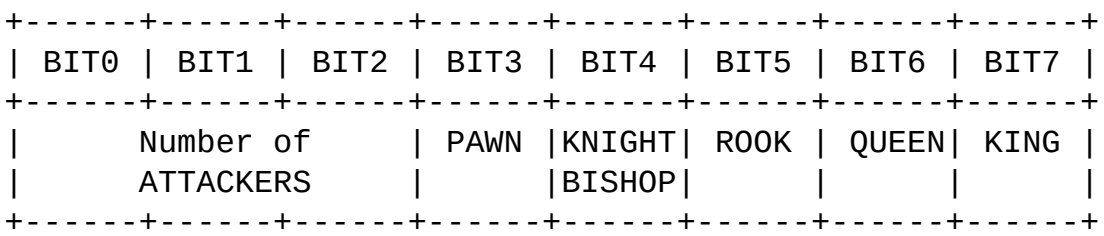
A Square Attacked By bitboard aka *ATKFR* as possible union-set of multiple pawns and pieces of either side require intersections with piece bitboards, or bitscanned square lookups, to determine which pieces and how many attack or defend.

Based on a fixed piece-type and bit-position relation with usual material dispositions (for each side, no more than one queen, two rooks, one bishop per square color, two knights), 32-bit Piece-Sets already inherit the information which pieces (and how many of both sides) attack a particular square, one can even imagine a 16-bit lookup inside a 64KByte table to get an denser attack indicator/count byte for each color a lá Ed Schröder. MS-DOS IsiChess maintained an array of 64 32-bit piece-sets for every square, and an array of up to 32 attack-to bitboards for every piece. However working with piece-sets requires an additional indirection via a Piece-list to get the square of that piece.

### Ed's lookup

As described by Ed Schröder in *Evaluation in REBEL* [6] , Rebel uses two board tables for both sides, one byte entry each, the three lower bits contain an attack counter, while the five upper bits indicate the

presence of least one pawn or piece attacking/defending:




The information might be inaccurate in some cases since it loses some information if multiple pieces of one kind are involved. However, since SEE might be erroneous anyway due to pins, x-rays or overloaded pieces, Ed's scheme seems sufficient for practical purposes - and it is fast. Each byte (for both sides) can act as index inside pre-calculated three-dimensional table to perform an SEE by looking up a target piece or square, attack- and defend-byte:

```
char see_table [14][256][256];   // 14*64 K = 896 KByte

see = see_table[Piece][attackByte][defendByte];
```

While the counter might be updated incrementally, the piece indicators as possible union of multiple pieces (i.e. two knights and one bishop) is not that simple to update, thus Ed generates those tables in evaluation on the fly by scanning the pieces of the board.

### Direction wise

An other alternative to incremental updated attack tables is motivated by direction wise fill algorithms like Kogge-Stone for sliding pieces, and that one may hide memory latencies from probes of the transposition table. Especially pawn attacks are cheap to determine on the fly, and likely reduce the set of capture targets of least valuable pieces defended by pawns, which are otherwise object of Quiescence Search or SEE.

## See also

- Piece-Sets
- Bitboards
  Sliding Piece Attacks
  Square Attacked By
  Pieces versus Directions

# Forums Posts

## 1995 ...

- Chess programming using bitboards by Joël Rivat, rgcc, August 18, 1995
- Attack Tables by Roberto Waldteufel, CCC, October 20, 1998

## 2000 ...

- Counting attacked squares: how? by Leen Ammeraal, CCC, January 24, 2002
- attacks_from[] and attacks_to[] info by Nagendra Singh Tomar, CCC, October 21, 2002
- Attack tables by Andreas Herrmann, CCC, November 20, 2002
- The Zappa Attack Table Code by Anthony Cozzie, CCC, May 05, 2004
- bitboards and incrementally updated attack tables by Eric Oldre, CCC, June 30, 2004
- Attack table by Anonymous, Winboard Forum, October 06, 2004

## 2005 ...

- Attack table musings by GeoffW, Winboard Forum, February 11, 2005
- Incremental updating for positional evaluation by Steven Edwards, CCC, March 27, 2008
- Piece attacks count by Marco Costalba, CCC, May 18, 2009 » Population Count

## 2010 ...

- Incrementally-updated attack map by Harm Geert Muller, April 21, 2014 » Incremental Updates

# References


1. ^ The Game of War from Samuel Bak - represented by Pucker Gallery since 1969
2. ^ Chess programming using bitboards by Joël Rivat, rgcc, August 18, 1995
3. ^ Speed of Move Generator by Valavan Manohararajah, rgcc, August 15, 1995, post 5 by Robert Hyatt where he mentions on the fly generation with rotated bitboards
4. ^ David Slate and Larry Atkin (**1977**). *CHESS 4.5 - The Northwestern University Chess Program.* Chess Skill in Man and Machine (ed. Peter W. Frey), pp. 82-118. Springer-Verlag, New York, N.Y. 2nd ed. 1983. ISBN 0-387-90815-3. Reprinted (**1988**) in Computer Chess Compendium
5. ^ Rotated bitmaps, a new twist on an old idea by Robert Hyatt
6. ^ Evaluation in REBEL (hanging pieces) from How Rebel Plays Chess by Ed Schröder, also available as pdf


# What links here?

| Page | Date Edited |
| --- | --- |
| Andreas Herrmann | Nov 7, 2014 |

| Page | Date Edited |
|---|---|
| Arasan | Apr 8, 2018 |
| Attack and Defend Maps | Nov 5, 2016 |
| Bebe | Dec 23, 2017 |
| Bitboards | Nov 14, 2017 |
| BlackBishop | Nov 7, 2014 |
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| Mate at a Glance | Sep 24, 2014 |
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| Movei | Jan 7, 2016 |
| MVV-LVA | Oct 26, 2017 |

| Page | Date Edited |
|---|---|
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| Node Types | Oct 22, 2017 |
| Nullmover | Jul 21, 2013 |
| Ostrich | Dec 28, 2017 |
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Up one Level