Seki and Graphs

Thomas Wolf
Brock University,
St. Catharines, Ontario, Canada,
twolf@brocku.ca

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Outline

Definition and Examples of Seki

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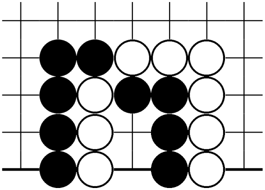
In its simple form, it is a sort of symbiosis where two live groups share liberties which neither of them can fill without dying.



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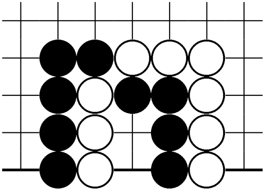

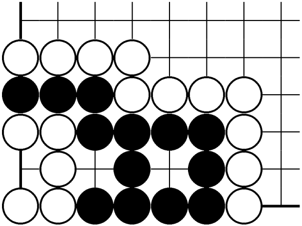

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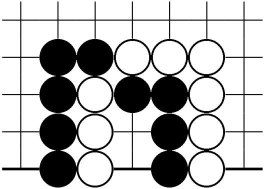

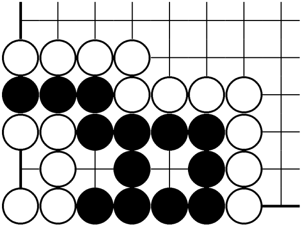

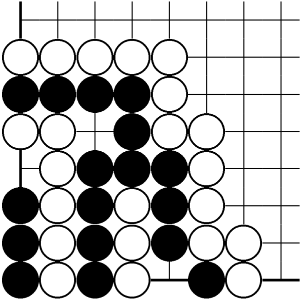

Hanezeki

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- non-terminal positions
- introduction of cuts

Outline

Non-terminal Positions

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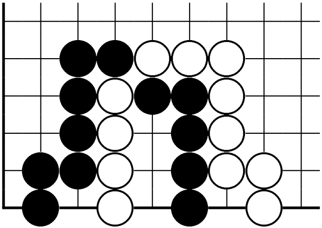
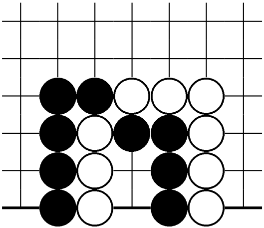


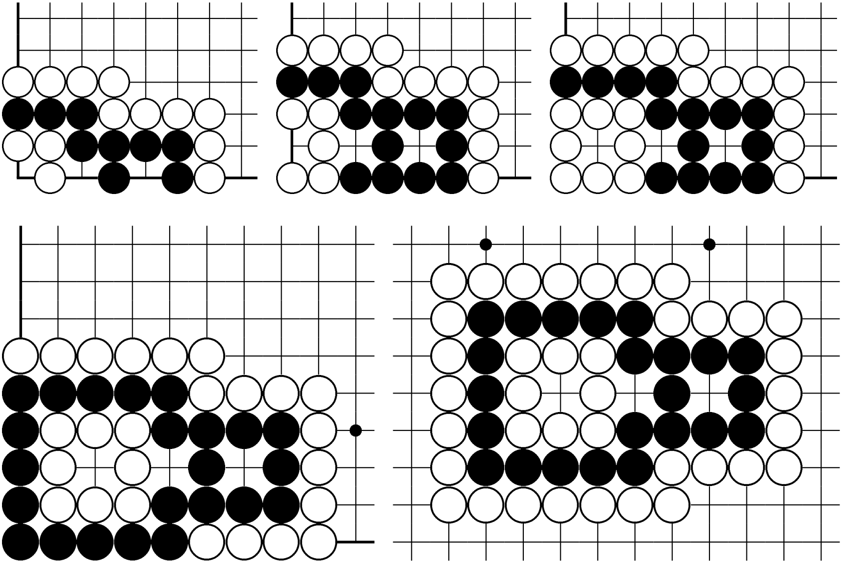
Non-terminal seki



Terminal seki

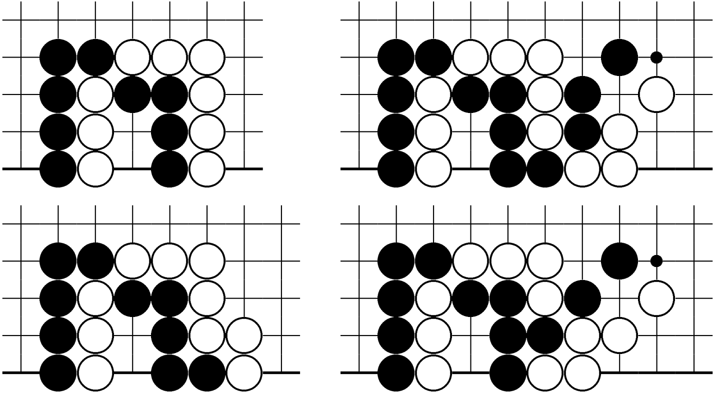
Shift and Deformation

All of these positions are equivalent.



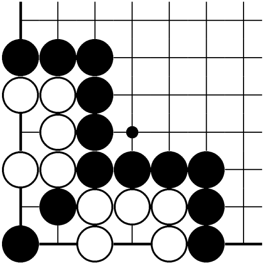
Introducing Cross Cuts I

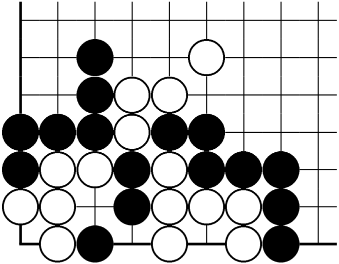
Also all of these seki are essentially identical despite two having a cross cut.

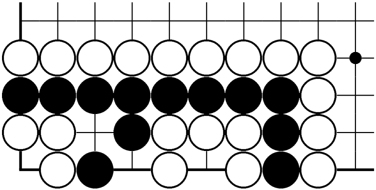


Introducing Cross Cuts II

The following positions differ even more but are still equivalent.

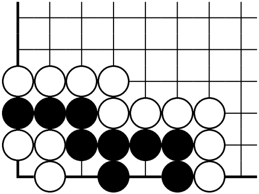






Common Fate Graphs

What is the essence of a seki position?
Commonly used in Go: the *Common Fate Graph* (CFG):



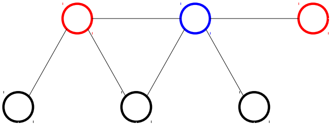


Figure: The corresponding CFG

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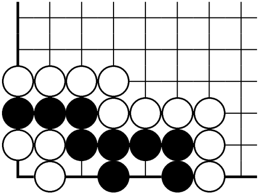

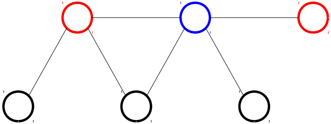

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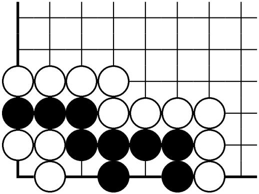

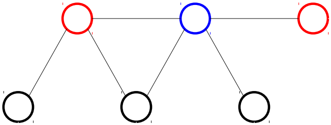

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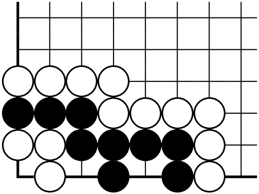

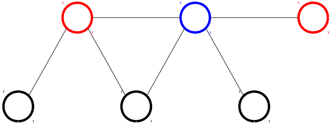

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The same types of seki on previous slide have different CFG.
→ We need a more compact graph.
But the choice of graph depends on the type of seki to be considered.

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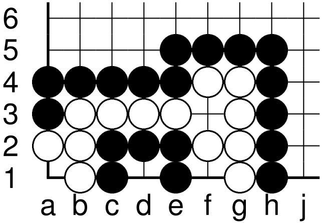
Positions are terminal, i.e. a move taking an opponent liberty gets instantly captured.

Basic Seki Graphs

This special class of seki allows more compact graphs: *Basic Seki Graphs* (BSG). Example:



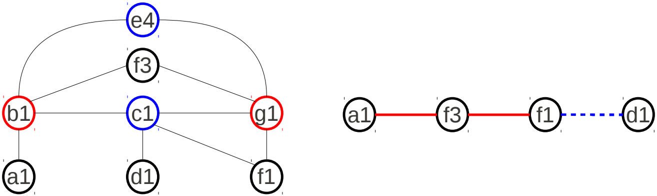


Figure: The 2 corresponding graphs: CFG and BSG

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- If two edges of same colour, say red, end in a shared node, say M, then both red edges must have their other end in the same other node, say N (otherwise White can move on M and give atari without being captured).

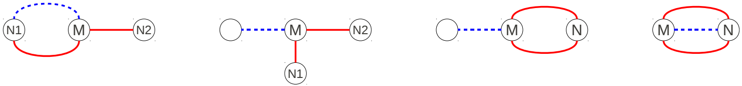

Figure: Two forbidden and two admissible graphs

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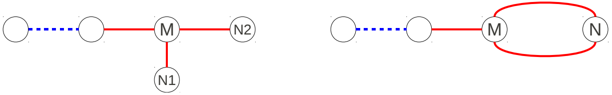
- If a node has edges of only one colour then these edges may reach only two other nodes (otherwise a move on M creates a chain with 3 liberties).



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- *Therefore Basic Seki consist either of a linear or a circular sequence of liberties where two neighbouring liberties are connected by only chains of one colour.*
- *The case of only 2 liberties connected by black and white chains can be seen as the smallest circular sequence.*

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A Numerical Encoding

Basic Seki are linear or circular (i.e. 1-dimensional)

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It turns out that conditions on Basic Seki Graphs shown before are not only necessary but also sufficient.

$\Rightarrow$ Generating all sequences of such number encodings will generate all Basic Seki.

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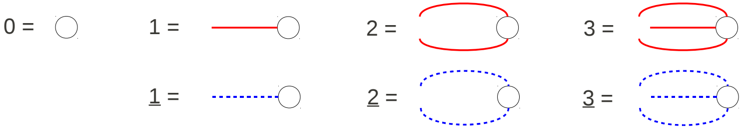

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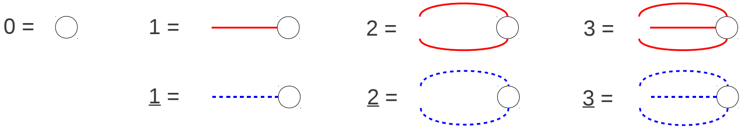

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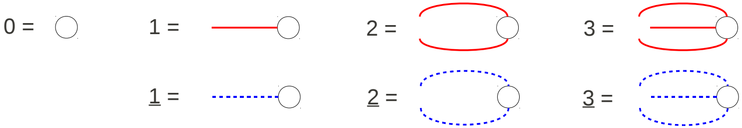

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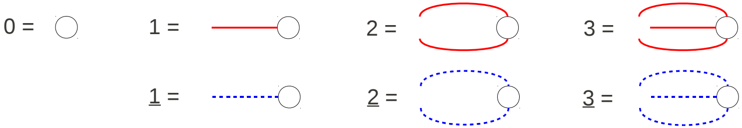

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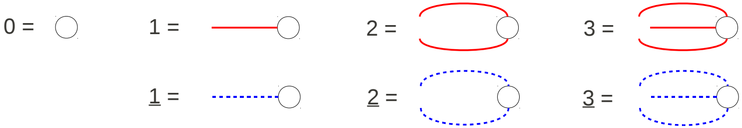

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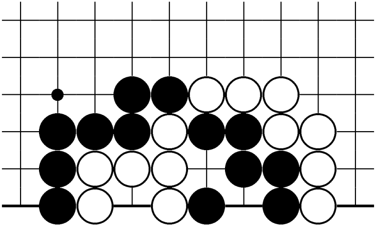
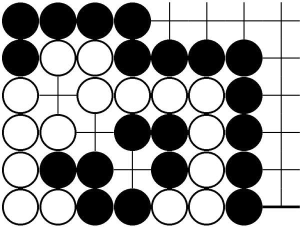
- two seki attached on board to one seki $\rightarrow$ ... + ...

Examples of linear Seki I



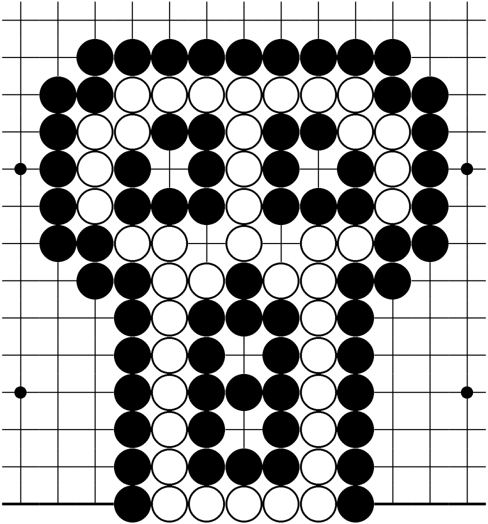
encoding: 01<u>2</u>

Examples of linear Seki II



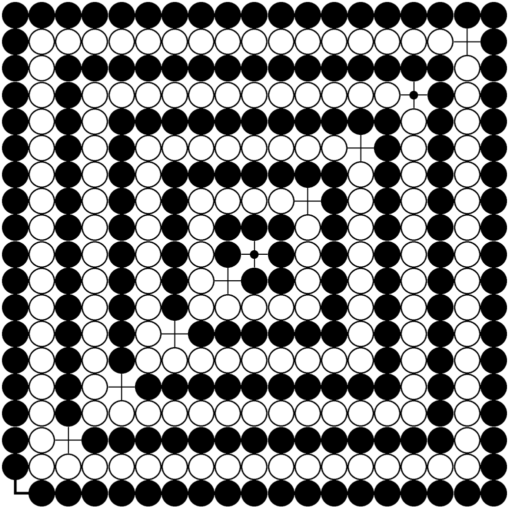
encoding: 022

Examples of linear Seki III



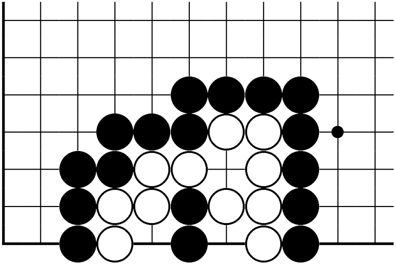
”The Scream” with encoding: $0\underline{1}2\underline{1}$

Examples of linear Seki IV



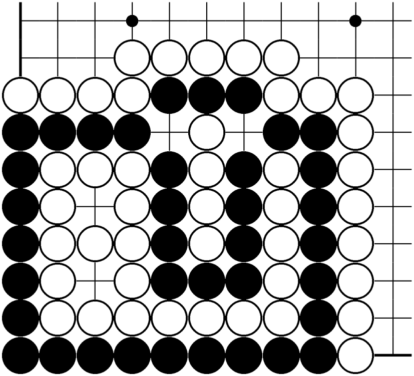
”The Onion” with encoding: $0\underline{1}1\underline{1}1\underline{1}1\underline{1}1\underline{1} = 0\underline{1}(1\underline{1})^4$
looks circular but is linear.

Examples of circular Seki I



encoding: 111

Examples of circular Seki II



encoding: 31

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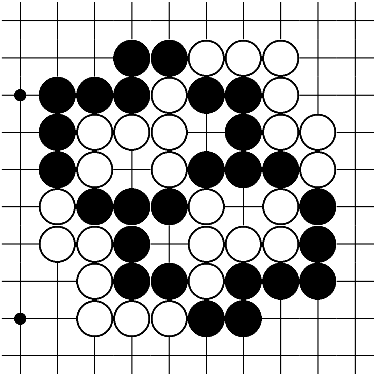

encoding: $\underline{1}1\underline{1}1 = (\underline{1}1)^2$

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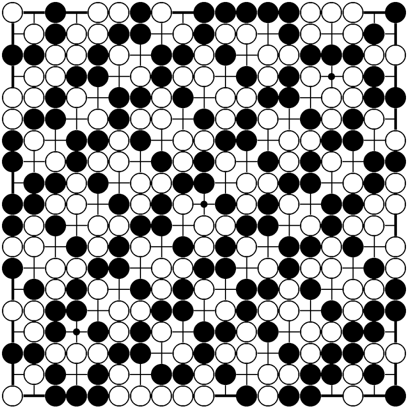
  - avoid identical circular basic seki (inversion, colour switch, cyclic permutation, e.g. 2$\underline{1}$1 = $\underline{1}$12 = 12$\underline{1}$ = ...)

Outline

Attaching Seki



A full board seki of G. Hungerink

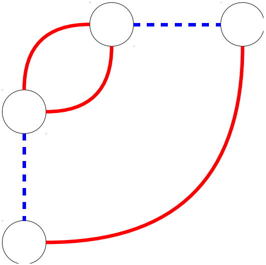
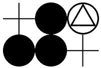
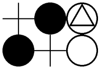


Figure: The upper left corner and the colour switched lower right corner of the board as BSG with encoding $\underline{1}2\underline{1}1$.

The BSG of the whole board consists of three disconnected sub graphs and has the encoding
$\underline{1}2\underline{1}1 + 0(\underline{2}2)^4\underline{1}(2\underline{2})^6 1\underline{1}2\underline{1}1(\underline{2}2)^6\underline{1}1\underline{2}1\underline{1}(2\underline{2})^6 1(\underline{2}2)^4 + \underline{1}1\underline{2}1.$

Cutting off a Stone I





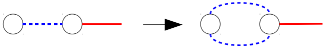
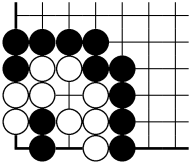
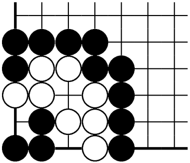


Figure: The change of BSG



encoding: 111



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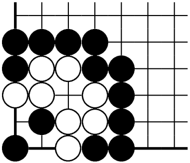
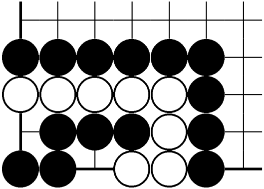
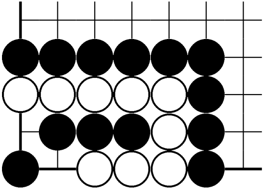


encoding: 211

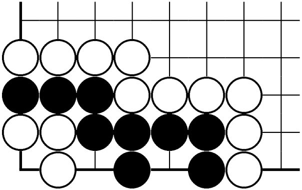
Cutting off a Stone II



encoding: 11



encoding: 21



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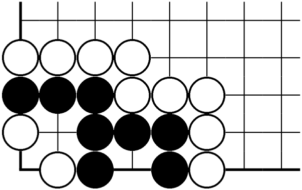


encoding: 021

Creating an Eye I

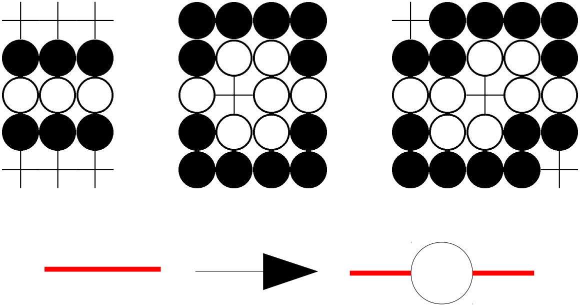
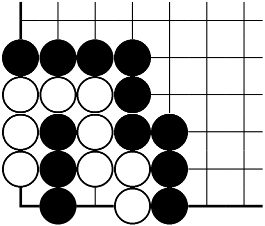


Figure: The change of CFG

Creating an Eye II



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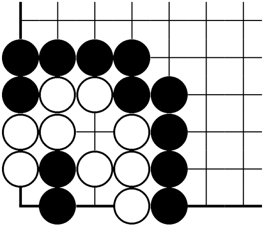

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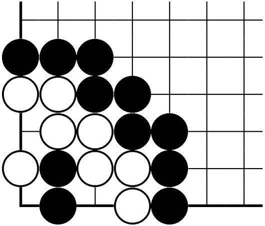

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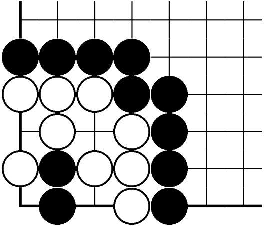
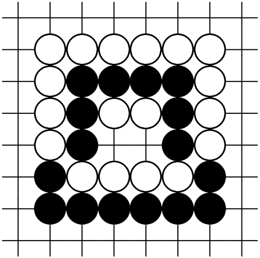
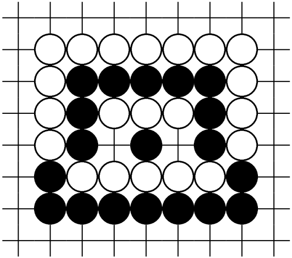


encoding: 1111

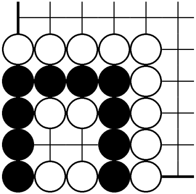
Bamboo Joints in Basic Seki I



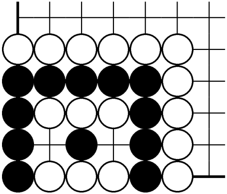
encoding: 21



encoding: 22

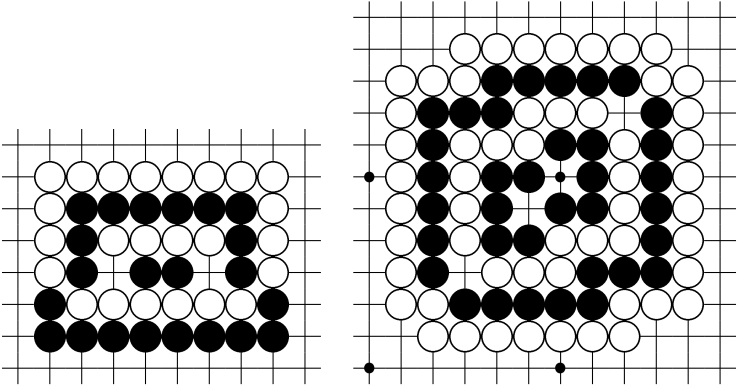


encoding 21



encoding: 22

Bamboo Joints in Basic Seki II



Both seki have the encoding 22 but different sequences of black and white stones around liberties (WBWB and WWBB).

Outline

Challenges

A theory of seki between chains

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- with more than 2 liberties,

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Work of Vladimir Gurvich I

In preprint [8] (2011) he considers positions

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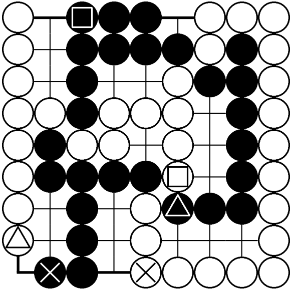
Problem: For a given computer determined seki matrix a Go position may not exist, e.g. not for:

$$\begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{pmatrix}.$$

Work of Vladimir Gurvich II

Example:



$i \backslash j$	▲	✖	■	s_i^W
△	0	3	3	6
⊗	3	3	1	7
□	3	1	2	6
s_j^B	6	7	6	

Table: The liberty matrix

Lemma: (giving sufficient conditions for Black to capture)
Even when playing second, Black captures if there is a row i such that $s_j^B - A_{ij} \geq s_i^W$ for every column j and $s_j^B > s_i^W$ if $A_{ij} = 0$.

Seki with >2 Liberties per Chain

We need new graphs where
- edges represent liberties and
- nodes represent chains
(because now only 2 chains per liberty but >2 liberties per chain).

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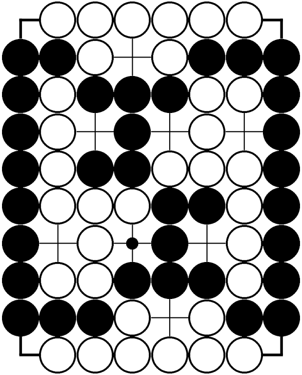
$\Rightarrow$ *We are looking for bi-partite planar graphs!*

Bi-partite planar 3-regular Graphs

Sensei's Library [4]:



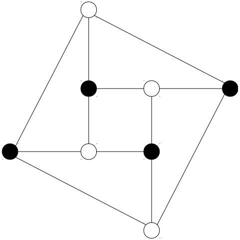


Figure: The corresponding Graph

Bi-partite planar 3-regular Graphs

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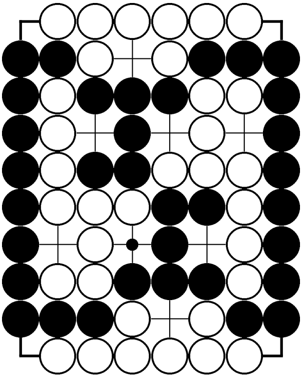

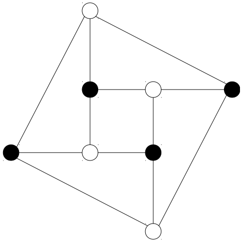

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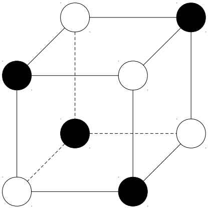
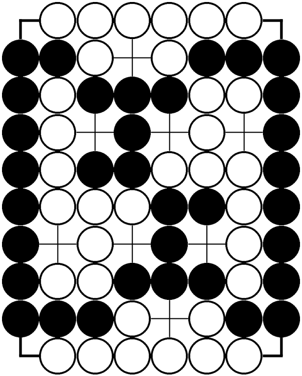
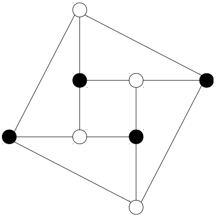


Figure: The same Graph

Planar Graphs and their Dual





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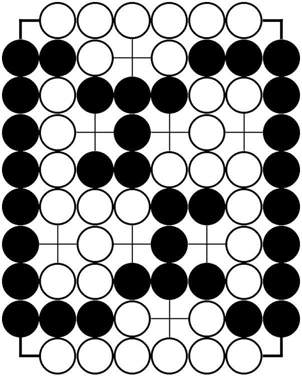

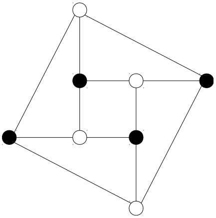

Figure: A planar Graph

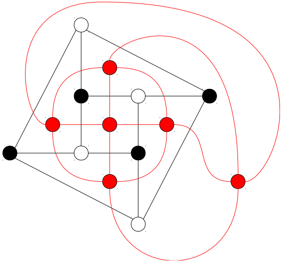

Figure: with it's dual Graph

The Cube and the Octagon

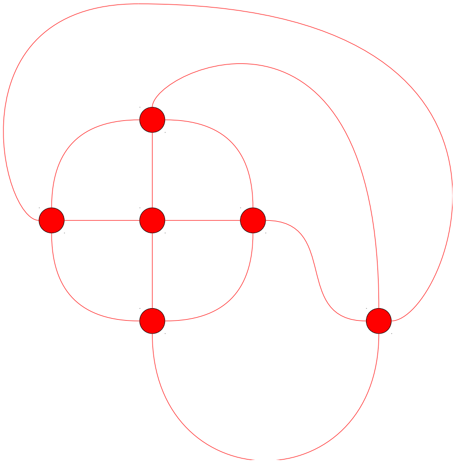

Figure: The dual Graph of a Cube

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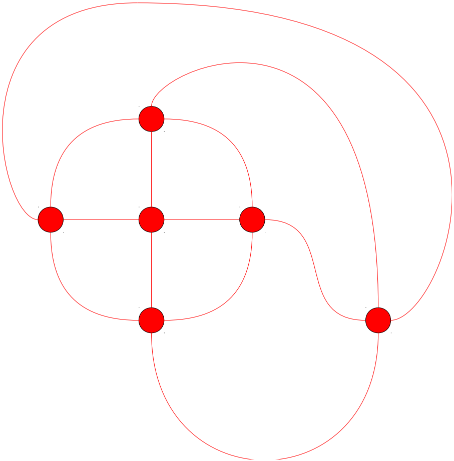

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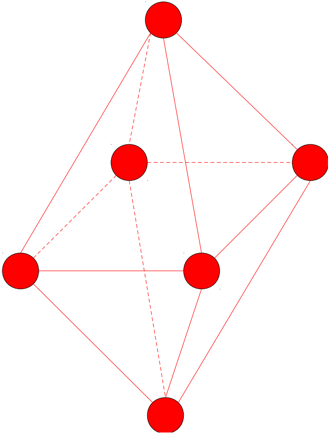


Figure: is an Octagon

Generating more bi-partite planar 3-regular Graphs I

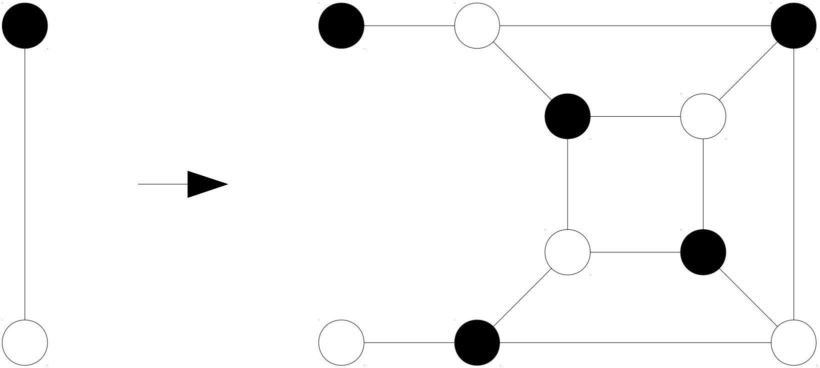
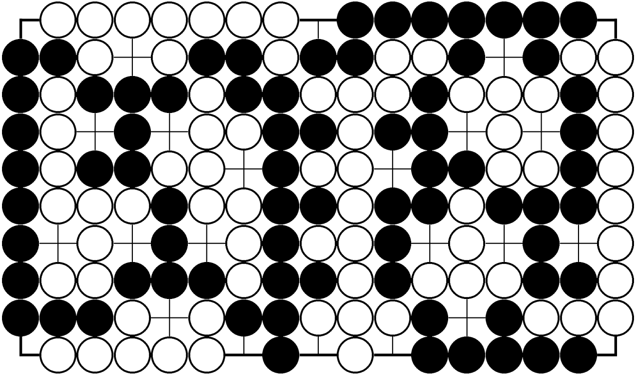


Figure: This replacement of any edge generates each time a new graph and thus a new seki.

Generating more bi-partite planar 3-regular Graphs II



The position resulting from the complication step.

Higher regular Graphs

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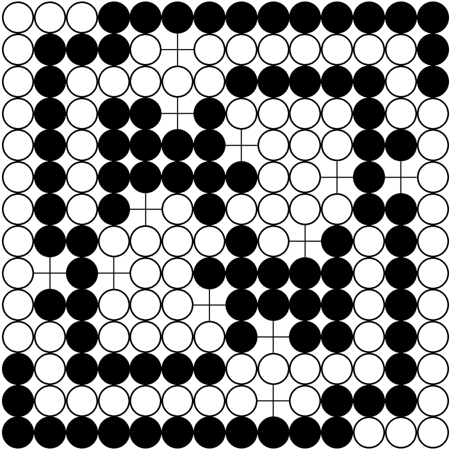
But, bi-partite planar 3-regular graphs are perfect matchings.

$\Rightarrow$ opportunity to generate higher regular graphs with multi-edges. (i.e. seki with pairs of chains sharing more than 1 liberty).

Again a bi-partite planar 3-regular Graph



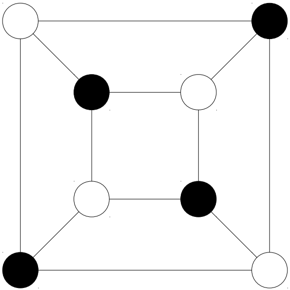
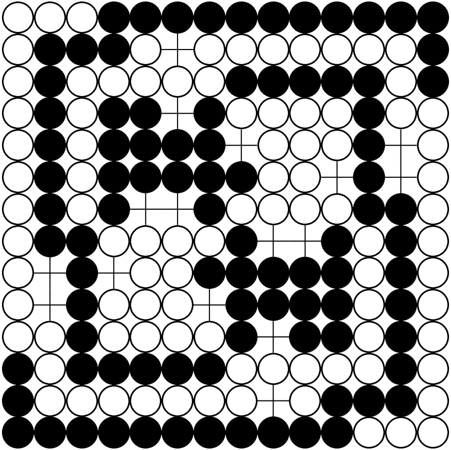


Figure: A cubical graph

A bi-partite planar 4-regular Graph



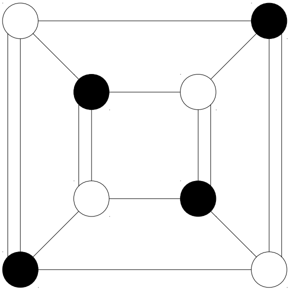
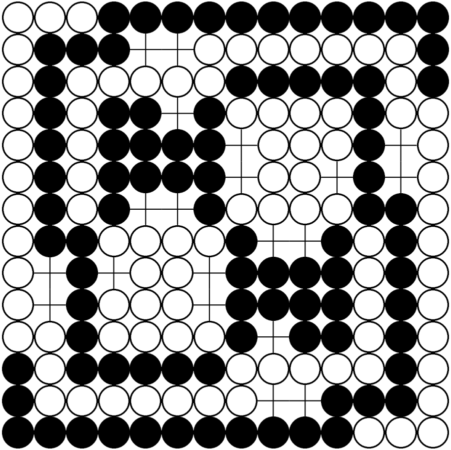


Figure: A cubical graph

A bi-partite planar 5-regular Graph



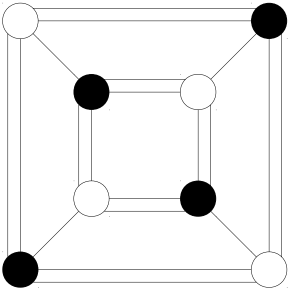
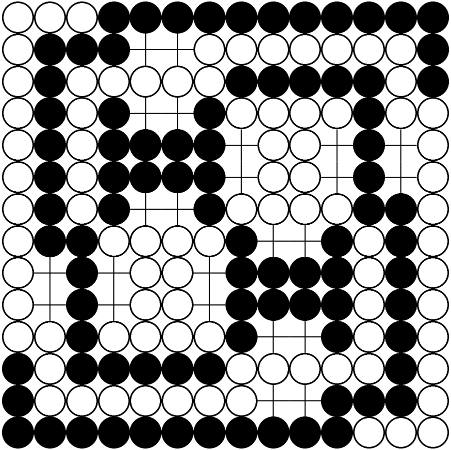


Figure: A cubical graph

A bi-partite planar 6-regular Graph



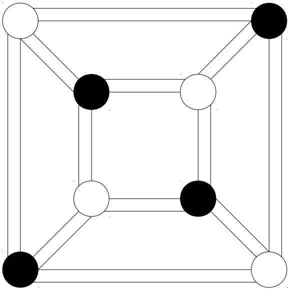
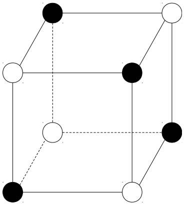


Figure: A cubical graph

Outline

‘Local Seki’ versus ‘global Seki’



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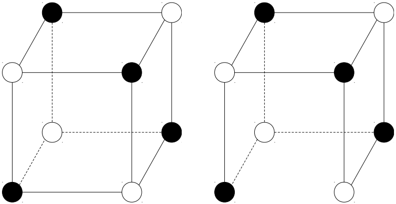
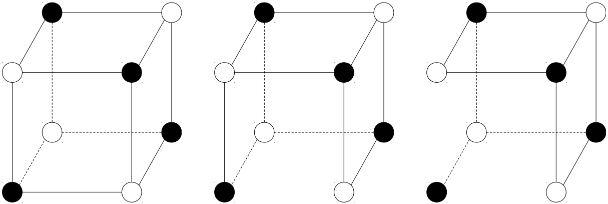
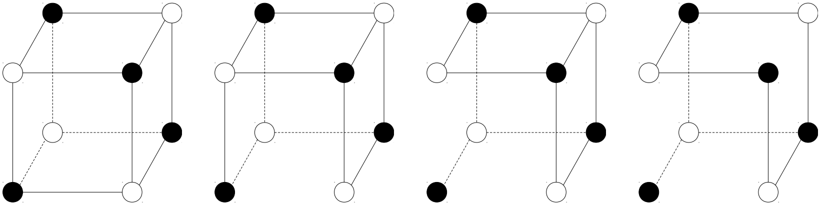


‘Local Seki’ versus ‘global Seki’



‘Local Seki’ versus ‘global Seki’



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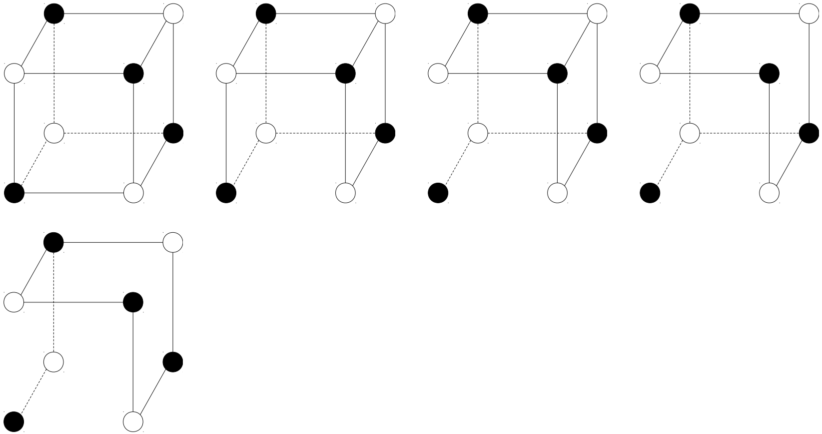
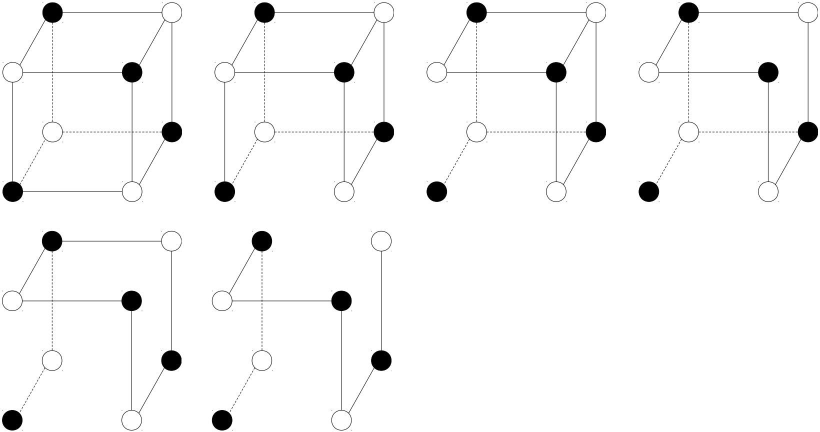


‘Local Seki’ versus ‘global Seki’



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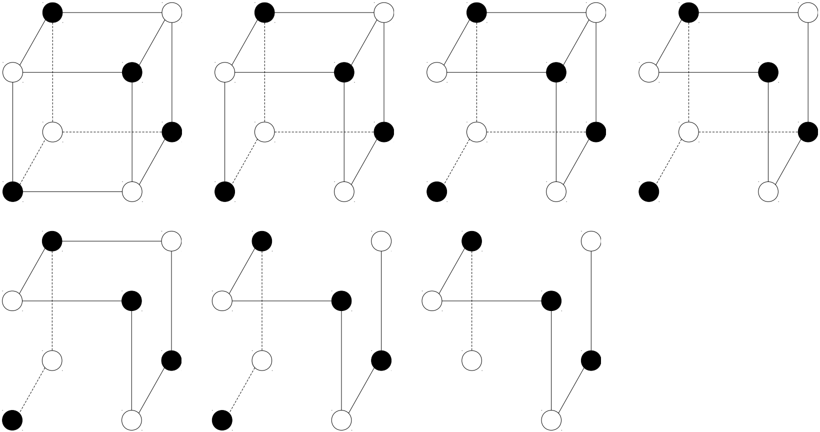


‘Local Seki’ versus ‘global Seki’

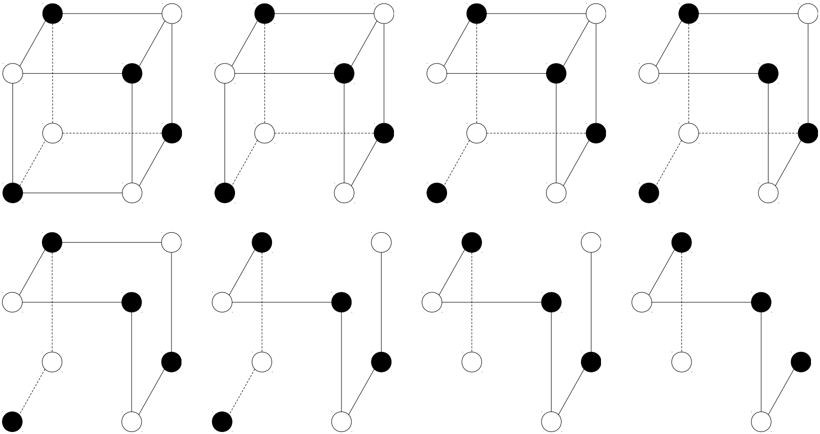


Figure: Global instability of Cubical Seki

⇒ Each attacking chain is captured (i.e. is a local seki) but in return an opponent chain can be captured (i.e. no global seki).

‘Local Seki’ versus ‘global Seki’

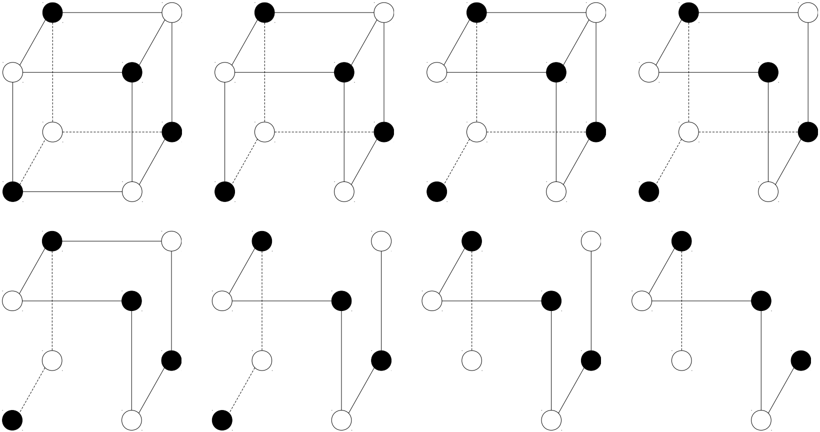
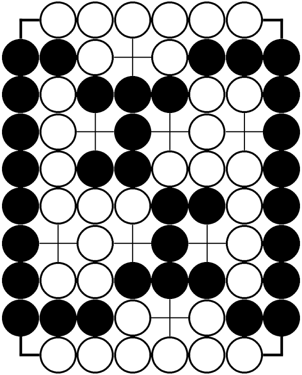


Figure: Global instability of Cubical Seki

⇒ Each attacking chain is captured (i.e. is a local seki) but in return an opponent chain can be captured (i.e. no global seki).

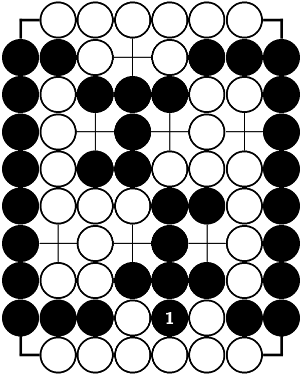
⇒ Sacrifice a small chain and catch a big one ⇒ no “real” seki.

A Sacrifice in a Local Seki



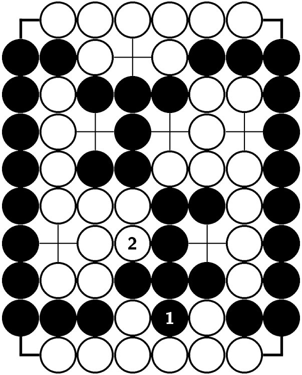
Black to play and sacrifice a small chain to catch a bigger one.

A Sacrifice in a Local Seki



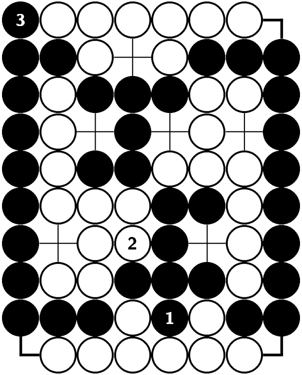
Black to play and sacrifice a small chain to catch a bigger one.

A Sacrifice in a Local Seki



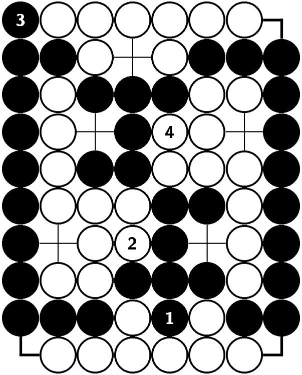
Black to play and sacrifice a small chain to catch a bigger one.

A Sacrifice in a Local Seki



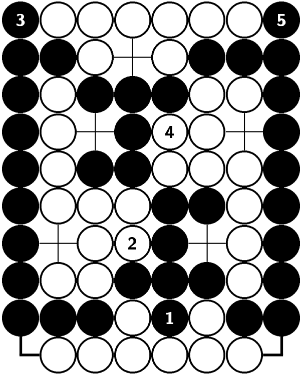
Black to play and sacrifice a small chain to catch a bigger one.

A Sacrifice in a Local Seki



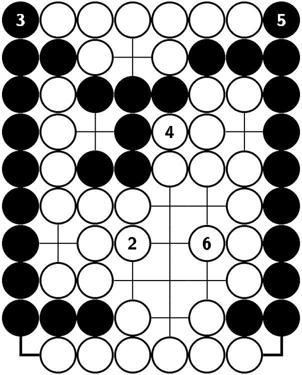
Black to play and sacrifice a small chain to catch a bigger one.

A Sacrifice in a Local Seki



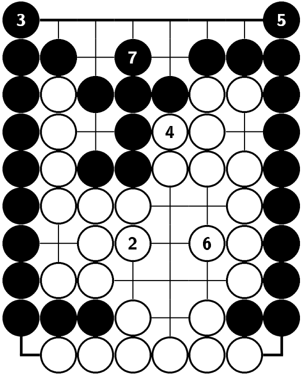
Black to play and sacrifice a small chain to catch a bigger one.

A Sacrifice in a Local Seki



Black to play and sacrifice a small chain to catch a bigger one.

A Sacrifice in a Local Seki



Black to play and sacrifice a small chain to catch a bigger one.

Outline

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The End

Thank you!