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Unusual Boards and Meeples

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Abstract
We introduce boards others than the usual chessboard. Further, we define meeples which can move in other ways than the usual chess meeples. We ask whether these meeples can reach every field, like a knight can reach every field on the chessboard.

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Introduction
We ask whether any figure on a board can reach all fields by valid moves. We assume that the reader is familiar with chess.

Definition 1: We use the term board as a synonym for a polyomino. For the definition of a polyomino see [1].

Definition 2: A meeple or a figure moves on the board by an action. An action is: 'Sway the meeple k squares horizontally and then l squares vertically', where k and l are natural numbers or zero. The move can also be vertically at first. For a meeple there may be more than one possible action. For a move of a meeple we choose one of the admissible actions. The admissible actions of a meeple are determined by a rule.

Definition 3: We say that a way of a meeple is a sequence of moves, such that every field is visited by the meeple a single time. With the final move it returns to the starting field. We call the set of all ways 'Ways'. We say that a meeple is reaching if and only if starting on an arbitrary field there exists a way for the meeple.

Proposition 1: A meeple is reaching if and only if there exists one way.
Proof: ⇒: If a meeple is reaching, the other claim is trivial.
⇐: We call the starting field of the way xxx. We take another field yyy.
There is one way of the meeple. Sometime it passes yyy. We take yyy as the new starting field. The meeple can go the same way in the same direction as before. It passes xxx, and after some moves it comes back to yyy. The proposition is proven. □

Proposition 2: On the usual chessboard the usual meeples king, queen, rook and knight are reaching. The bishop and the pawn are not reaching.
Proof: For bishop and pawn the claims are trivial. If the king or the queen or a rook is on a2 it goes to b2, c2, d2, e2, f2, g2, g3, f3, e3, d3, c3, b3, a3, a4, b4, c4, d4, e4, f4, g4, g5, f5, e5, d5, c5, b5, a5, a6, b6, c6, d6, e6, f6, g6, g7, f7, e7, d7, c7, b7, a7, a8, b8, c8, d8 e8, f8, g8, h8, h7, h6, h5, h4, h3, h2, h1, g1, f1, e1, d1, c1, b1, a1, and with one final move it returns to a2.
By Proposition 1, the king and the queen and the rook are reaching.

If a knight is on a2, it moves to b4, d5, e7, g8, h6, g4, h2, f3, g1, h3, f2, h1, g3, h5, f6, e4, g5, h7, f8, g6, h8, f7, e5, d7, b8, a6, c5, a4, b6, a8, c7, e8, g7, e6, d4, c6, d8, b7, a5, b3, a1, c2, e3, f1, d2, c4, b2, d1, c3, b1, a3, b5, a7, c8, d6, f5, h4, g2, e1, d3, f4, e2 and c1.

Alternatively, from a2 the knight goes to b4, a6, b8, c6, a7, c8, b6, a8, c7, e6, d8, b7, a5, c4, b2, d1, e3, g4, e5, d7, f8, h7, g5, e4, d6, b5, d4, f5, e7, d5, f4, e2, c3, a4, c5, d3, e1, g2, h4, g6, h8, f7, h6, g8, f6, e8, g7, h5, g3, h1, f2, h3, g1, f3, h2, f1, d2, b1, a3, c2, a1, b3 and c1. □
By Proposition 1, the knight is reaching.

On Ways we define an equivalence. We say that two ways way1 and way2 are equivalent if and only if both ways have the same order. This means that a field xxx is visited after field yyy in way1 if and only if field xxx is visited after field yyy in way2. Please see the proof of Proposition 2. There the field d5 is visited before e7 in the first way of the knight, but d5 is after e7 in the second way. Both ways are not equivalent.

Equivalent ways may have different starting fields. The equivalent classes of Ways we call [Ways]=~, i.e. we write [way1]~= = [way2]~=.

We define for each meeple the number of different ways.

Definition 4: Let M be a meeple on any board. We define the natural number W (M) as the number of eqivalent classes in [Ways]~=.

Proposition 3: A meeple M is reaching if and only if W (M) is positive.

Proposition 4: For a bishop or a pawn W (M) is 0, while for a knight W (M) is at least 2.

Questions 1: Let M be a meeple on any board. We ask whether M has a way. We ask for the value of W (M).

Remark 1: The entire concept can easily be generalized into higher dimensions.

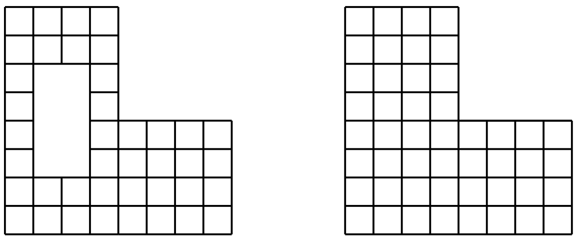

Figure 1: On the left-hand side, we see two boards. They have 40 and 48 fields, respectively

Please see the picture below. We show two boards. They have 60 and 64 fields, respectively. We call the right a chessboard.

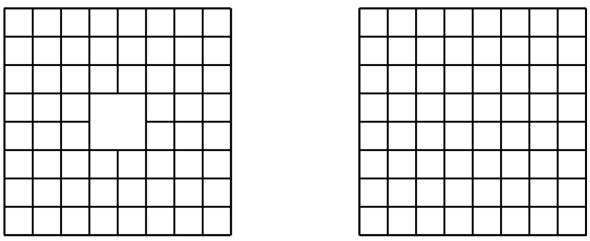

Figure 2: On the left-hand side, we show two boards. They have 60 and 64 fields, respectively

There is another possibility to generate boards. Instead the usual squares we can use other r-gons as fields.

Assume that r is an even natural number larger than 4. We take r-gons as fields. Even there is no complete covering of the plane by regular poly- gons with an even number of vertices except with 4-gons and 6-gons, we can form boards with them. The fact that r is an even number ensures that there is a unique direction, while the meeple comes from the other side. We will not continue this concept.

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References
[1]. Anthony J. Guttmann: Polygons, Polyominoes and Polycubes, Springer 2009.