

UNIDENTIFIED RESEARCH OBJECT

# Monte Carlo Tree Search and video games

Matthew Bedder

# Structure

- Background
- Monte Carlo Tree Search
  - What it is, why it's great
- Aside: Challenges in video games
- Monte Carlo Tree Search (cont.)
  - Why it's terrible
- Research directions

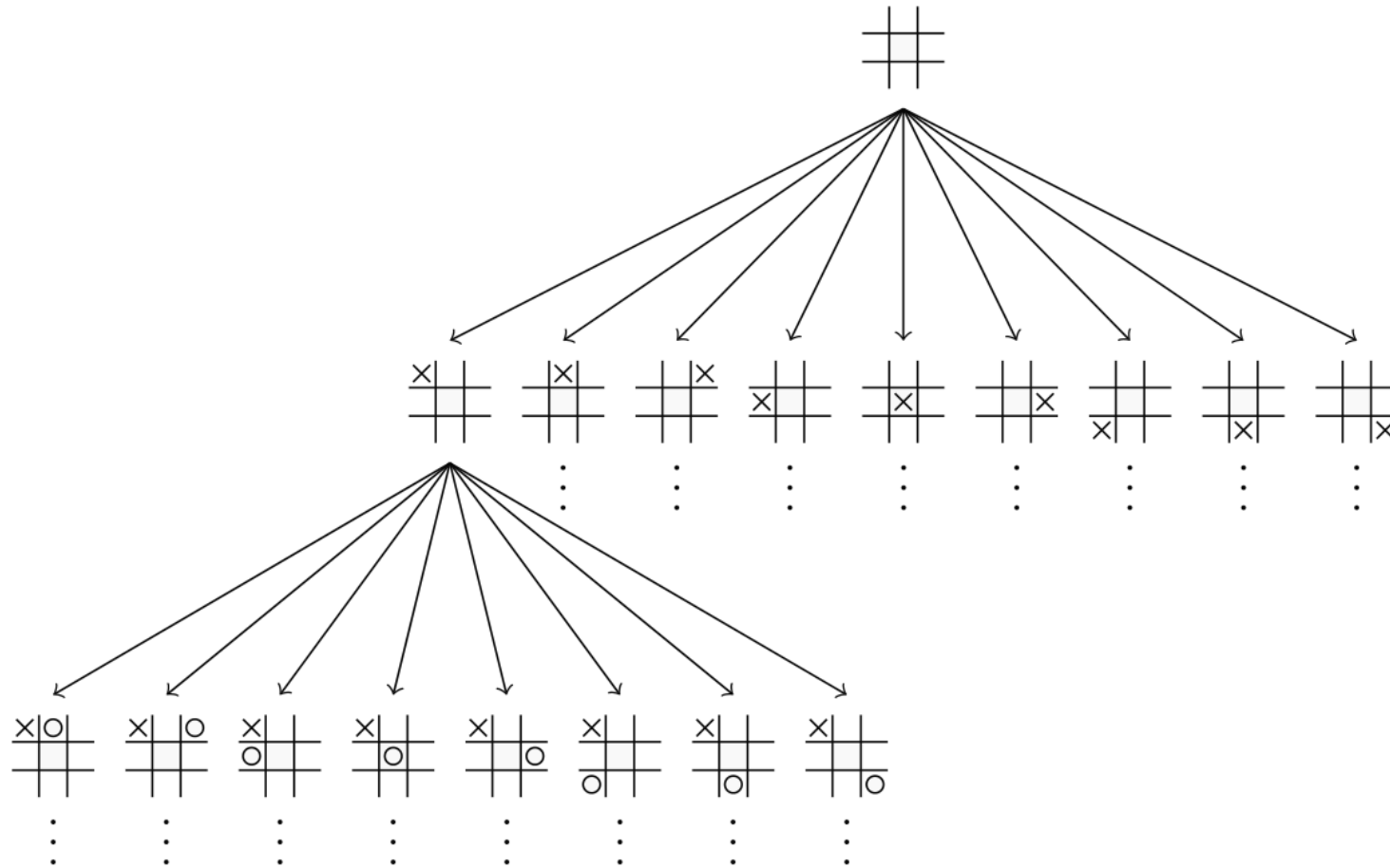
# Background

# Conventional view of games AI

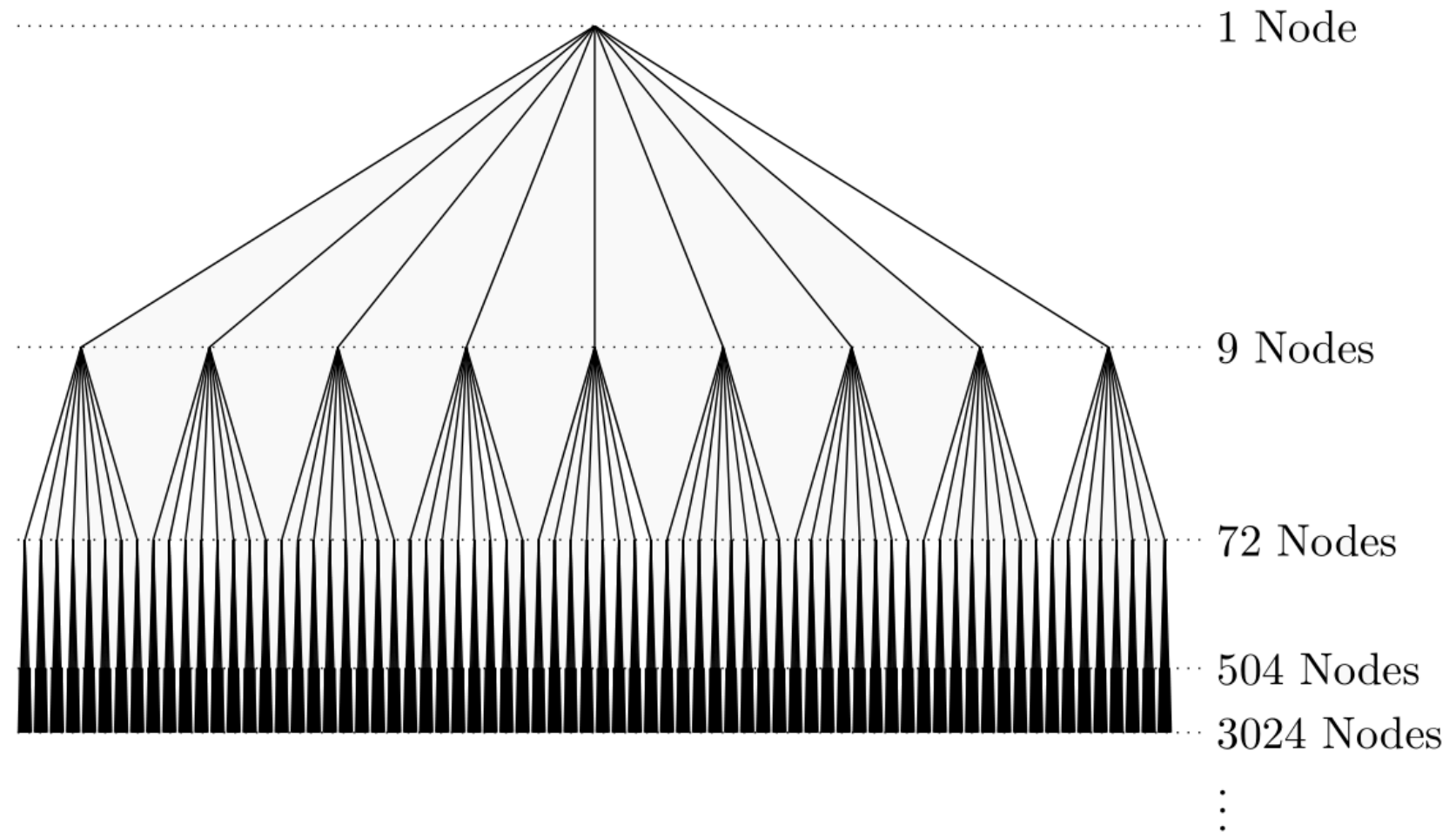
- Assume games are MDPs
- Often we only get rewards at terminal states
- Generate decision trees
- Pick a branch
- Try to maximise win rate/realism/enjoyment/interestingness/something else

NOTE : This ignores lots of cool research

# Noughts and Crosses



# Noughts and Crosses



# Conventional approaches (non-comprehensive)

- Minimax search
  - Requires us to look at every node
- Alpha-beta pruning
  - Trees can be incredibly deep
- Depth-limiting using heuristics
  - Unsuitable for some domains

# Monte Carlo Evaluations

Perform random actions until some terminal state

- Provides a **very** lossy value estimate
- Akin to sampling the reward distribution
- Aheuristic, but requires forward model



# Monte Carlo Search

Repeatedly apply MCEs to successor states, then select the state we think is best

- Domain independent
- Converges to optimal action selection
  - ... assuming that each player acts randomly
- No notion of planning

# Monte Carlo Tree Search

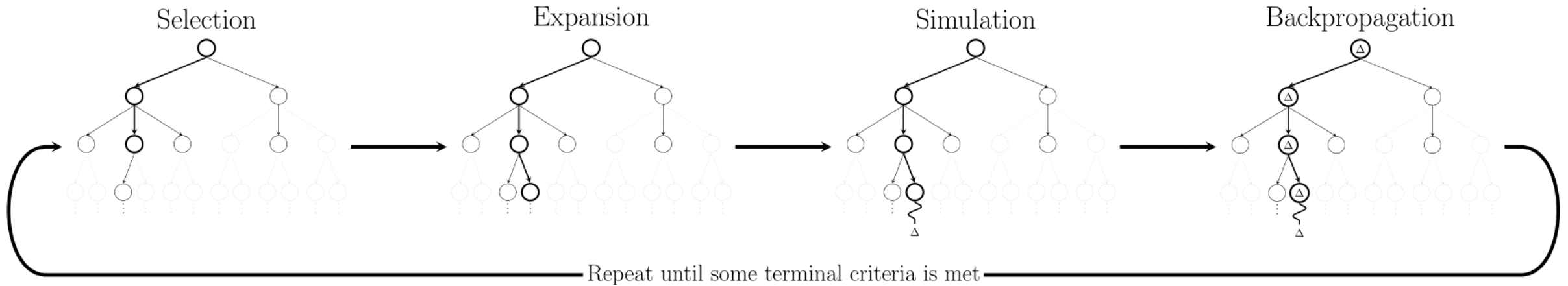
# MCTS – Core Concept

Monte Carlo Search is OK, but..

- We waste time evaluating poor states
- Only thinks one move ahead

IDEA: Subdivide “good” states

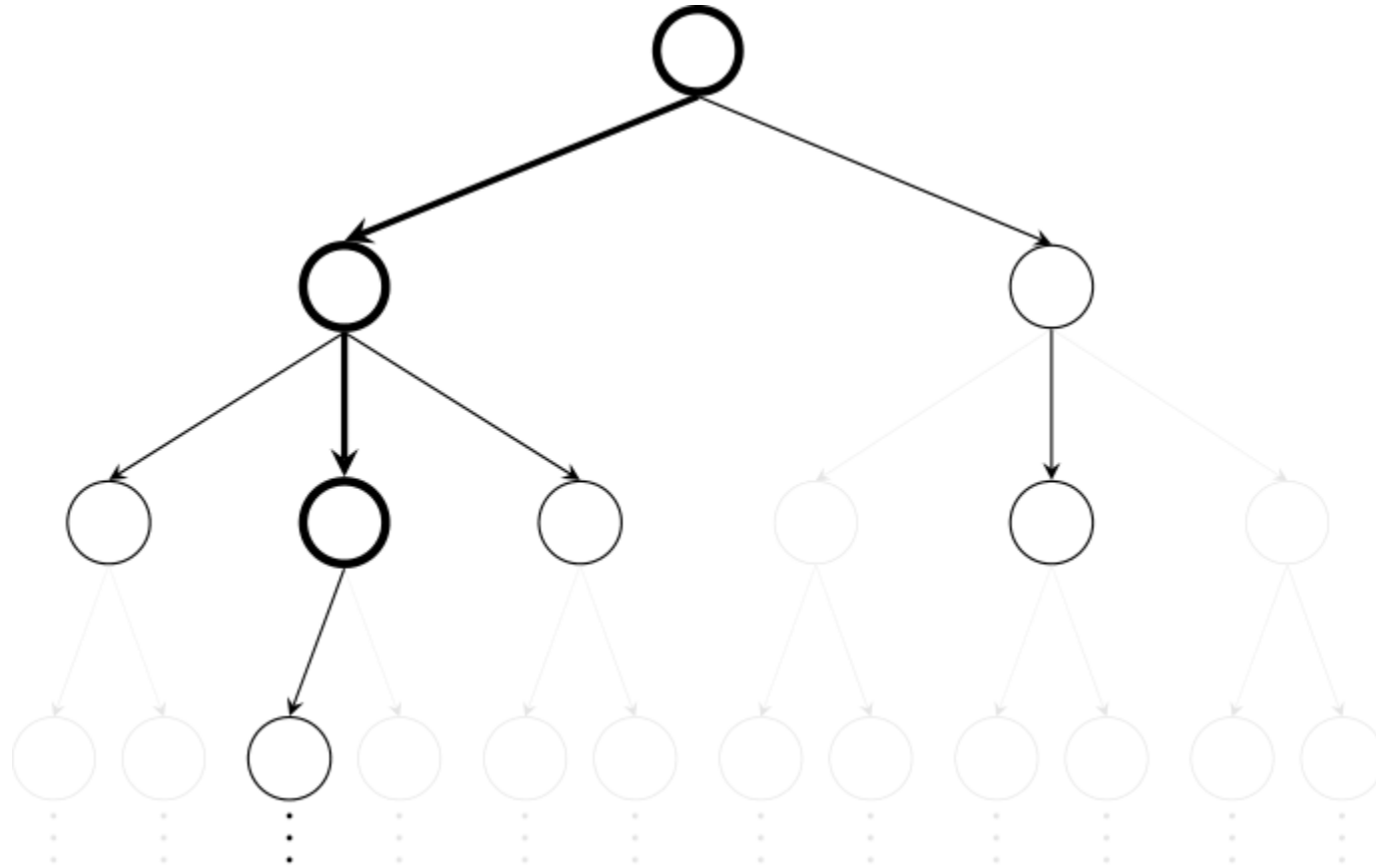
# MCTS – the basics



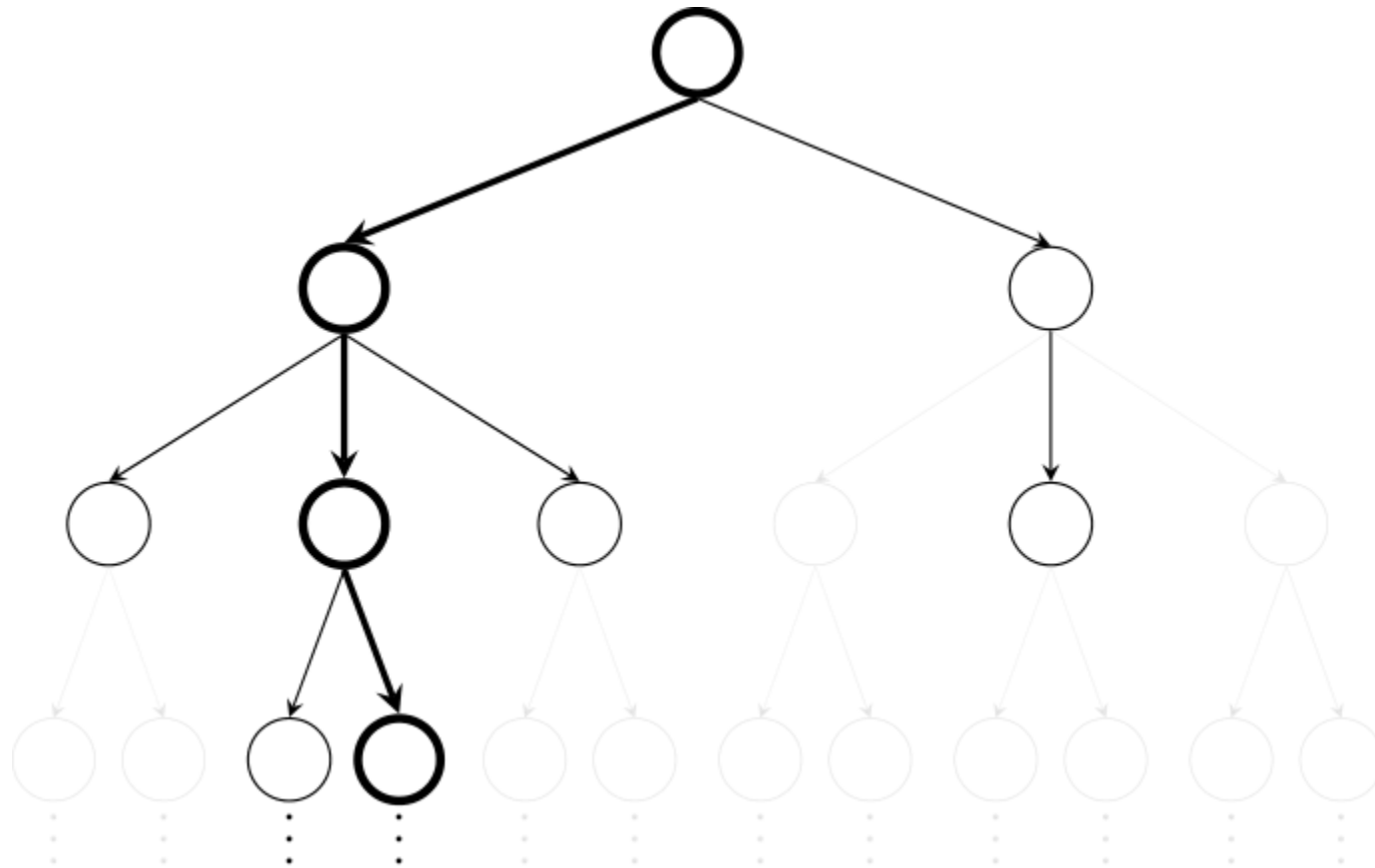
Iteratively build a decision tree

- Concentrate effort on promising areas
- Select actions to perform from the partial tree

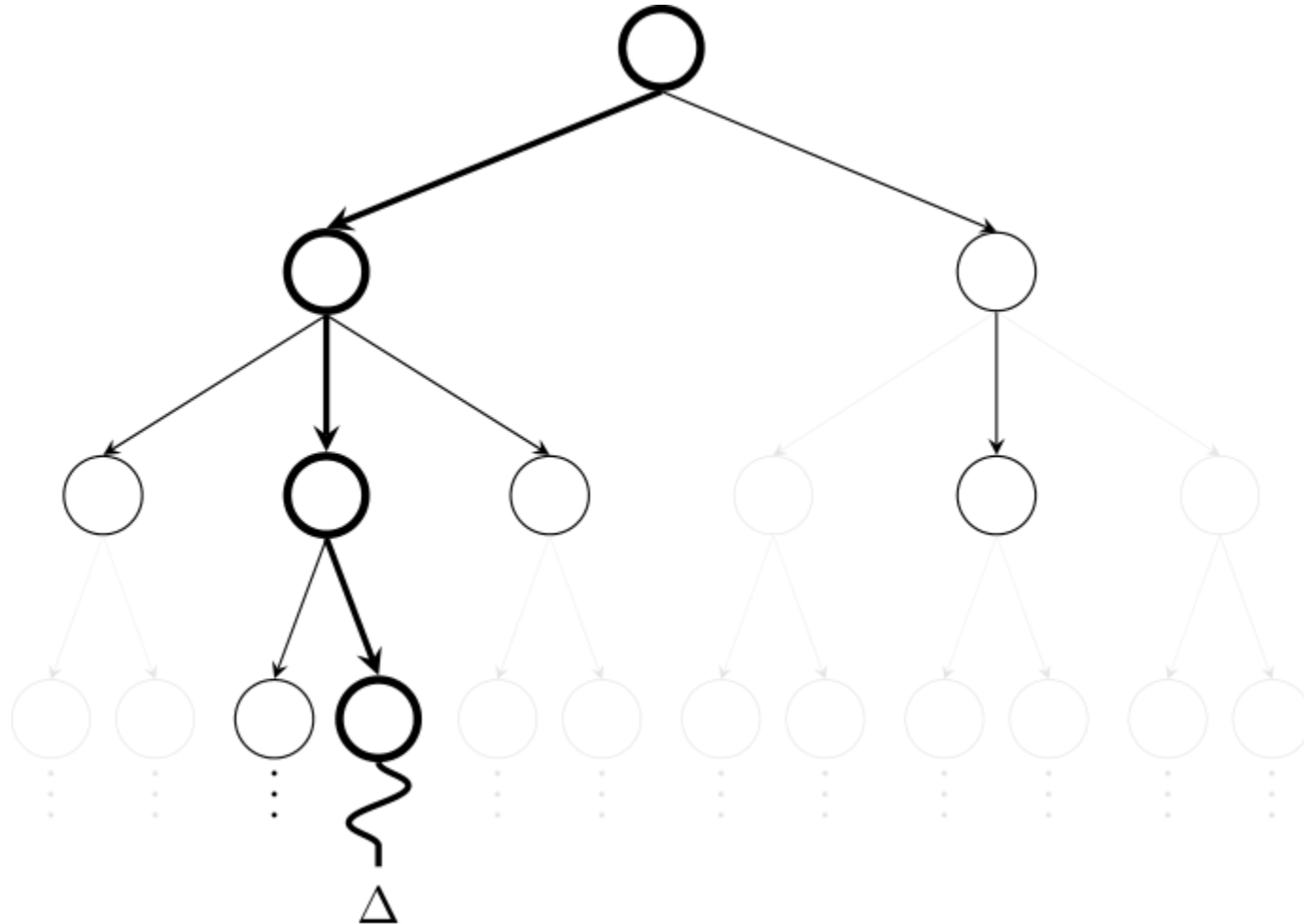
# MCTS Selection



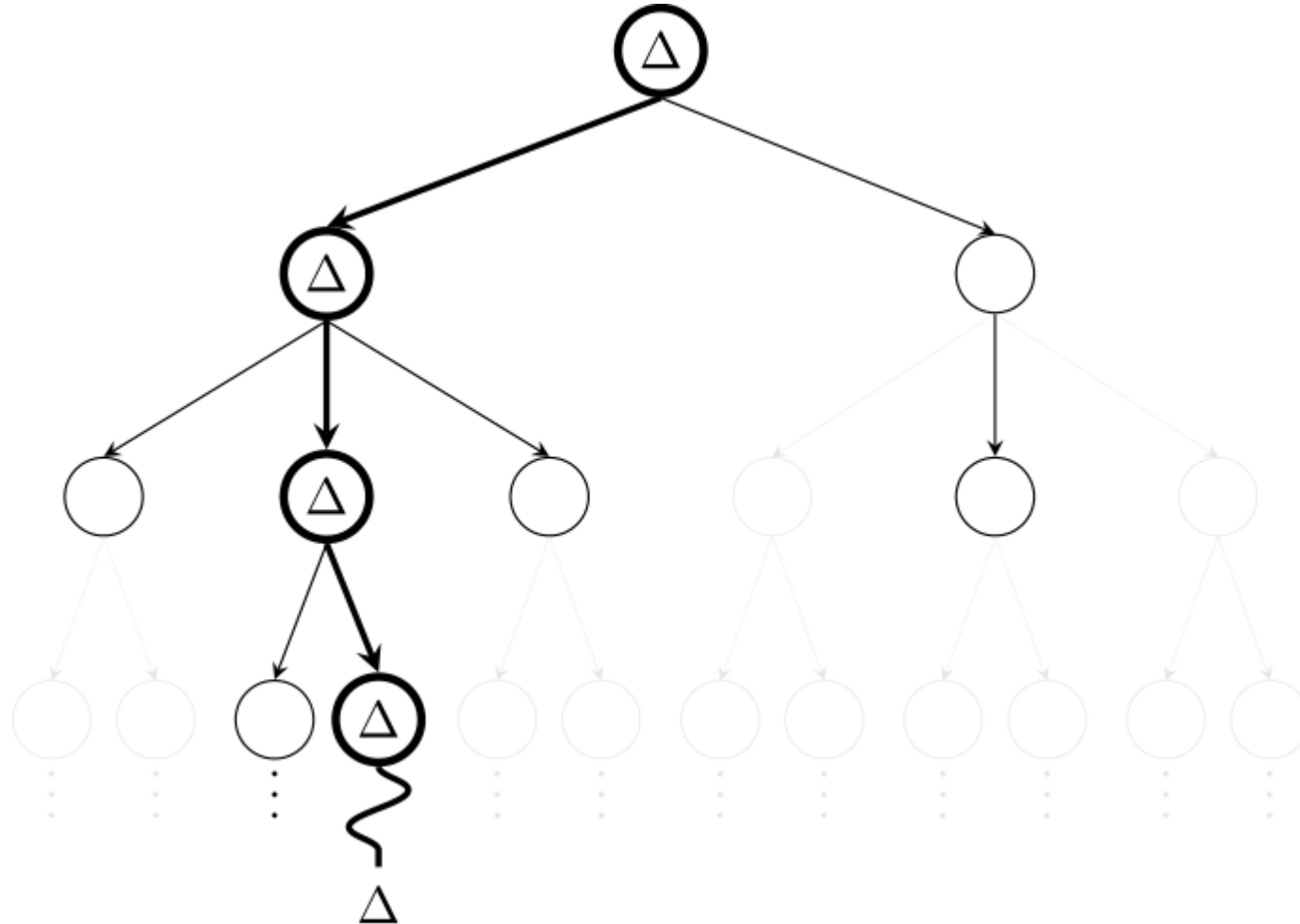
# MCTS Expansion



# MCTS Simulation



# MCTS Backpropagation





# MCTS Features

- Aheuristic
- Anytime
- Asymmetric
- Simple to implement
  - Hard to analyse
  - Hard to implement well

# MCTS Optimisations

- Seeding nodes
  - Use prior knowledge, heuristics
- Tree pruning
  - Soft versus hard pruning
  - Use rollout statistics, heuristics
- Heavy rollouts
  - This doesn't always help

# MCTS Performance

- Shown to be very strong over certain domains
  - Go
  - Card/board games
  - General Video Game playing
- Limited uses so far in video games



# Commercial video games

# Why should we care?

- They don't seem to be a fad
- “the impact agenda”
- Collaboration is still not common
- They present some interesting challenges

# Challenges to AI

- Big state spaces
  - The state-space of Civilization dwarfs that of Go
- Constrained resources
- Authorship/Tractability of AIs
- Making adversaries fun

# Monte Carlo Tree Search

(cont.)

# Problems in MCTS research

Reasons game developers dislike MCTS research

- Irrelevant test domains
- Less thought given to hardware limitations
- Approach shortcomings dismissed/ignored



# Problems in MCTS research

Reasons game developers dislike MCTS research

- Irrelevant test domains
  - Board games, card games
- Less thought given to hardware limitations
- Approach shortcomings dismissed/ignored

# Problems in MCTS research

Reasons game developers dislike MCTS research

- Irrelevant test domains
- Less thought given to hardware limitations
  - Comparisons in rollouts rather than time
  - AlphaGo used 1,202 CPUs and 176 GPUs
- Approach shortcomings dismissed/ignored

# Problems in MCTS research

Reasons game developers dislike MCTS research

- Irrelevant test domains
- Less thought given to hardware limitations
- Approach shortcomings dismissed/ignored
  - Heavy tailoring to domains
  - Rarely testing techniques against multiple games
  - Sweeping statements

# Heavy rollouts

Sometimes great, sometimes counterproductive

“an imperfect heuristic may destroy the benefit of Monte Carlo sampling by **exploring an unreasonable subset of the space** of possible game completions”

“the performance of MCTS can often be improved if a **more informed simulation policy** is used”

“our random simulation is likely to have **more meaningful sequences** in random simulations than before”

“direct games are not a reliable way of comparing heuristics”

# My current research focus

# What features of heavy rollout policies and domains influence the performance of MCTS?

Comparing the ranking performance of different heavy rollout policies for domains with different features

Exploring mixed-strategy policies

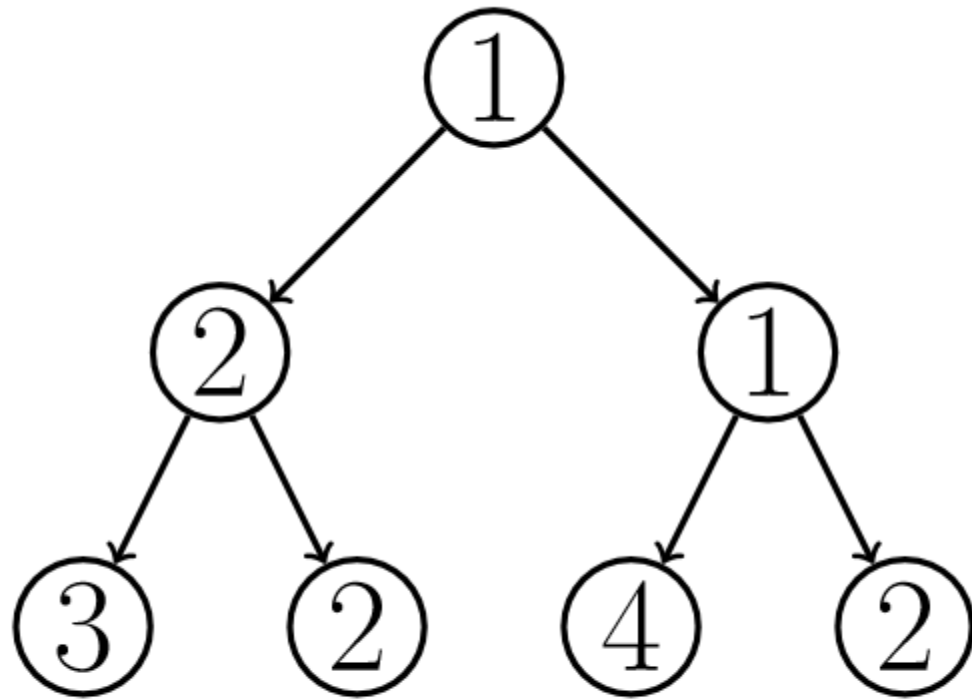
I'm planning on generating a framework/guidelines for implementing heavy rollout policies

# How can domain abstractions be used to help create useful pseudo-heuristics for MCTS?

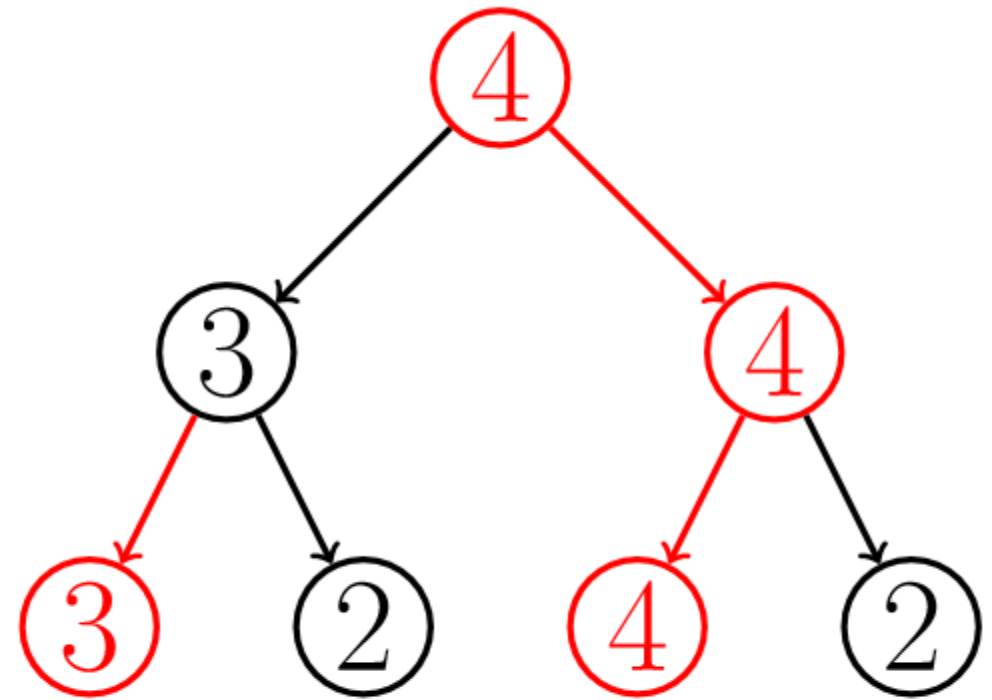
Domain abstractions can be easier to design than explicit heuristics, and have shown some potential for guiding MCTS

Applied as heavy policies, node seeding, abstract reward signals?

# Abstract Reward Signals



a) Before propagation



b) After propagation



# Attempting to apply learnt techniques to an existing commercial game

Slide redacted – sorry!

Any feedback or questions?

# Matthew Bedder

 [www-users.cs.york.ac.uk/~bedder](http://www-users.cs.york.ac.uk/~bedder)

 [matthew@bedder.co.uk](mailto:matthew@bedder.co.uk)

 [@bedder](https://twitter.com/bedder)



pintofscience.co.uk  
23<sup>rd</sup>–25<sup>th</sup> May



# UNFUN GAMES

## THE WINNING POST

127-129 Bishopthorpe Road, York, YO23 1NZ, United Kingdom

**WEDNESDAY 25 MAY 2016**

**DOORS 7PM, EVENT 7.30PM-10PM**

Unfun Games: How to take the joy out of games and make them really uncomfortable. Most people would think that playing games is "fun". In this set of talks we will find out that this isn't always the case; games can be infuriating, embarrassing, and designed to take you out of your comfort zone. This evening of talks is provided by members of the Digital Creativity Labs (<http://www.digitalcreativity.ac.uk/>) who are looking into the huge potential of games and interactive media for economic, social and cultural impact.

### THE GAMES AI PLAY

**Dr Sam Devlin** (Digital Creativity Lab,  
Department of Computer Science,  
University of York)

In 2014, Google brought a UK start-up for a reported \$500million. Roughly two years later, an Artificial Intelligence (AI) developed by Google Deepmind defeated a world champion Go player. This is only the latest result in the history of AI and games, where both academic and industry researchers have sunk large amounts of time, effort and money into

### UNCOMFORTABLE GAMES

**Dr Ben Kirman** (Department of Theatre,  
Film & Television, University of York)

Why do games always have to make you smile? In this talk, we'll explore the weird and unsettling world of games purposefully designed to be uncomfortable and awkward experiences. From games that are played wearing gas masks or while trapped in a coffin, through to the most embarrassing game ever made, the name of which is simply too rude to print.