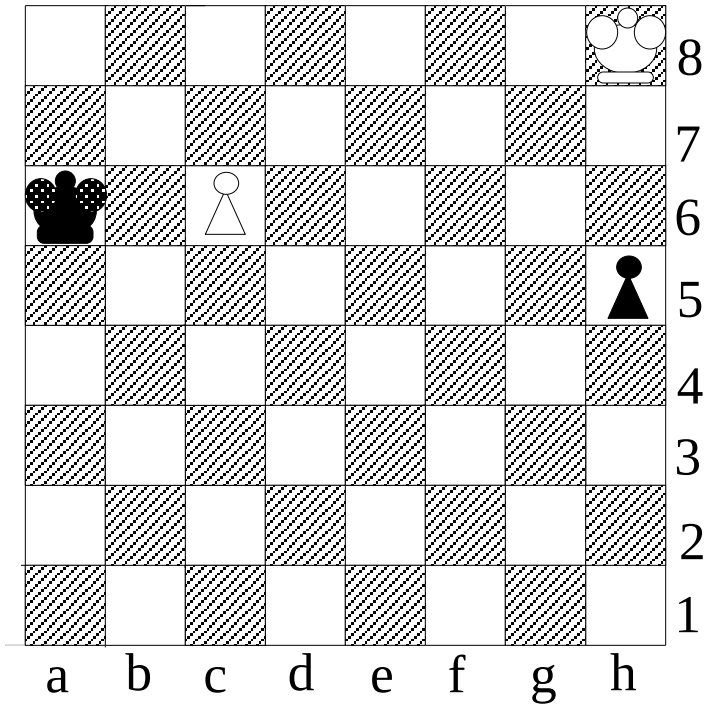
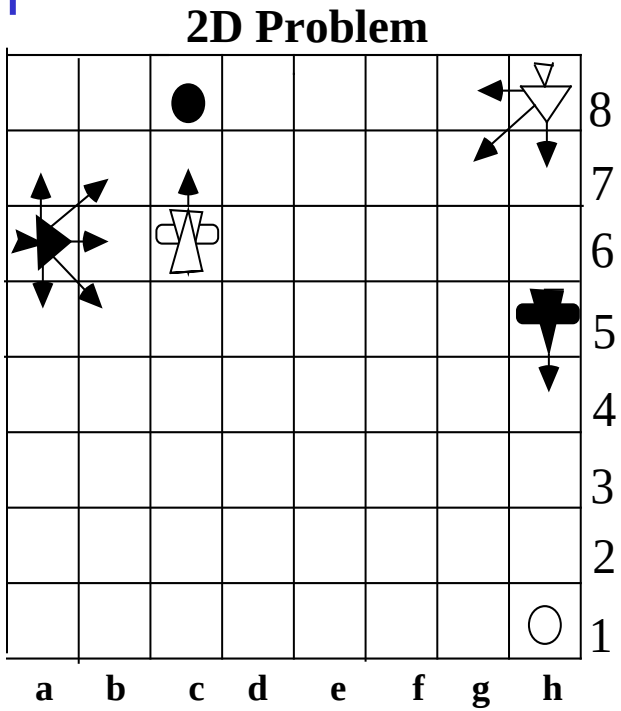
Linguistic Geometry Tools: Solving Intractable Search Problems without Search

Boris Stilman
University of Colorado Denver, USA
STILMAN Advanced Strategies, USA


8
7
6
5
4
3
2
1
a b c d e f g h

❑ Sample Problem



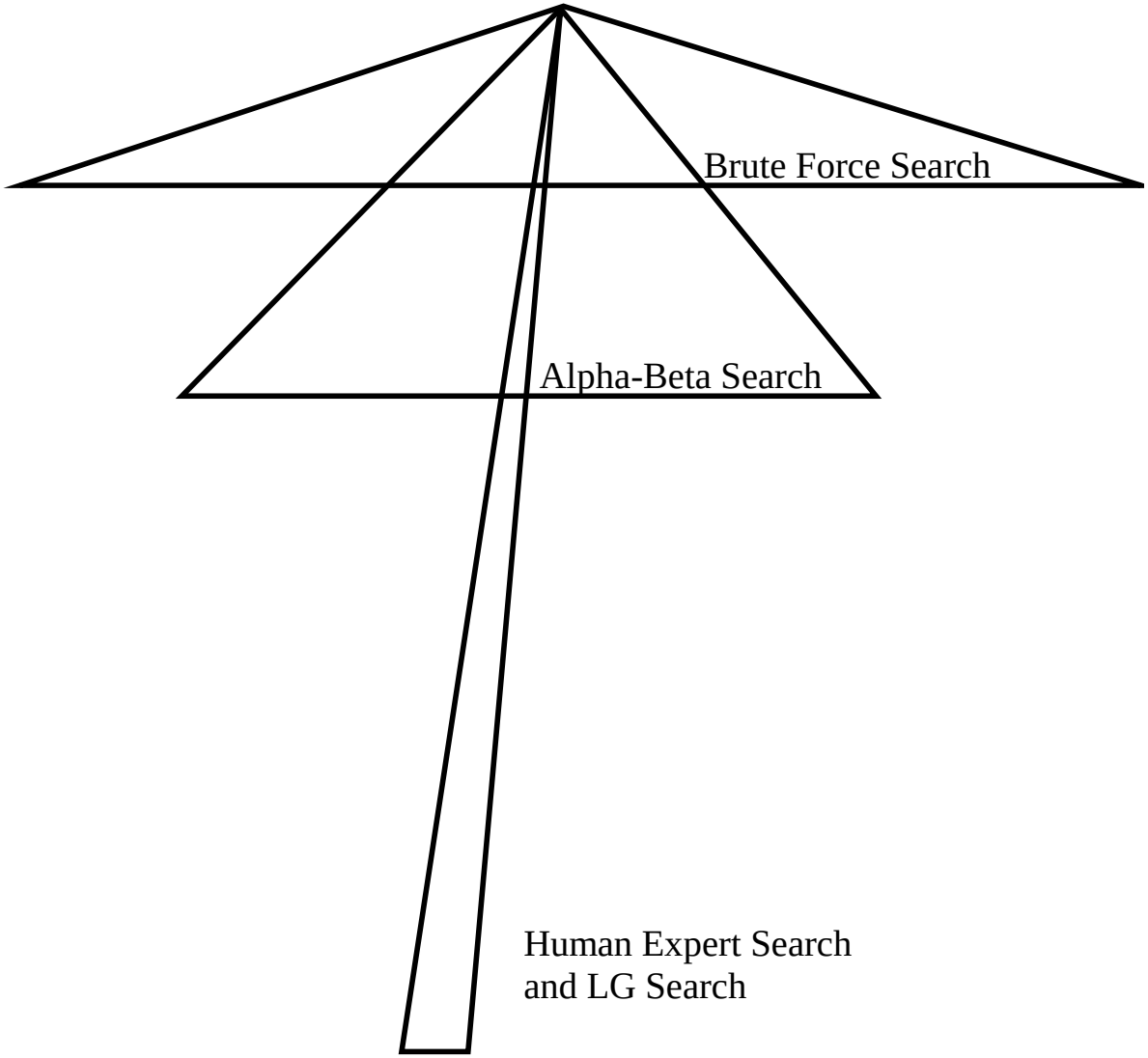
***Is there a strategy for the White to make a draw*?**

The specific question is as follows.
Is there an optimal strategy that provides one of the following?

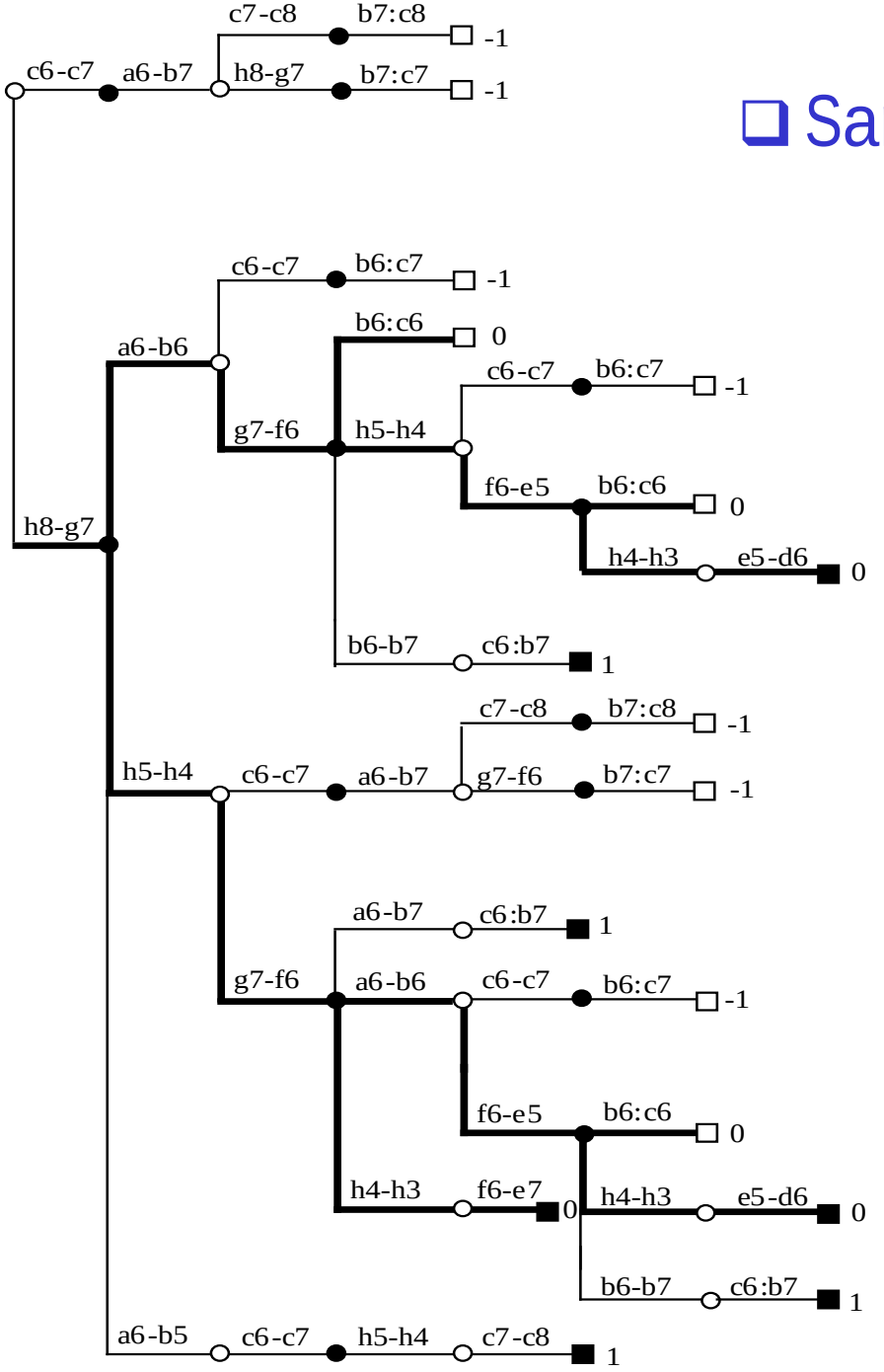
1. **Both BOMBERs hit their targets on subsequent time increments and stay safe for at least one time increment.**

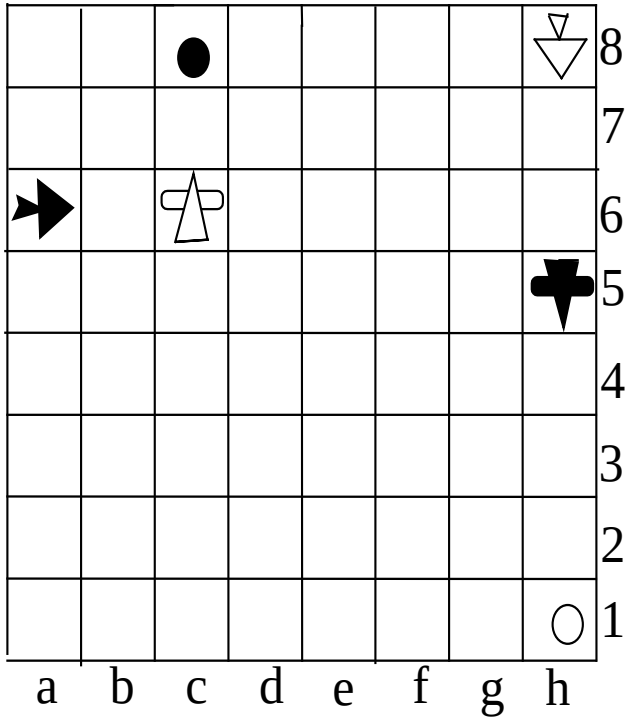
2. **Both BOMBERs are destroyed before they hit their targets or immediately after that.**

Different Searches
(for the same processing time)

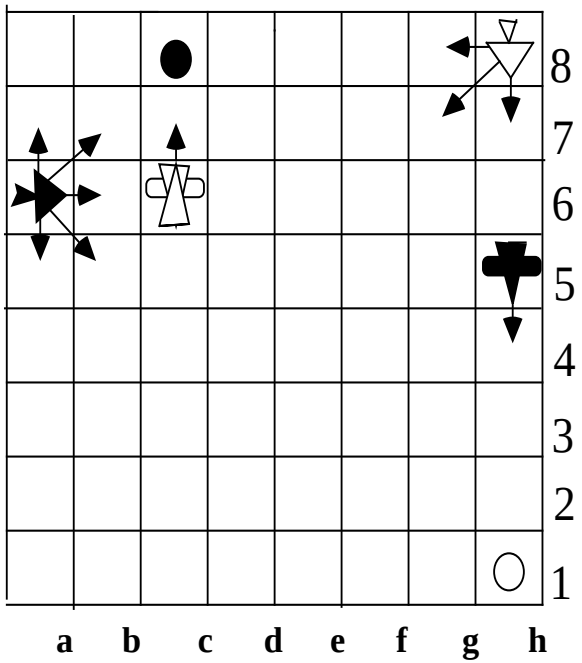


❑ Sample Problem: LG Search





2D Problem: Terminal Sets



1. **W-Win** = **BB-Destroyed** ∩ **WB-Safe**

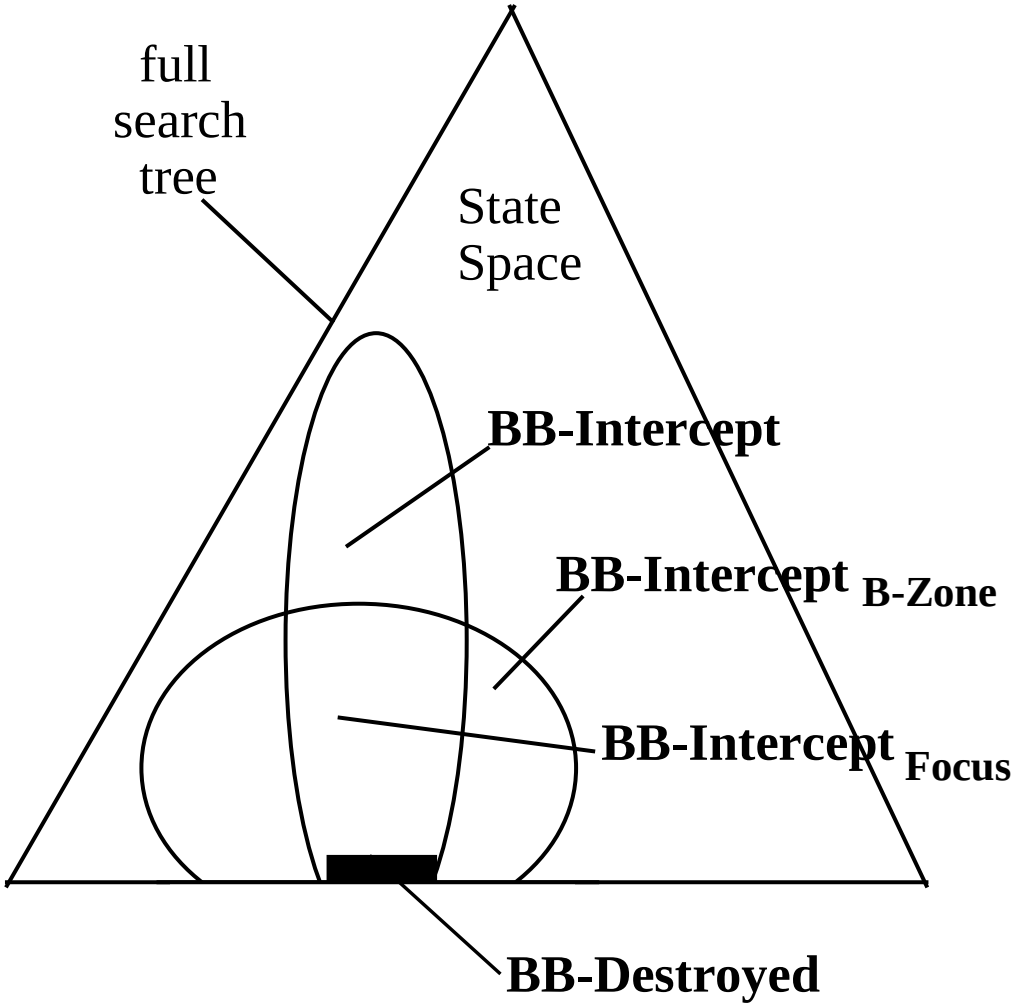
2. **B-Win** = **WB-Destroyed** ∩ **BB-Safe**

3. **Draw** = **Safe** ∪ **Destroyed**, where
   Destroyed = **BB-Destroyed** ∩ **WB-Destroyed**,
   Safe = **BB-Safe** ∩ **WB-Safe**

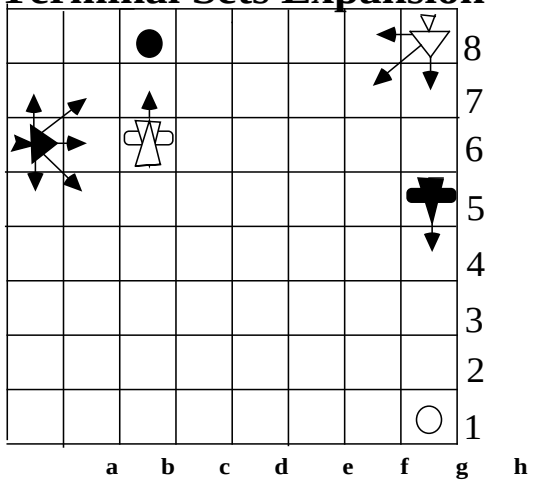
Let A be a set of states.

The strategy is called an A strategy if it is represented by the optimal subtree with the terminal nodes which represent states from A, only.

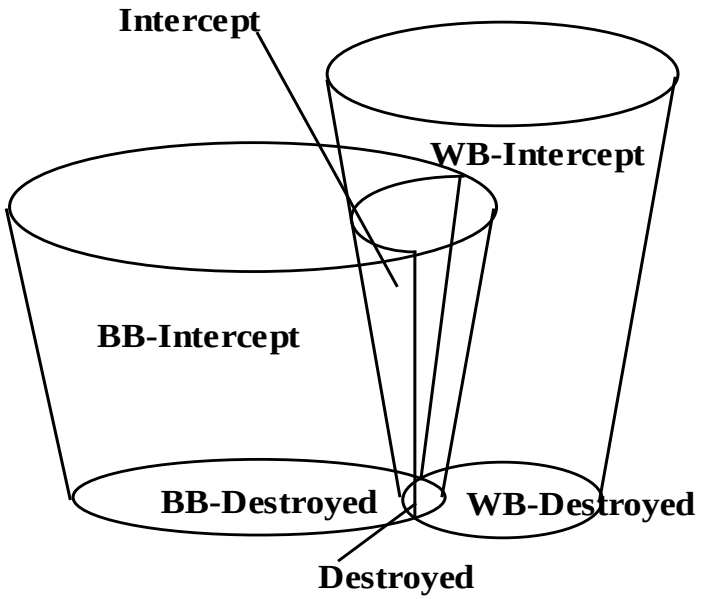
Why do we need the terminal sets expansion?



Terminal Sets Expansion

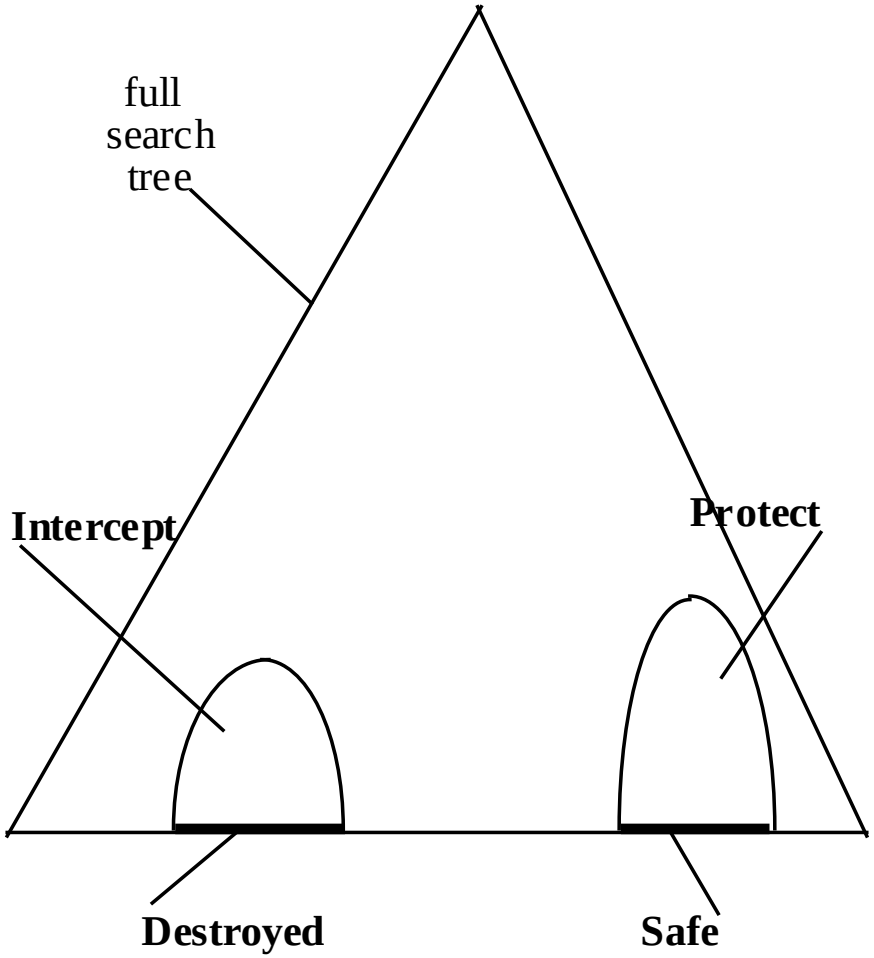


BB-Intercept is the set of states where BB-Destroyed strategy exists



Intercept = BB-Intercept ∩ WB-Intercept
Destroyed = BB-Destroyed ∩ WB-Destroyed.
Destroyed ⊂ DrawExpand.

Expanded Terminal States



Terminal Sets Expansion

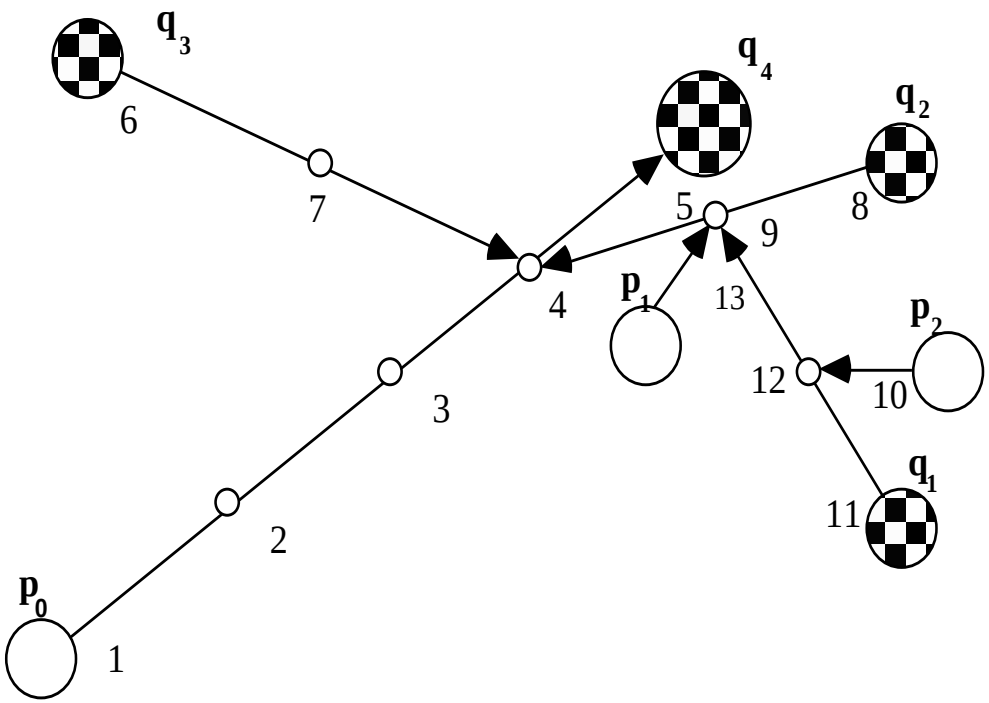
Intercept = **BB-Intercept** ∩ **WB-Intercept**

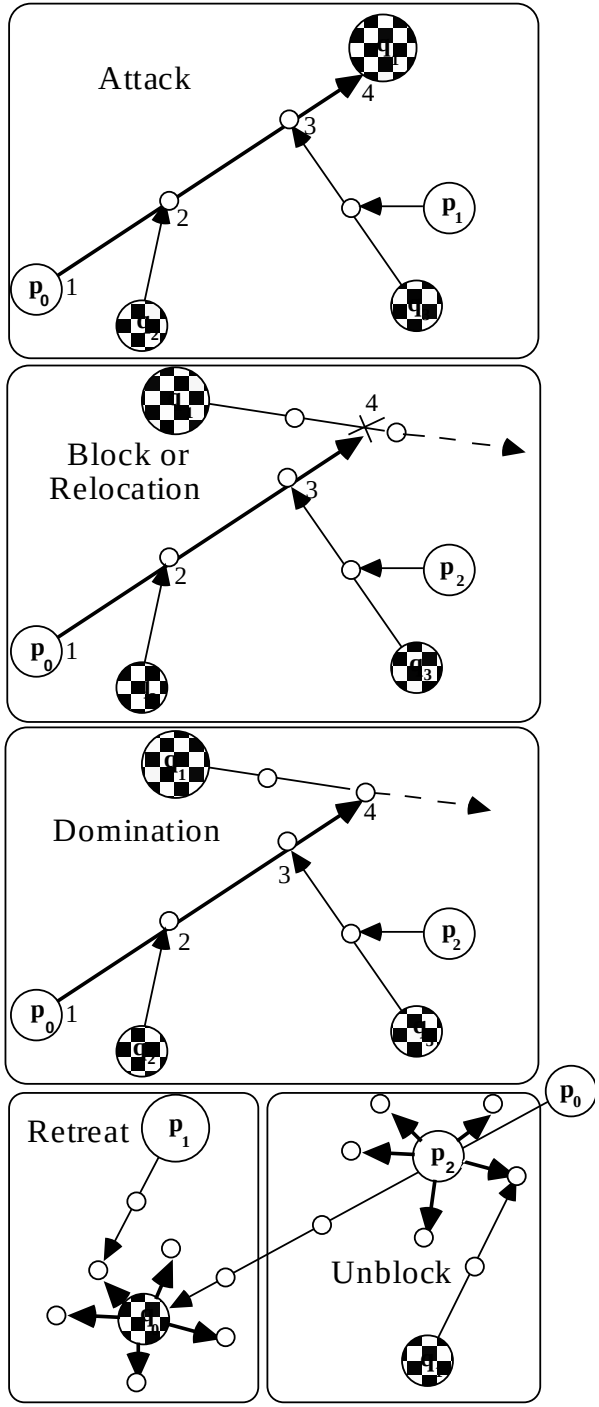
is the set of states where the **Destroyed strategy** exists
Destroyed = **BB-Destroyed** ∩ **WB-Destroyed**.

Protect = **BB-Protect** ∩ **WB-Protect**

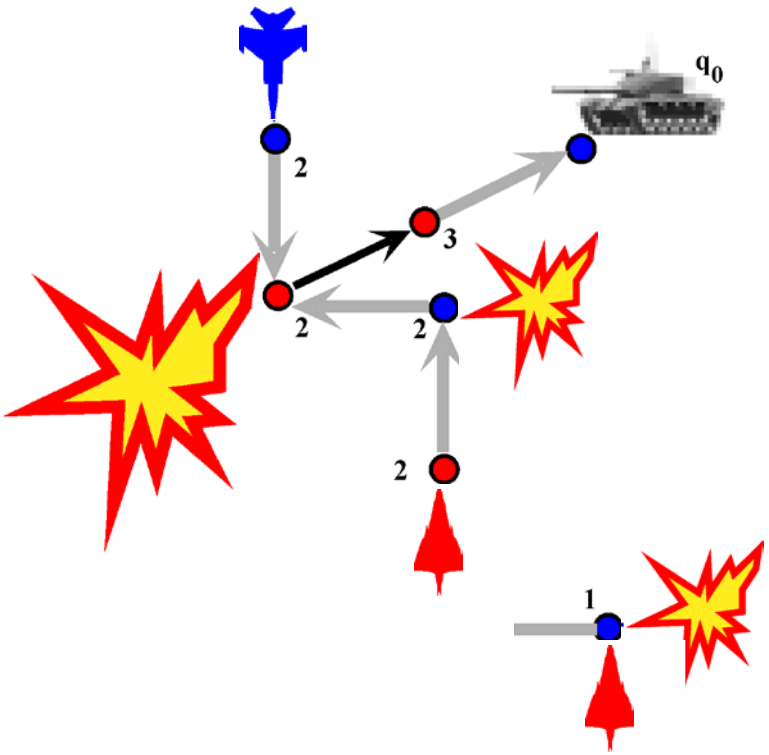
is the set of states where the **Safe strategy** exists
Safe = **BB-Safe** ∩ **WB-Safe**.

LG Zone





Types of Zones



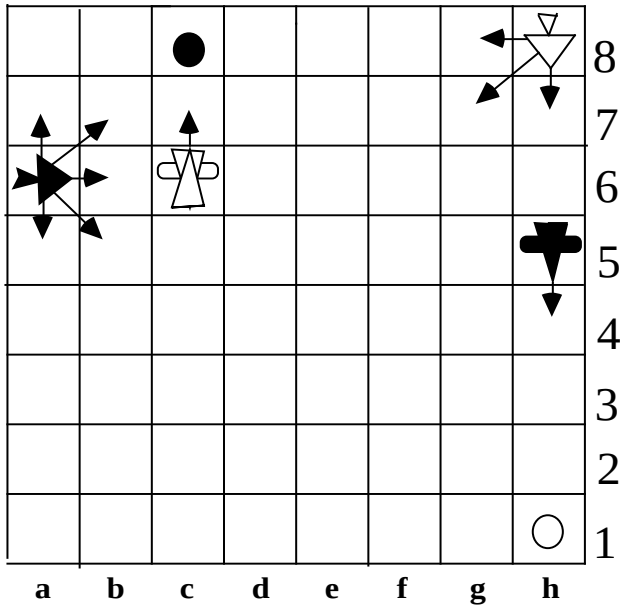
Concurrent Zones for Defense Systems

move

strike

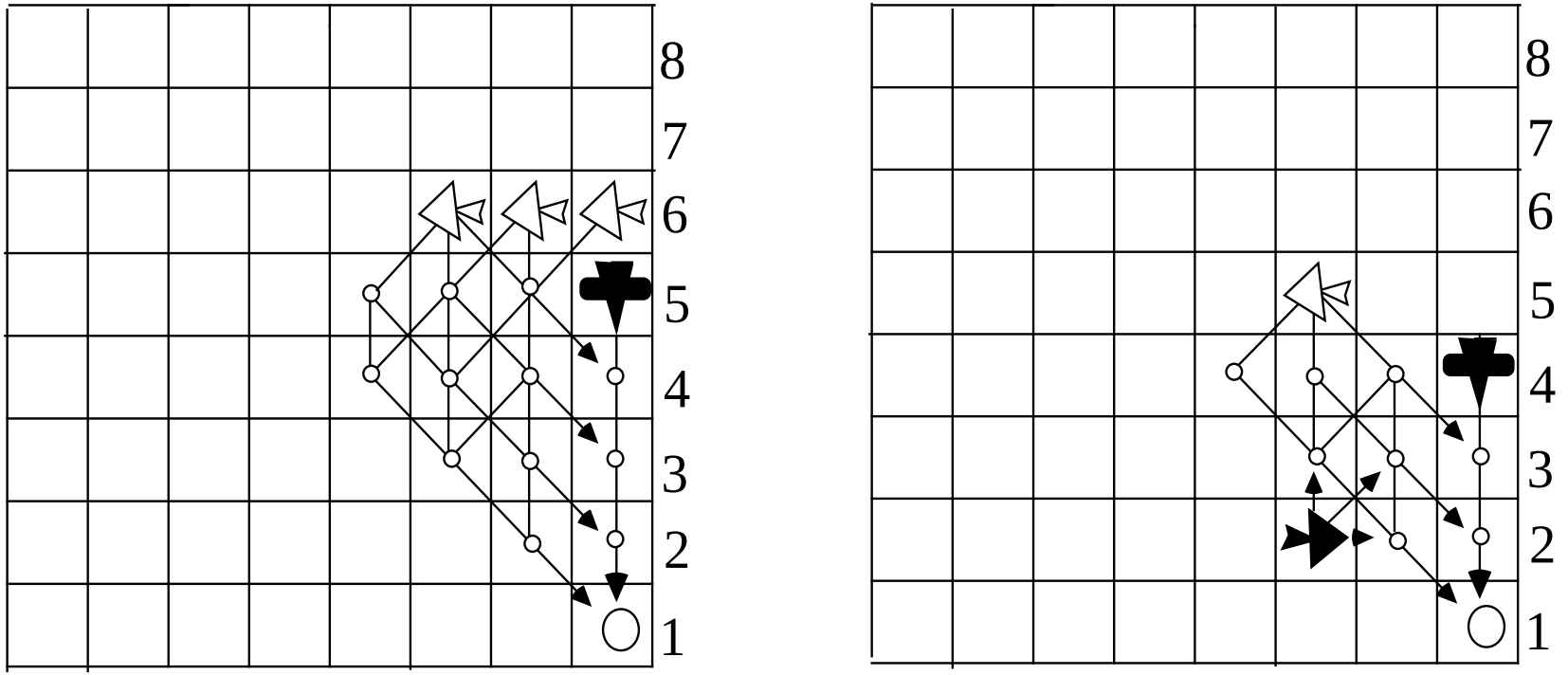
trajectory nodes

Structure of Expanded Terminal Sets

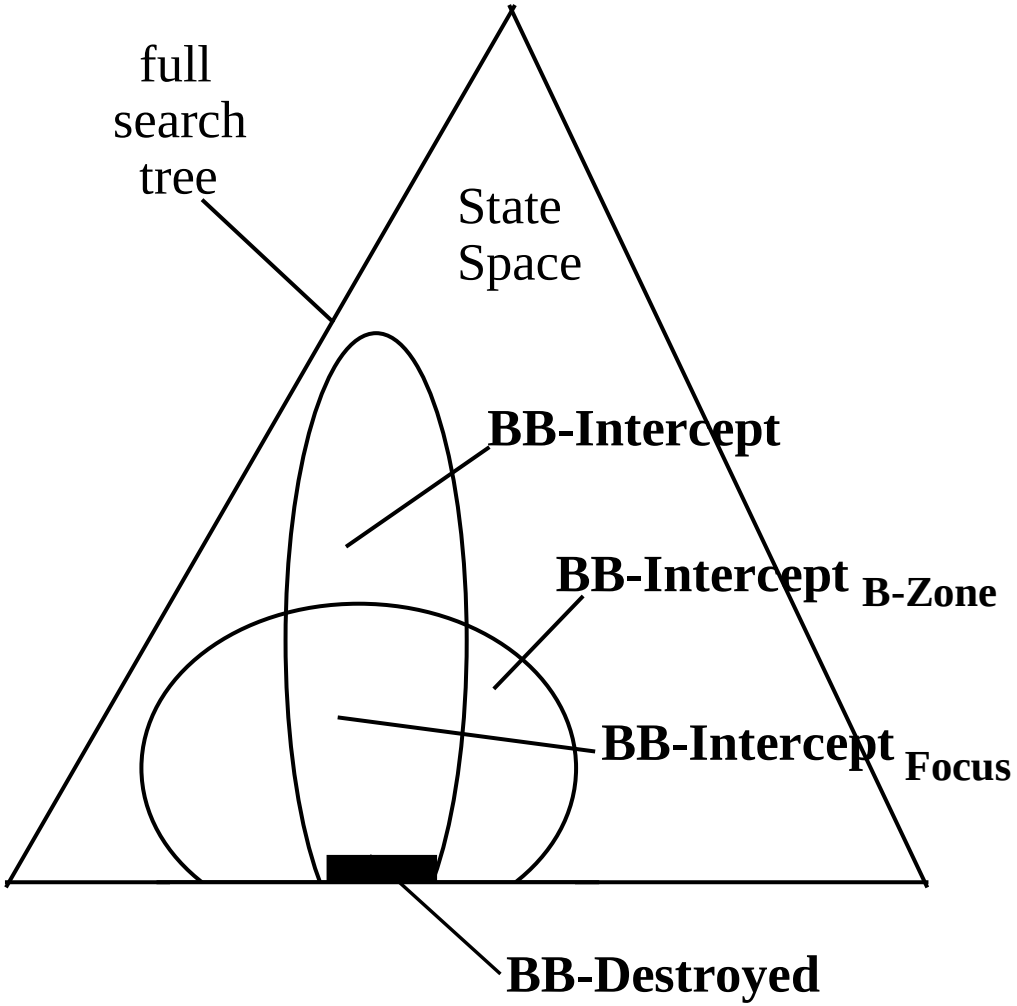


Structure of BB-Intercept,
the set of states
where BB-Destroyed strategy exists

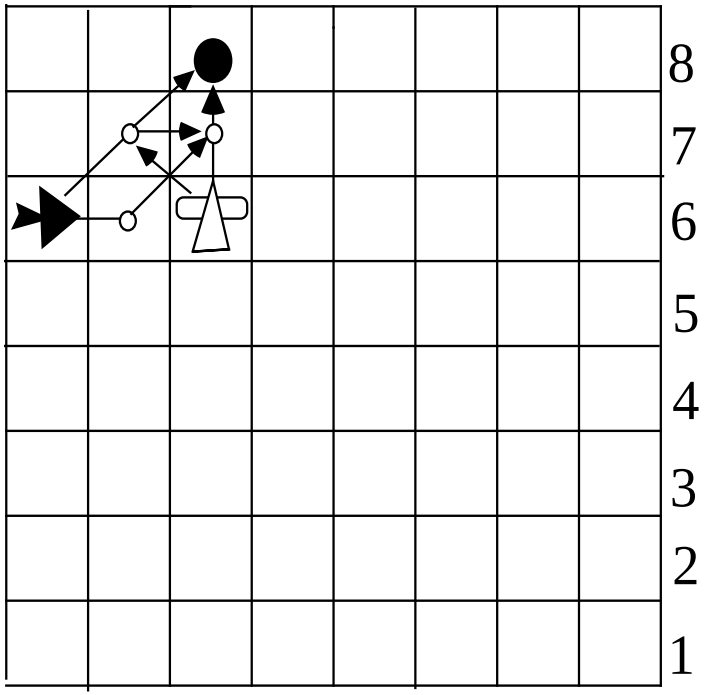
Structure of Expanded Terminal Sets:
BB-Intercept $_{\text{B-Zone}}$

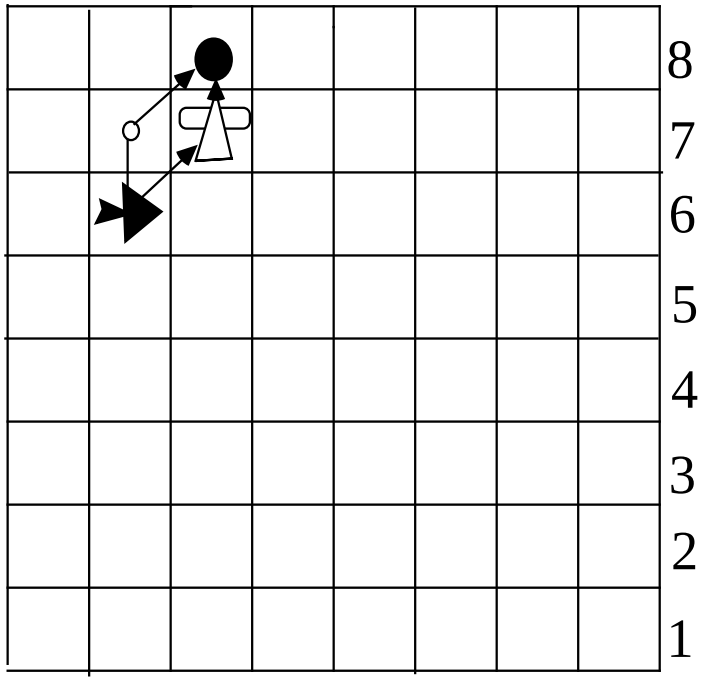


What has been achieved?

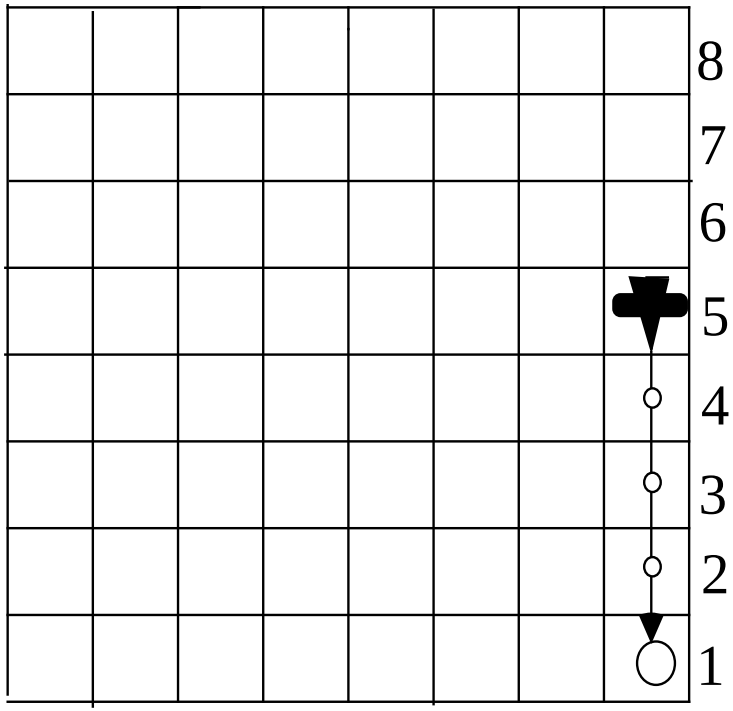


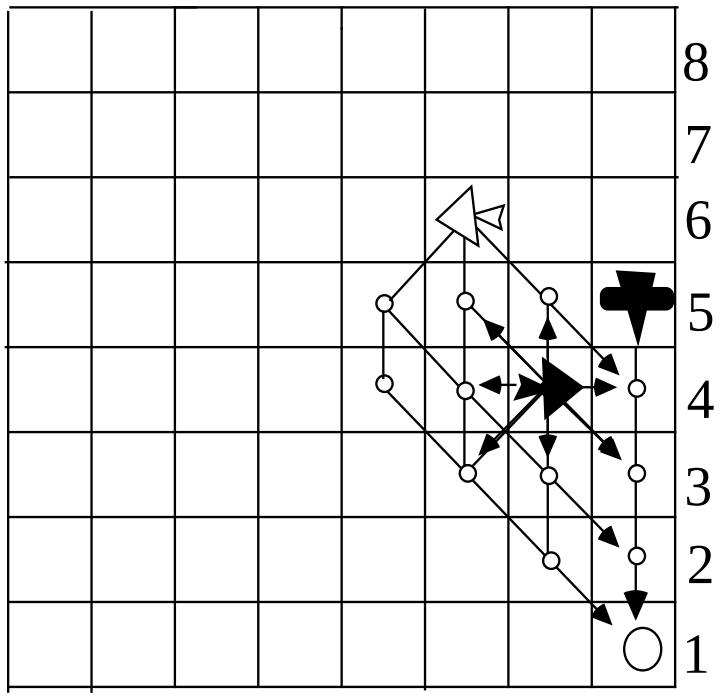
Structure of Expanded Terminal Sets
WB-Intercept$_{\text{W-Zone}}$





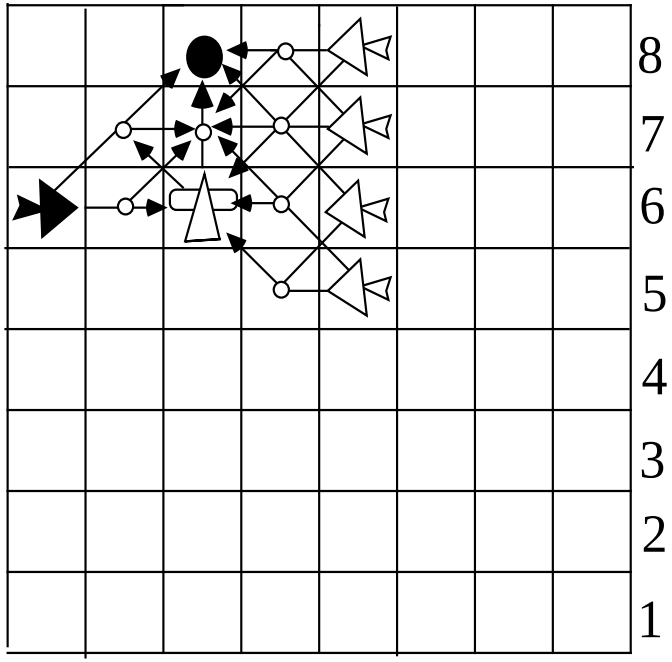
Structure of Expanded Terminal Sets
BB-Protect$_{\text{B-Zone}}$



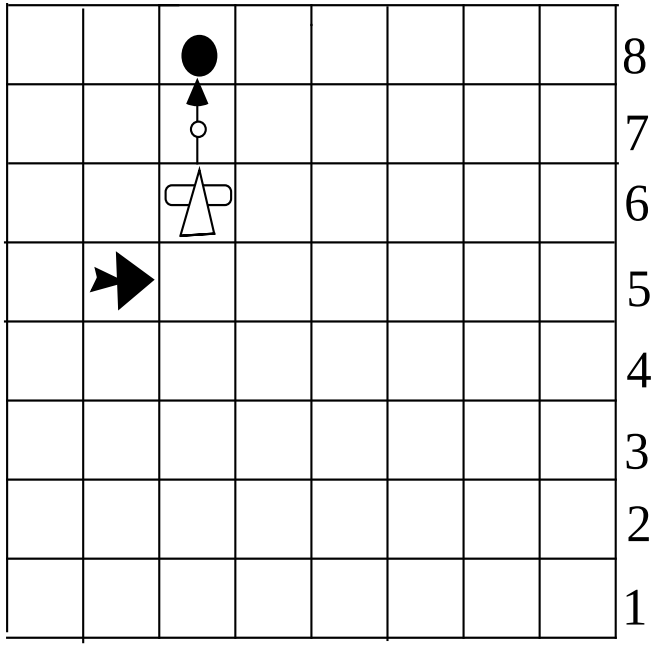


Structure of Expanded Terminal Sets

WB-Protect



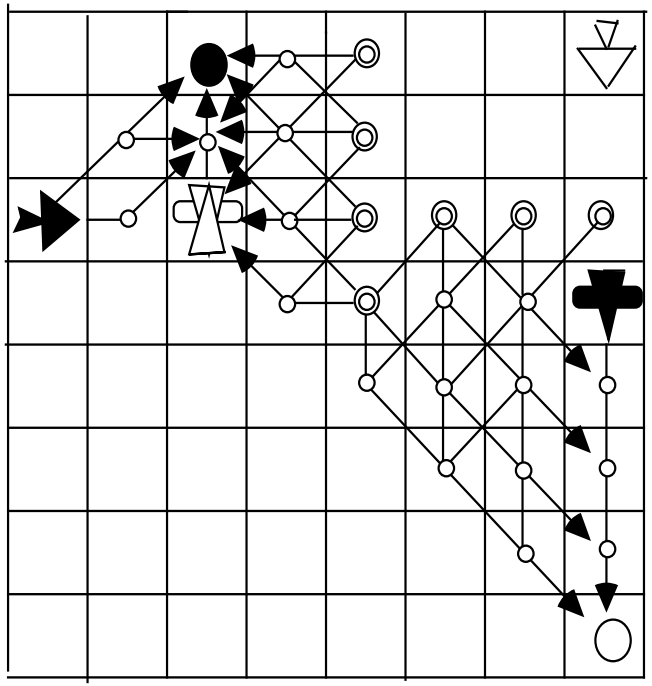
W-Zone



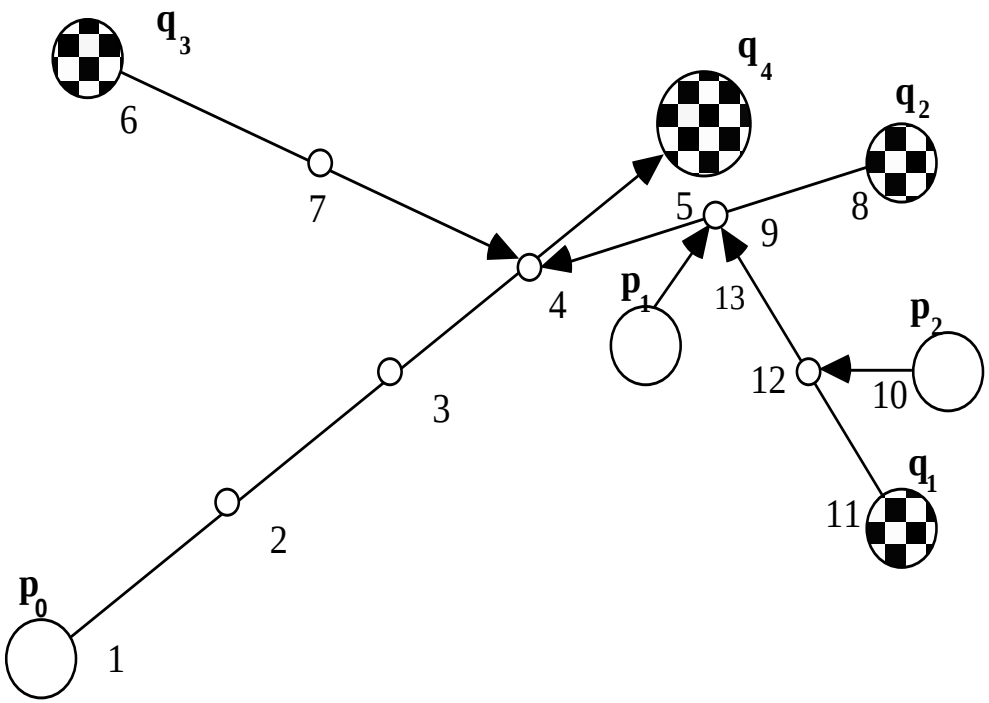
State Space Decomposition

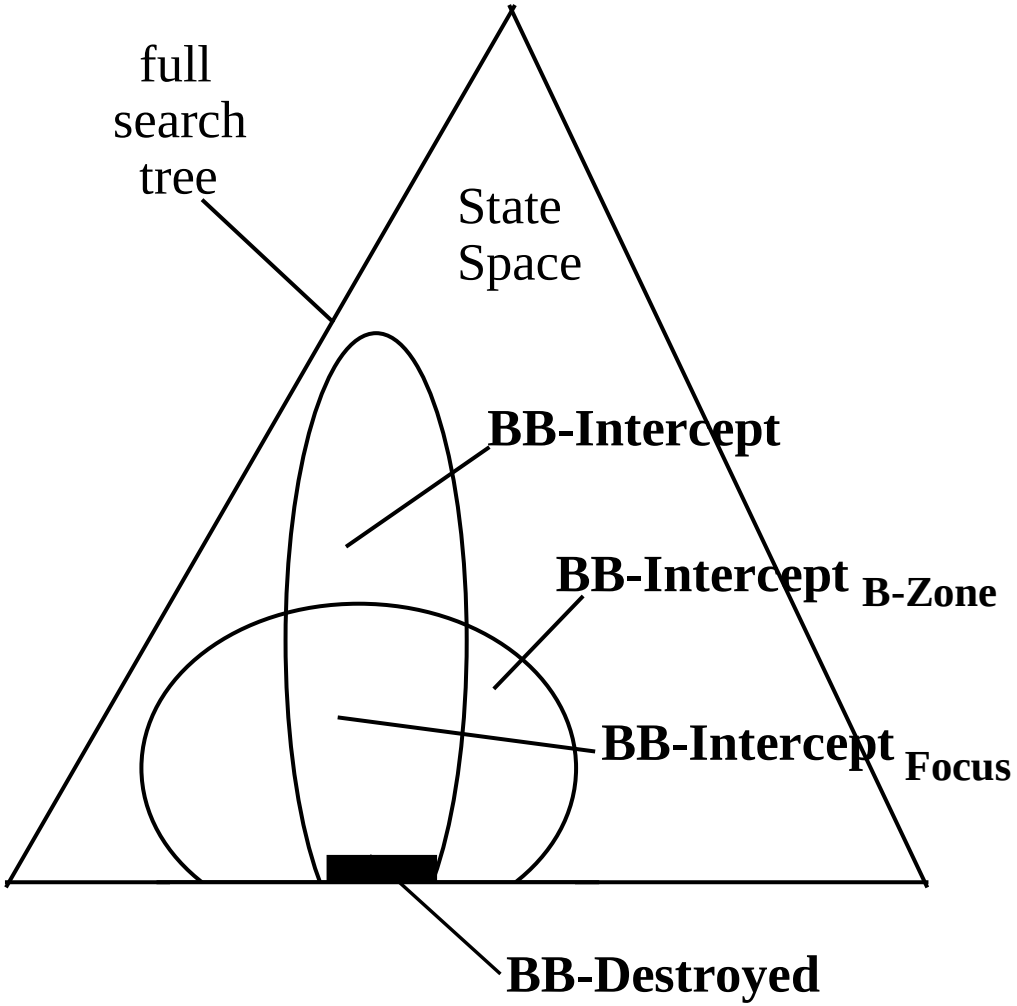
$$\text{SPACE} = \text{BB-Intercept}_{\text{B-Zone}} \cup \text{BB-Protect}_{\text{B-Zone}}$$

$$\text{SPACE} = \text{WB-Intercept}_{\text{W-Zone}} \cup \text{WB-Protect}_{\text{W-Zone}}$$



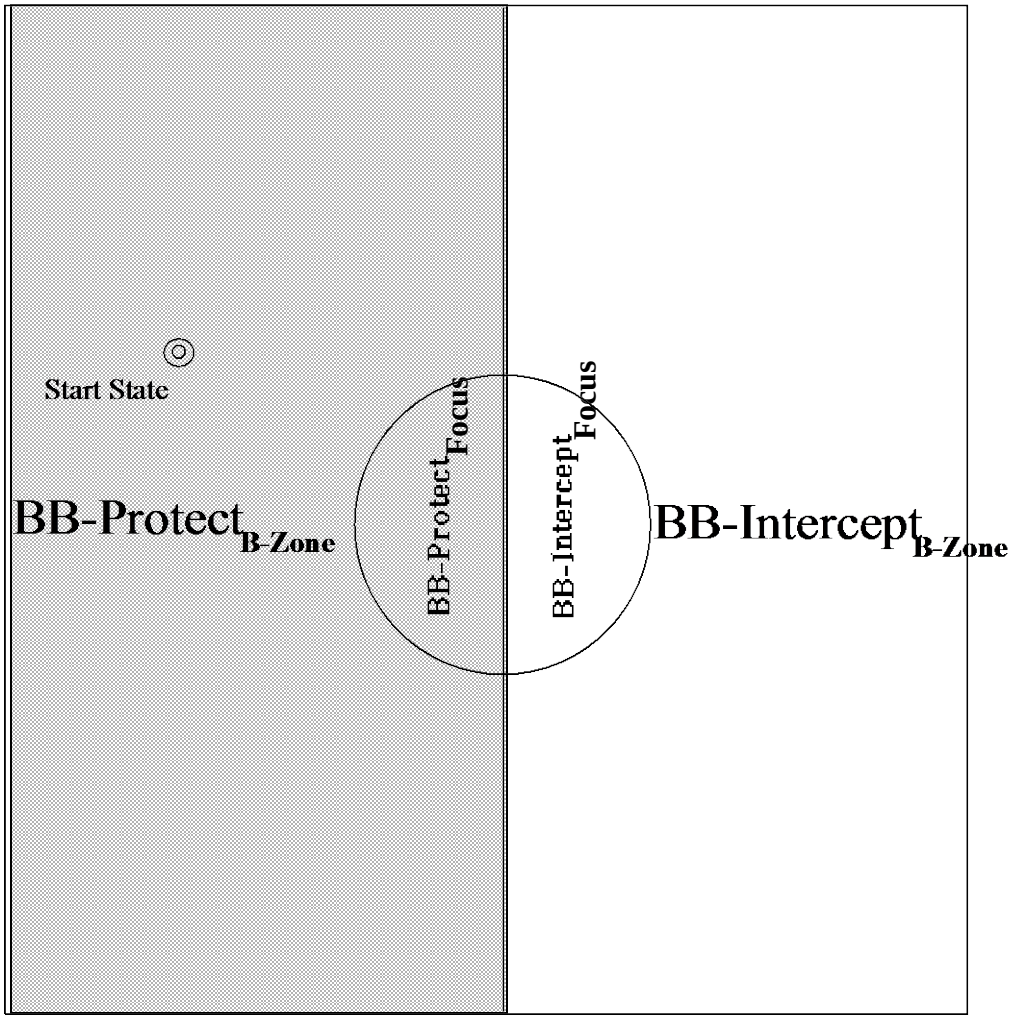
LG Zone




full
search
tree
State
Space
BB-Intercept
BB-Intercept
B-Zone
BB-Intercept
Focus
BB-Destroyed

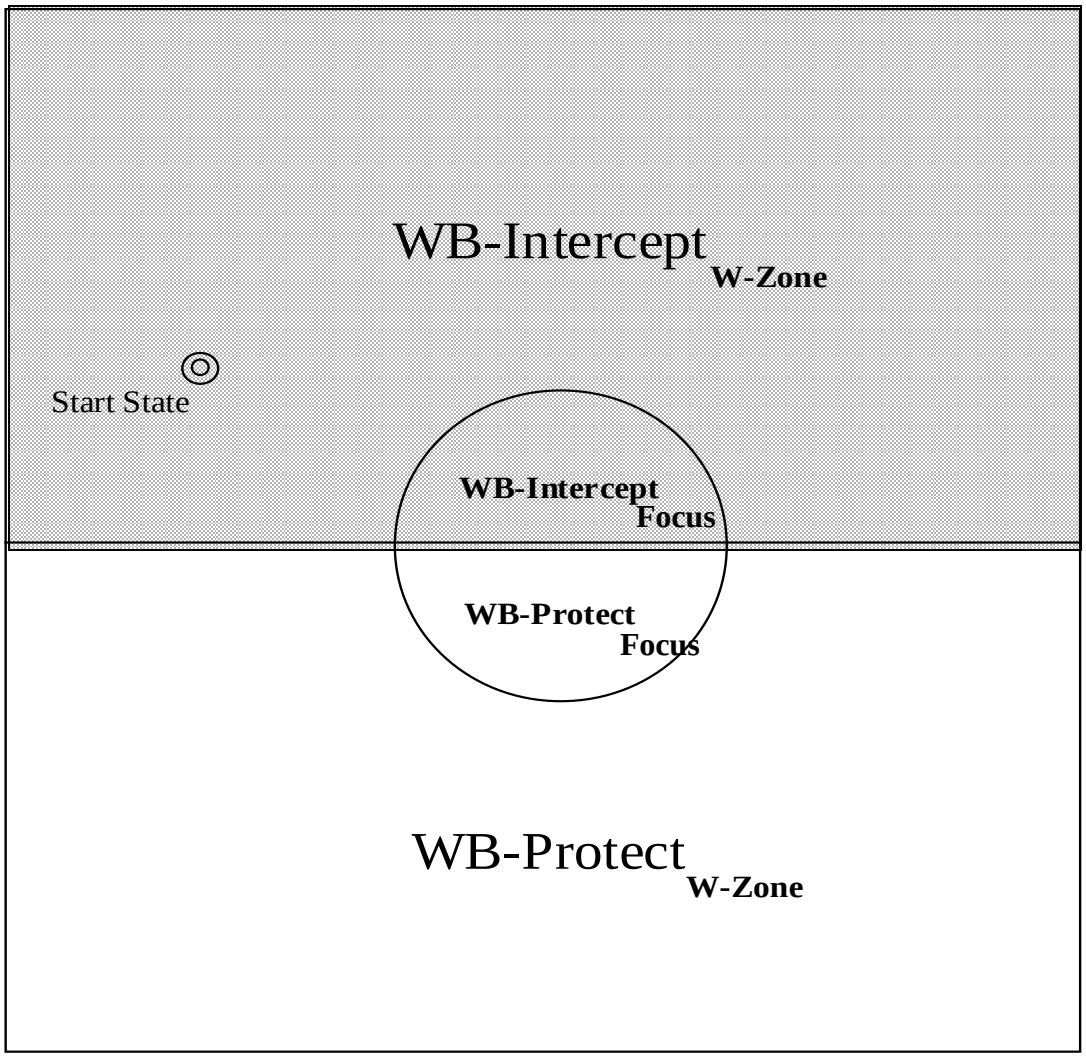
State Space Decomposition

SPACE = BB-Protect$_{B\text{-}Zone}$ ∪ BB-Intercept$_{B\text{-}Zone}$

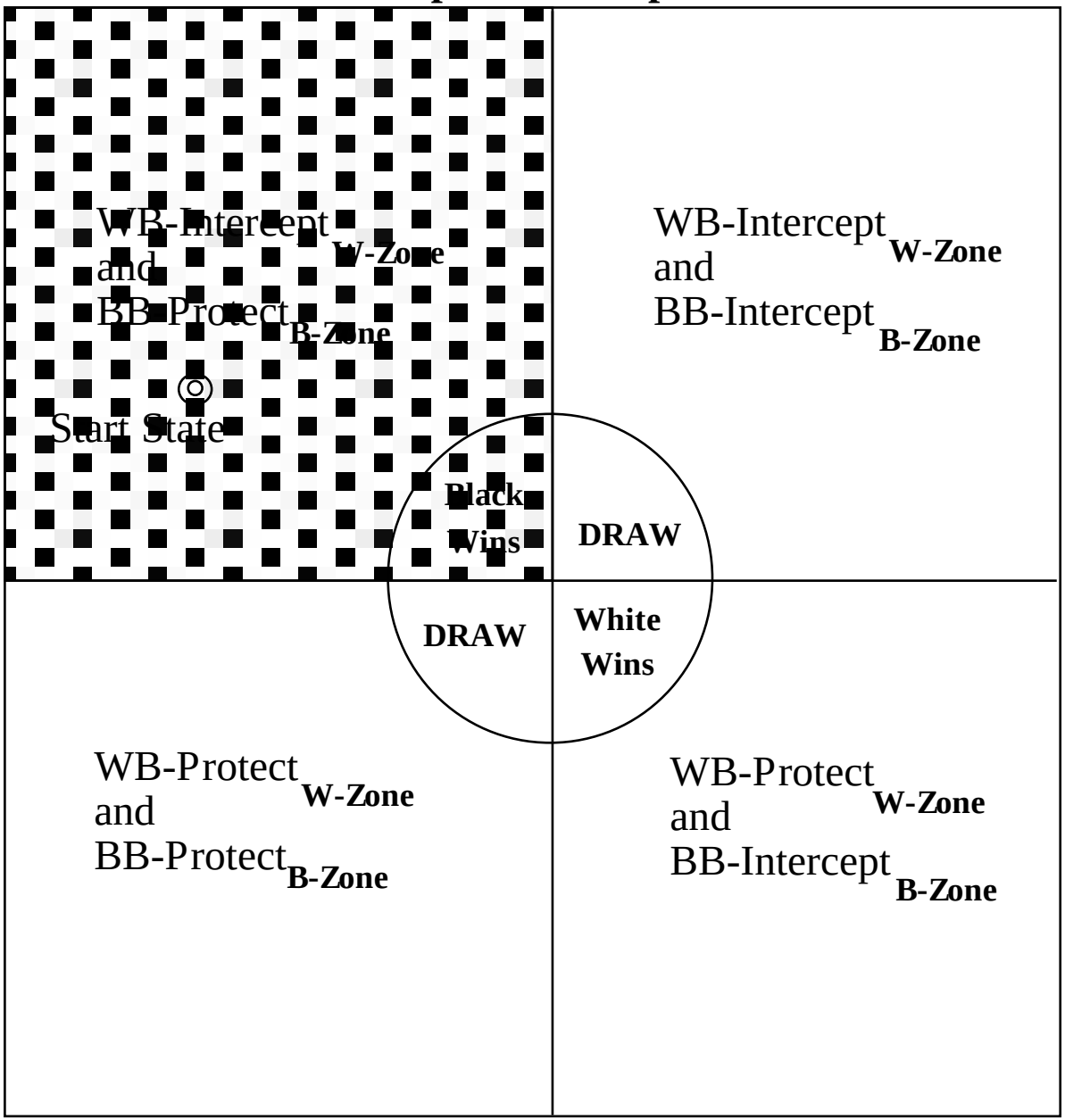


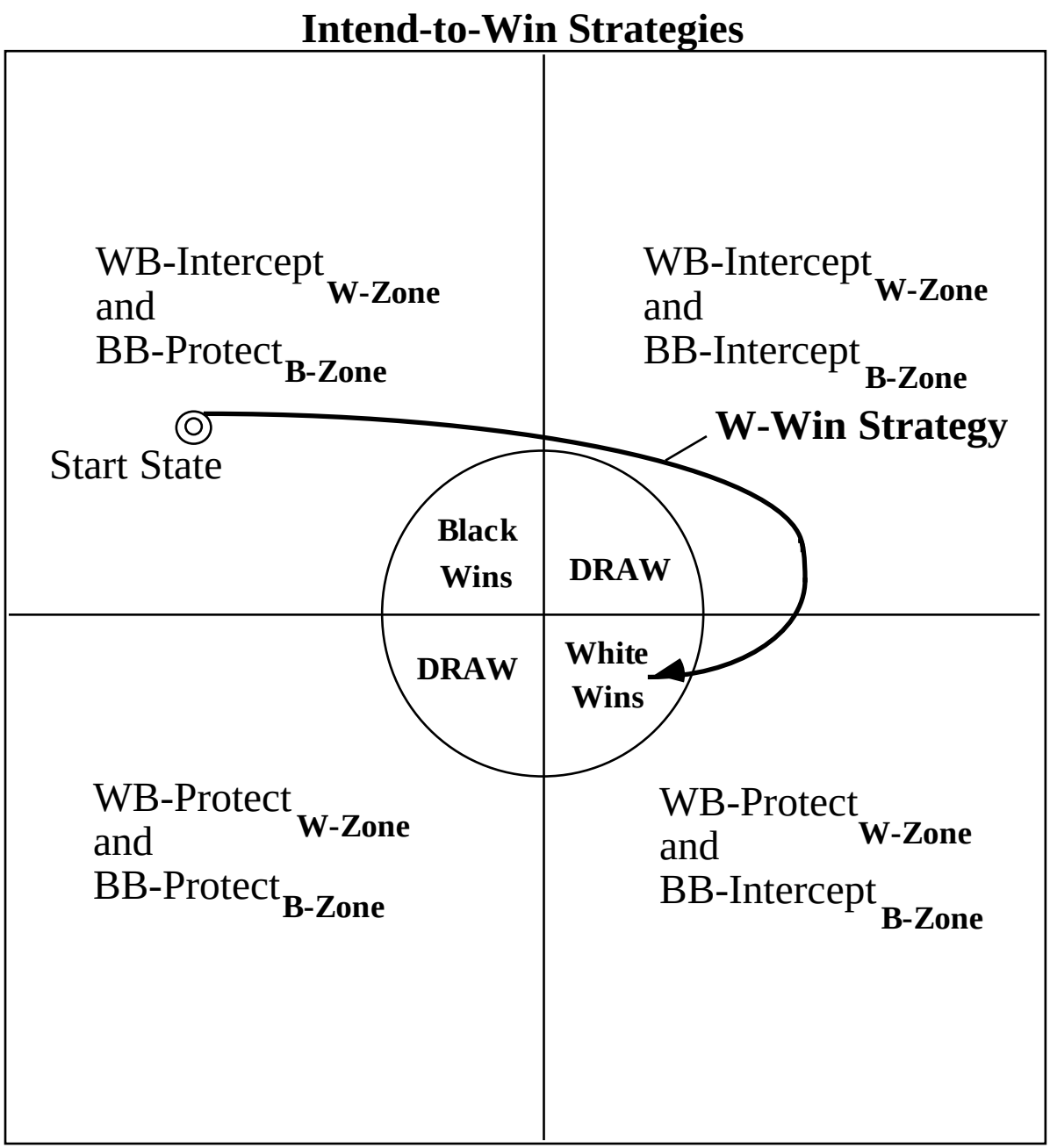
State Space Decomposition

SPACE = WB-Protect$_{W\text{-}Zone}$ $\cup$ WB-Intercept$_{W\text{-}Zone}$



State Space Decomposition




Intend-to-Win Strategies
WB-Intercept and BB-Protect
W-Zone
B-Zone
WB-Intercept and BB-Intercept
W-Zone
B-Zone
W-Win Strategy
Start State
Black Wins
DRAW
DRAW
White Wins
WB-Protect and BB-Protect
W-Zone
B-Zone
WB-Protect and BB-Intercept
W-Zone
B-Zone

Intend-to-Win Strategies

In reality, ***only one of them takes place.***

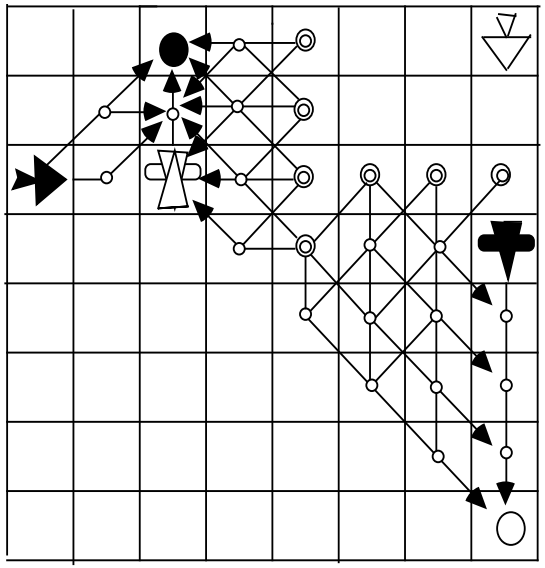
1. W-Win strategy: W-Win = WB-Safe ∩ BB-Destroyed

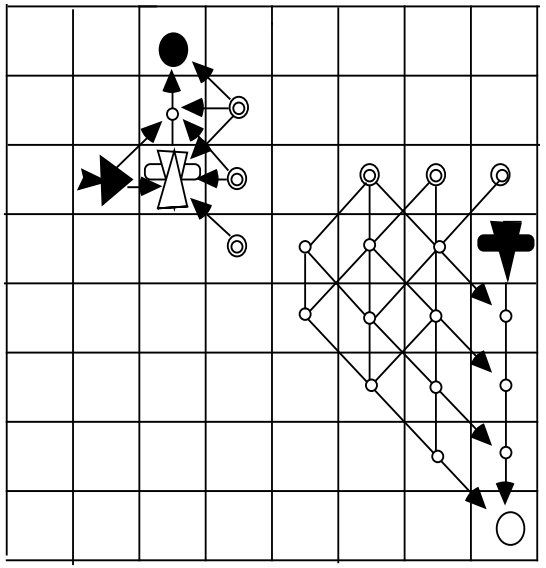
The W-Win strategy, if it exists, is to change the status of <u>both</u>
W-Zone and B-Zone,

$$\textbf{WB-Intercept}_{\textbf{W-Zone}} \cap \textbf{BB-Protect}_{\textbf{B-Zone}}$$

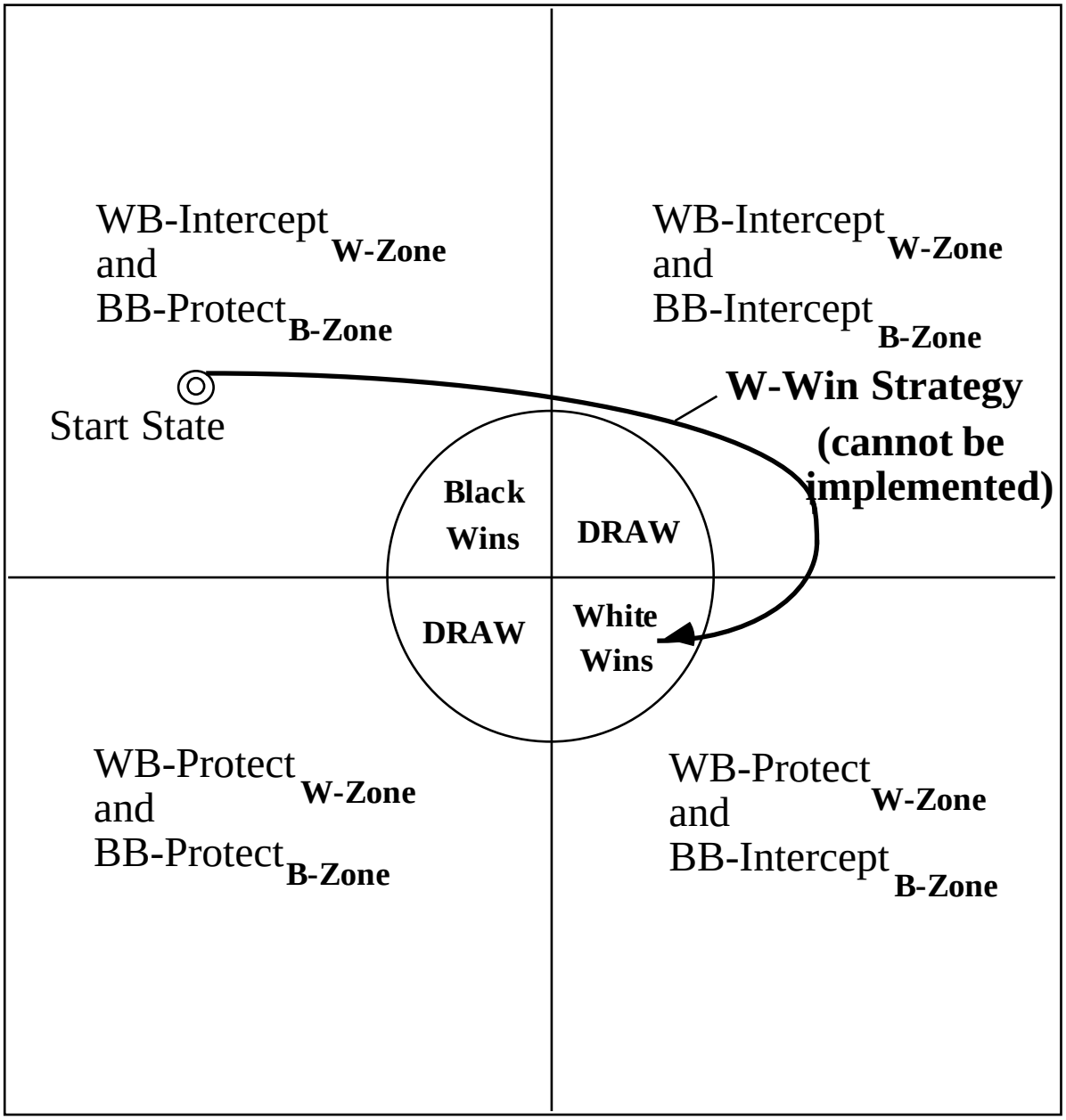
$$\Downarrow$$

$$\textbf{WB-Protect}_{\textbf{Focus}} \cap \textbf{BB-Intercept}_{\textbf{Focus}}$$

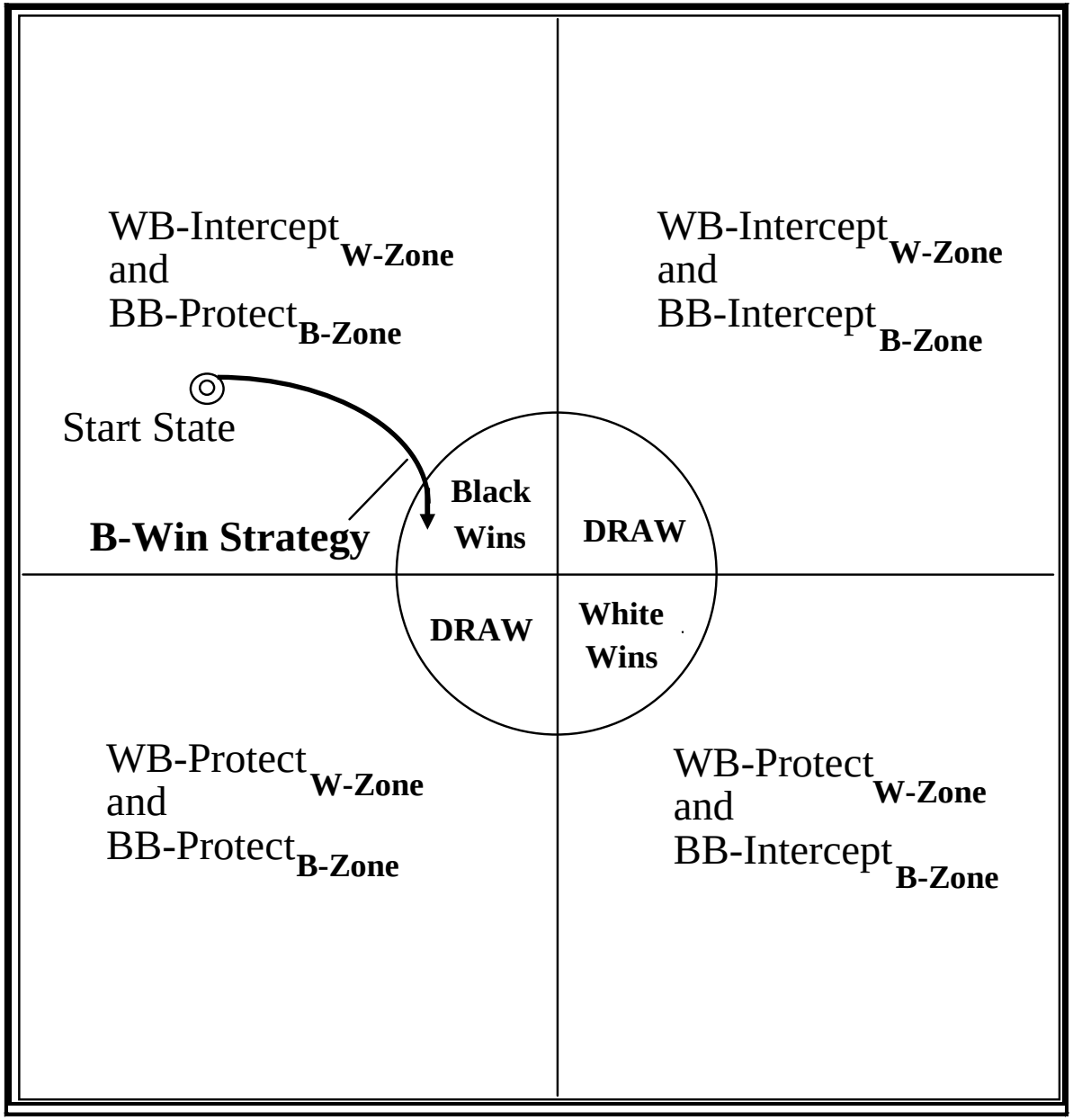




Intend-to-Win Strategies



Intend-to-Win Strategies



Intend-to-Win Strategies

In reality, ***only one of them takes place.***

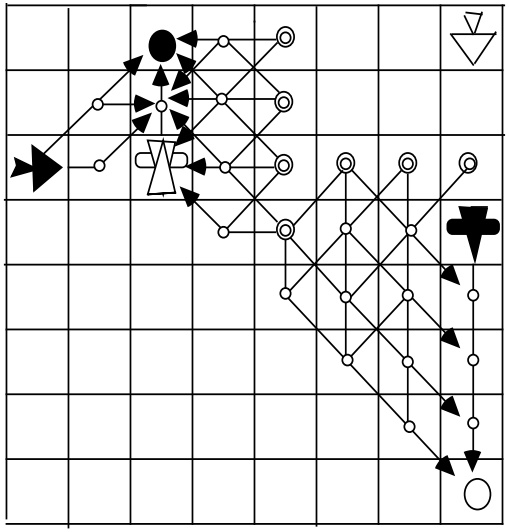
2. B-Win strategy: **B-Win = WB-Destroyed ∩ BB-Safe**

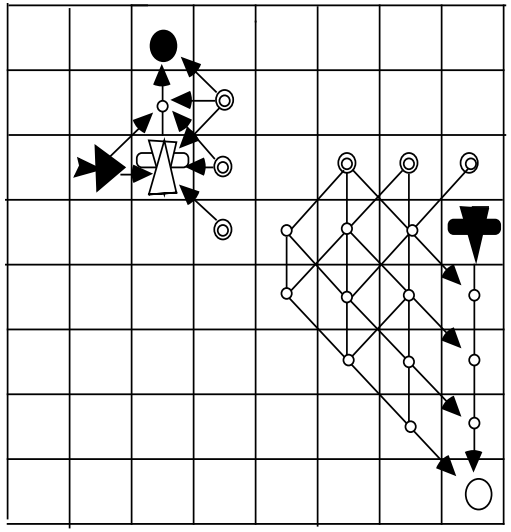
The B-Win strategy, if it exists, is to keep the status of <u>both</u>
W-Zone and B-Zone
unchanged as they are in the Start State.

$$\textbf{WB-Intercept}_{\textbf{W-Zone}} \cap \textbf{BB-Protect}_{\textbf{W-Zone}}$$

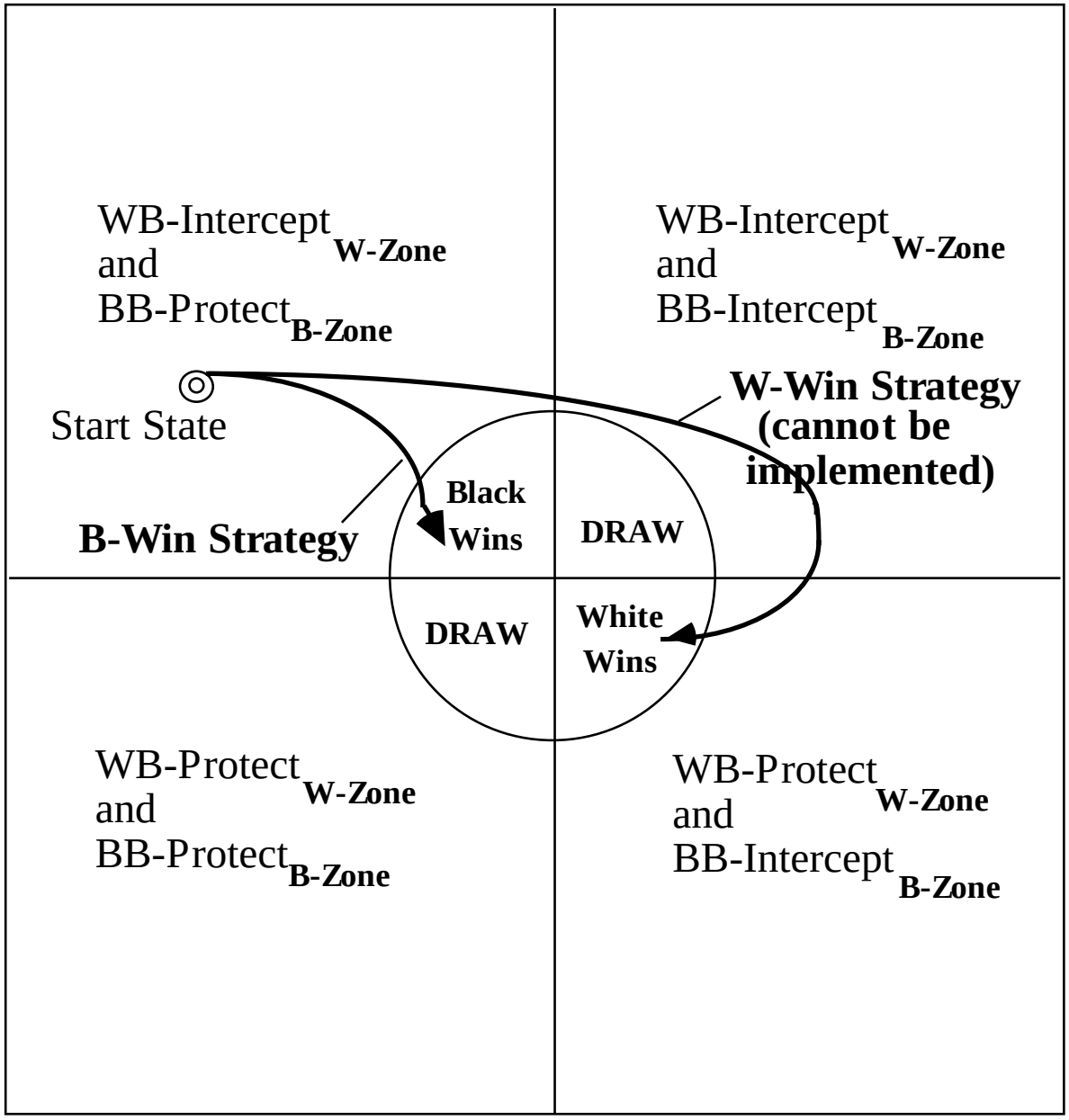
$$\Downarrow$$

WB-Intercept ∩ **BB-Protect**
Focus **Focus**

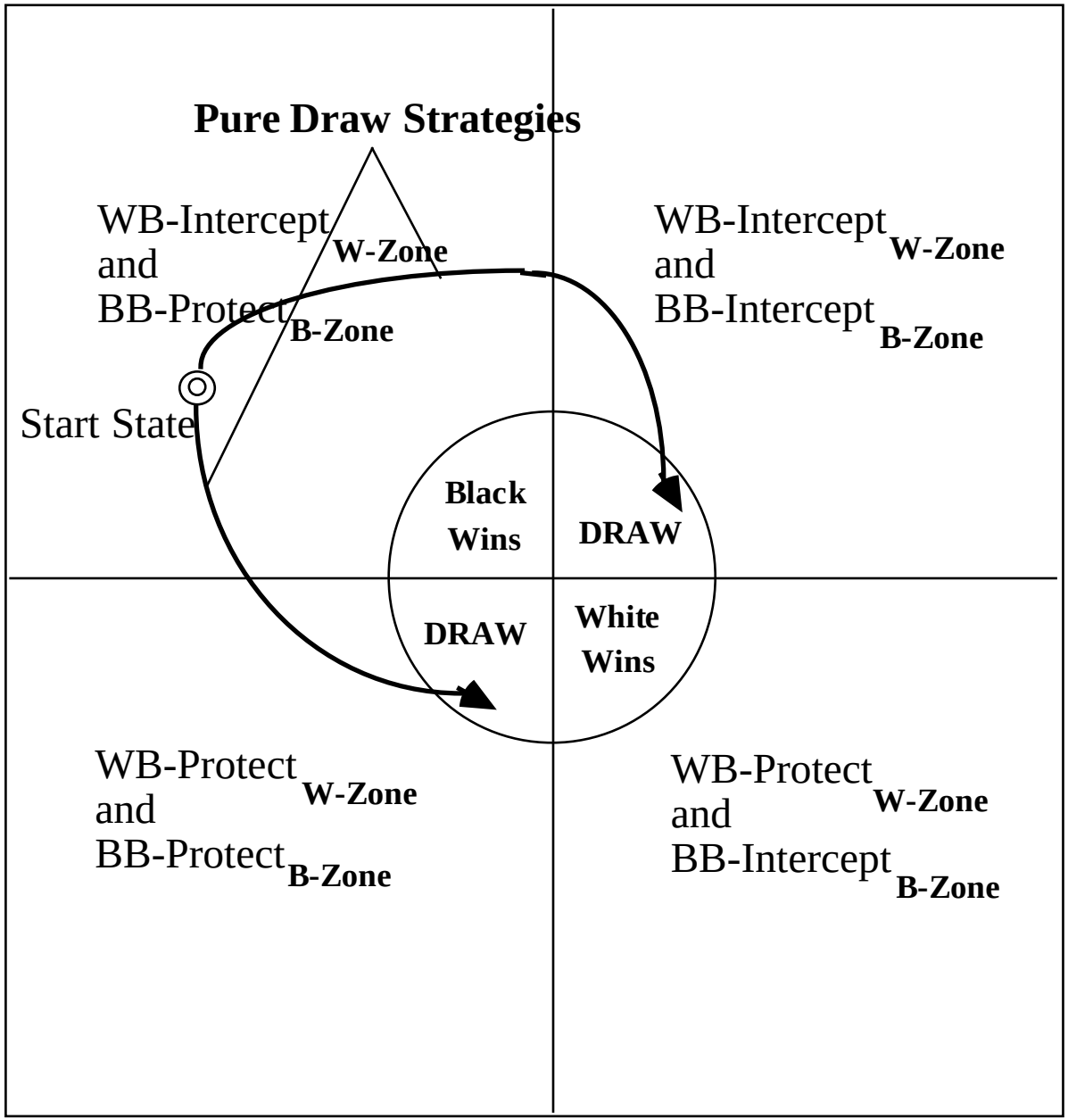




Intend-to-Win Strategies



Intend-to-Draw Strategies



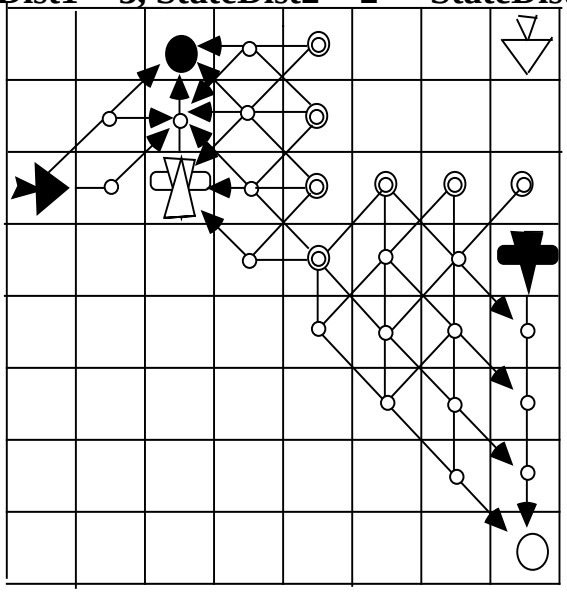
Pure Draw Strategy

StateDist1 = sd(Current State, WB-Protect$_{W\text{-}Zone}$)

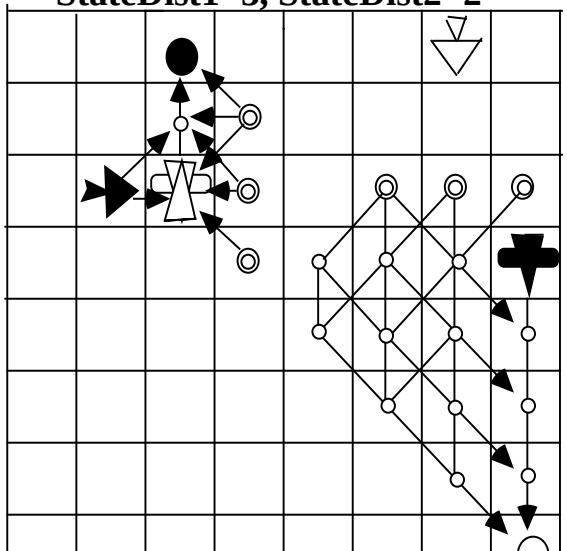
StateDist2 = sd(Current State, BB-Intercept$_{B\text{-}Zone}$)

StateDist = StateDist1 + StateDist2

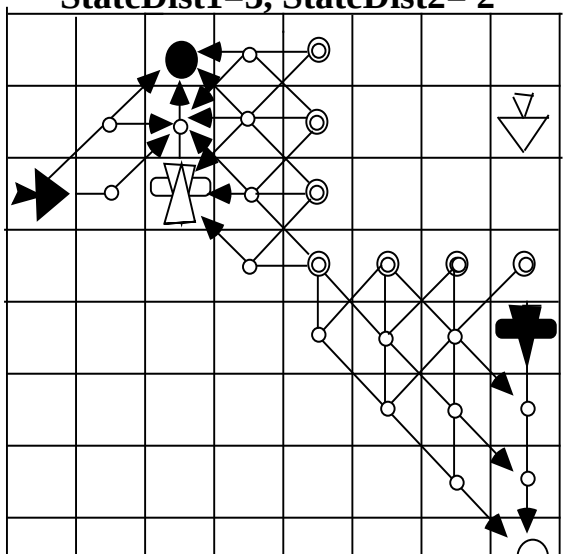
StateDist1 = 3, StateDist2 = 2 =>StateDist = 5

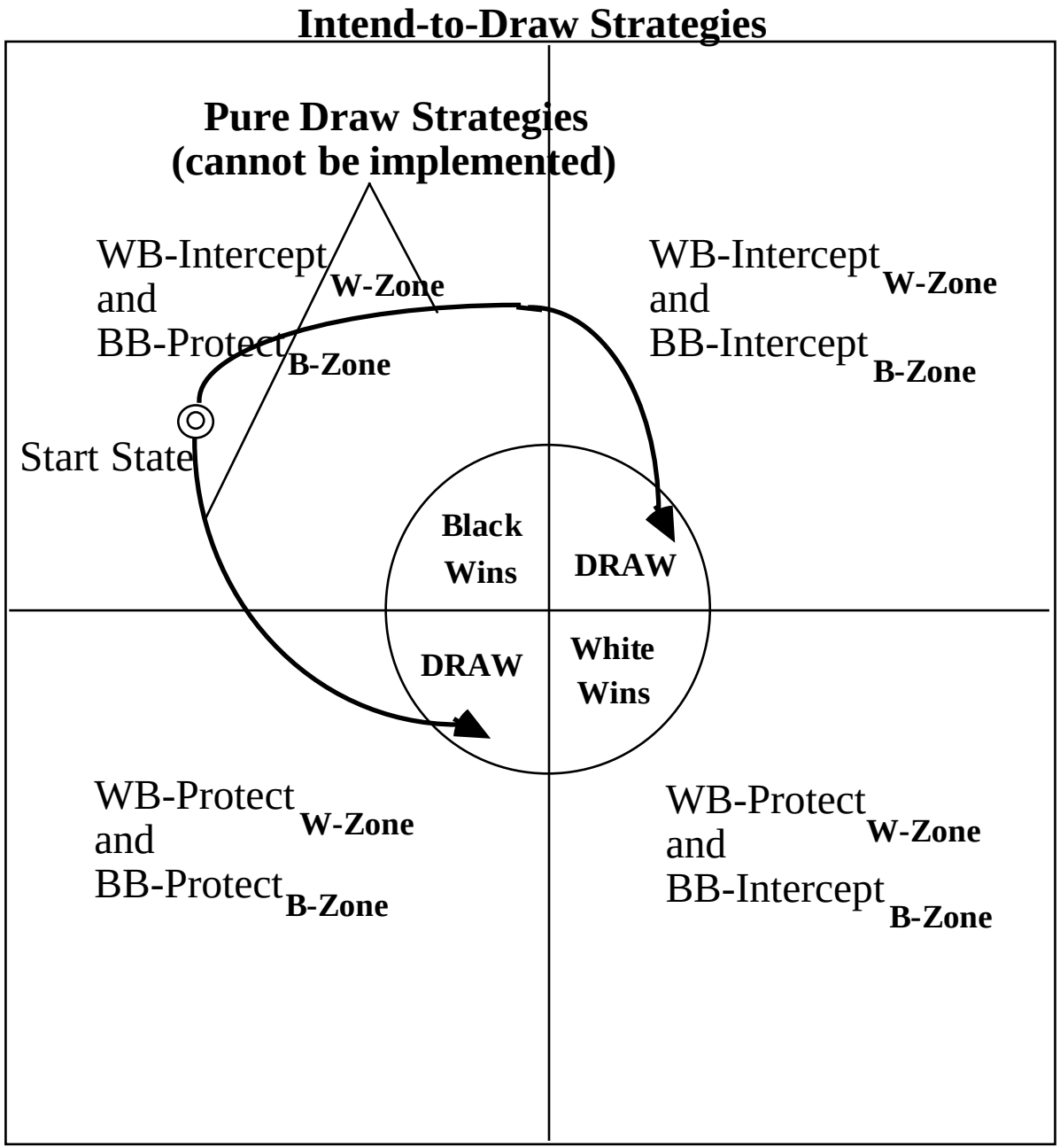


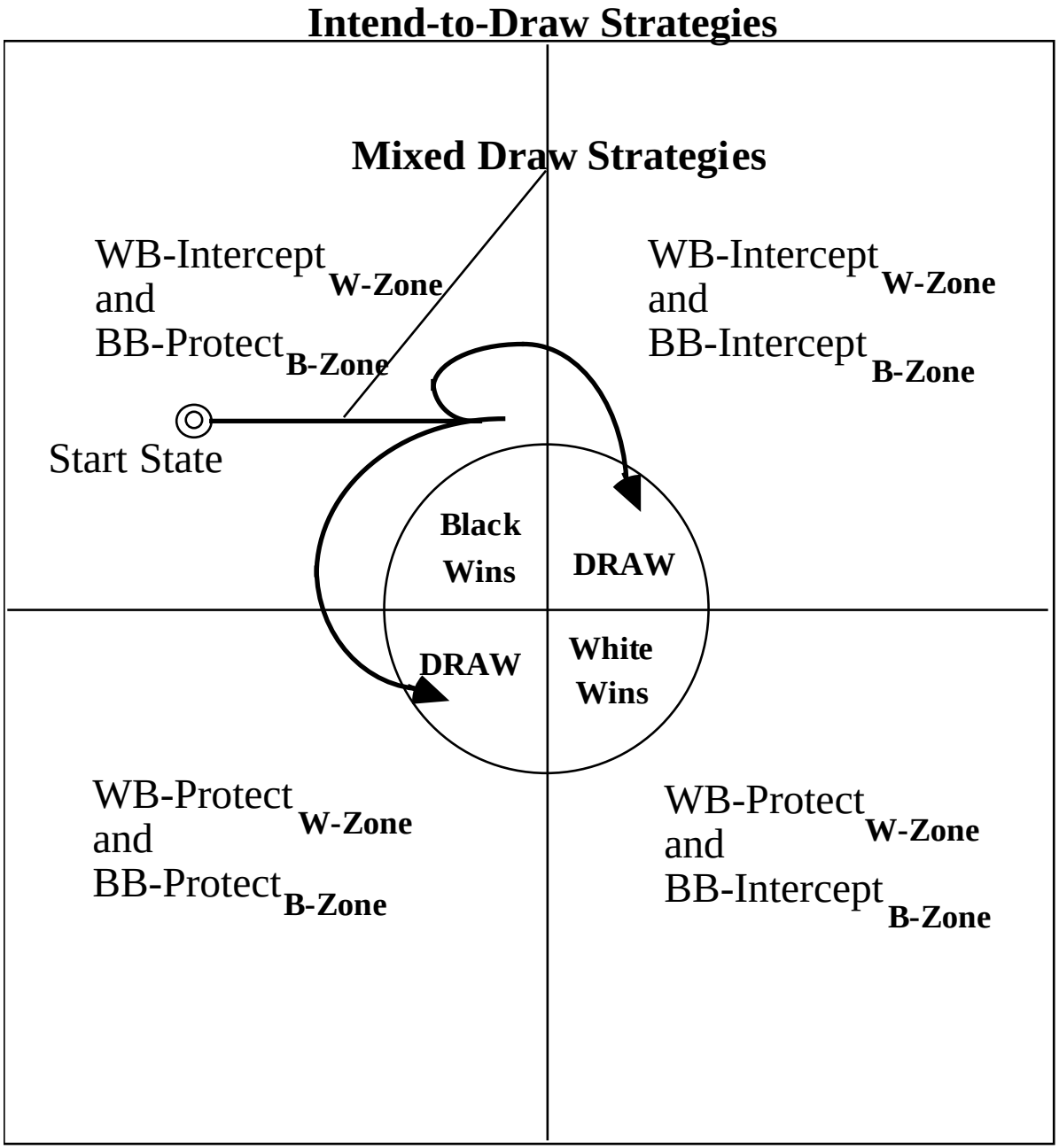
StateDist1=3, StateDist2=2



StateDist1=3, StateDist2= 2




Intend-to-Draw Strategies
Pure Draw Strategies
(cannot be implemented)
WB-Intercept
and
BB-Protect
W-Zone
B-Zone
WB-Intercept
and
BB-Intercept
W-Zone
B-Zone
Start State
Black
Wins
DRAW
DRAW
White
Wins
WB-Protect
and
BB-Protect
W-Zone
B-Zone
WB-Protect
and
BB-Intercept
W-Zone
B-Zone


Intend-to-Draw Strategies
Mixed Draw Strategies
WB-Intercept and BB-Protect
W-Zone
B-Zone
WB-Intercept and BB-Intercept
W-Zone
B-Zone
Start State
Black Wins
DRAW
DRAW
White Wins
WB-Protect and BB-Protect
W-Zone
B-Zone
WB-Protect and BB-Intercept
W-Zone
B-Zone

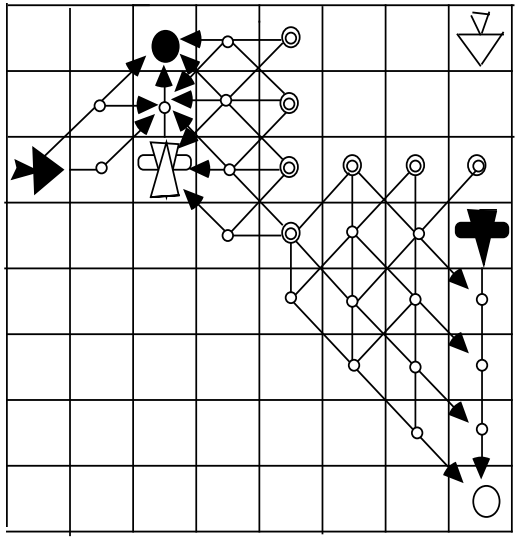
Mixed Draw Strategy

$StateDist1 = sd(Current\ State, WB\text{-}Protect_{W\text{-}Zone})$

$StateDist2 = sd(Current\ State, BB\text{-}Intercept_{B\text{-}Zone})$

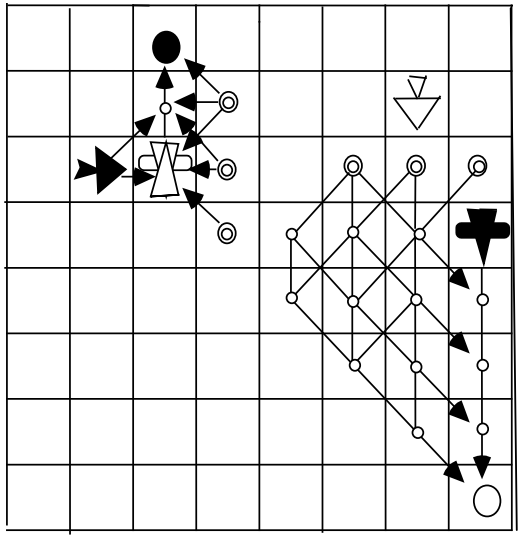
$StateDist = StateDist1 + StateDist2$

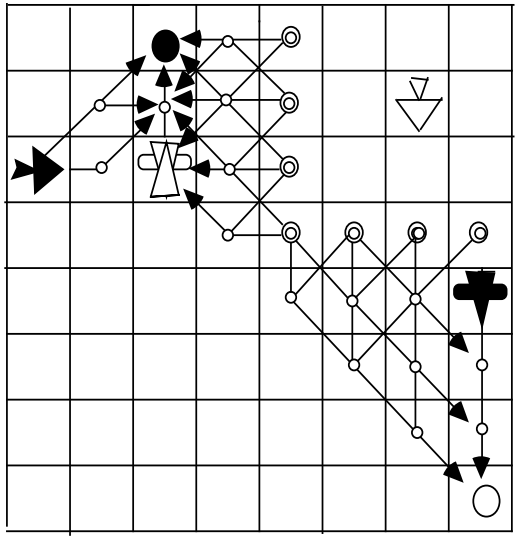
$StateDist \geq sd(Current\ State, WB\text{-}Protect_{W\text{-}Zone} \cup BB\text{-}Intercept_{B\text{-}Zone})$



StateDist = 5

StateDist= 4

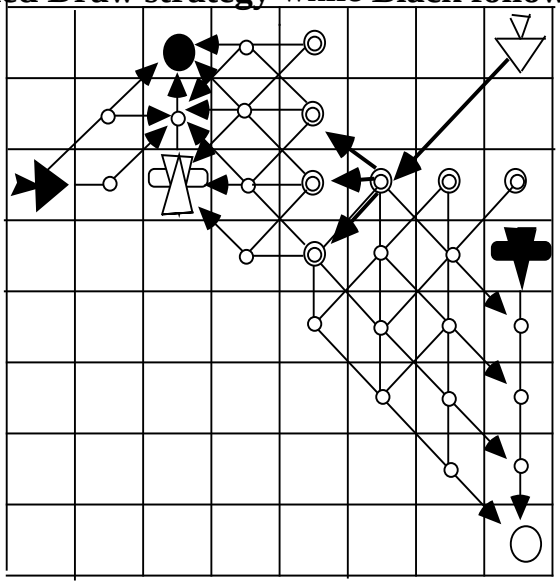


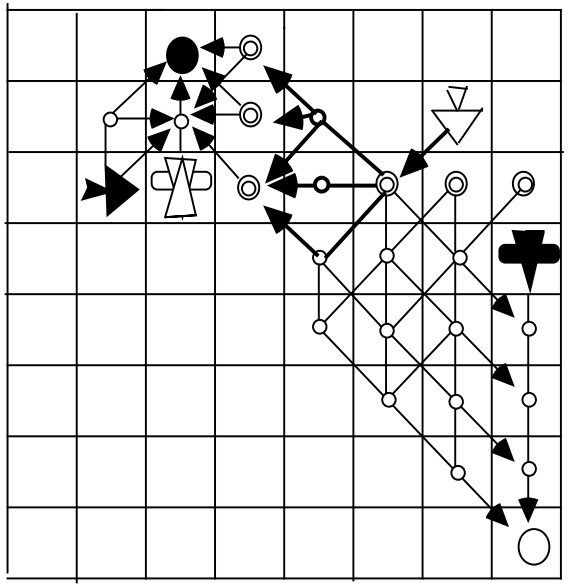


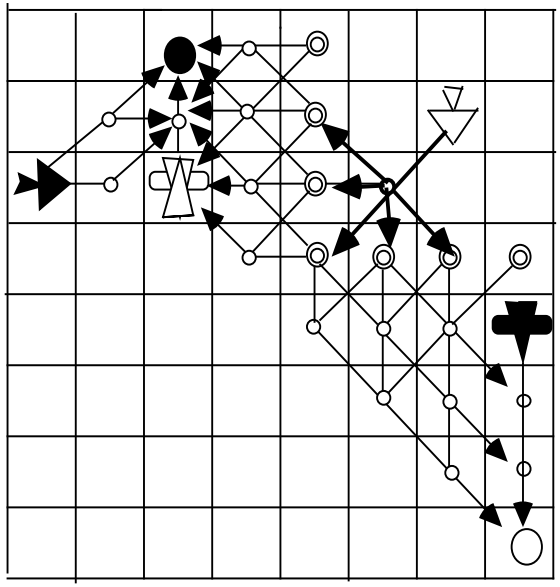
StateDist = 4

Strategy at the Start State

White follows Mixed Draw strategy while **Black follows B-Win strategy**







Strategy at the Start State

White follows **Mixed Draw strategy** while Black follows **B-Win strategy.**
This resulted in **a Draw strategy.**