Presenting Multiagent Challenges in Team Sports Analytics

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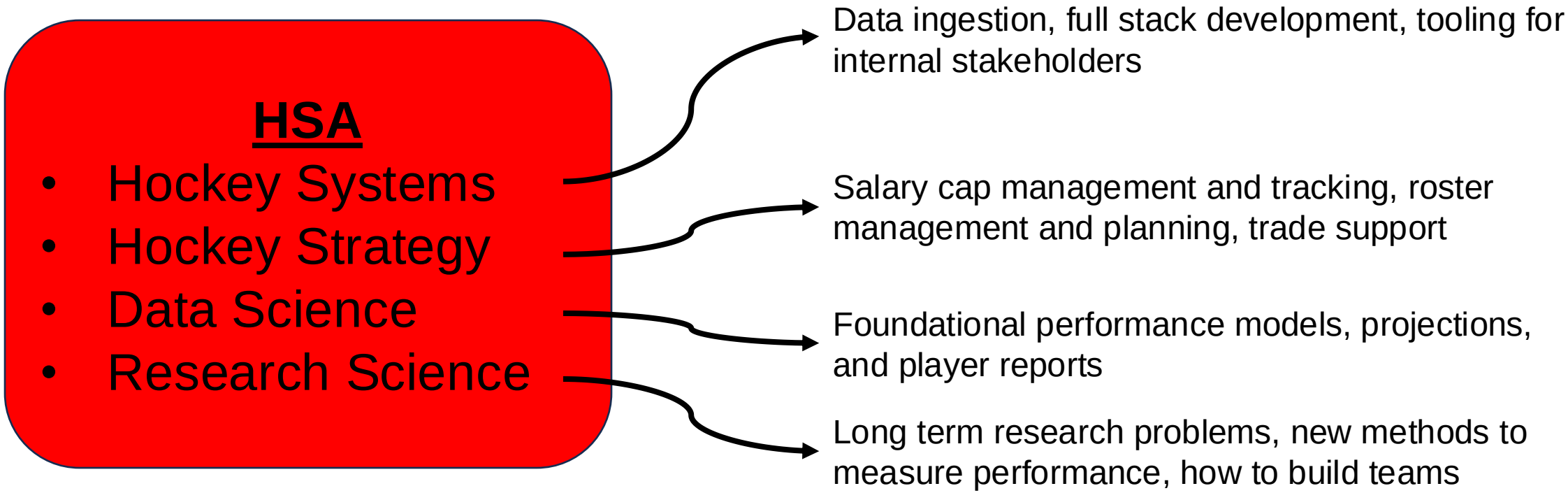
CHICAGO BLACKHAWKS

Hockey Strategy & Analytics (HSA)



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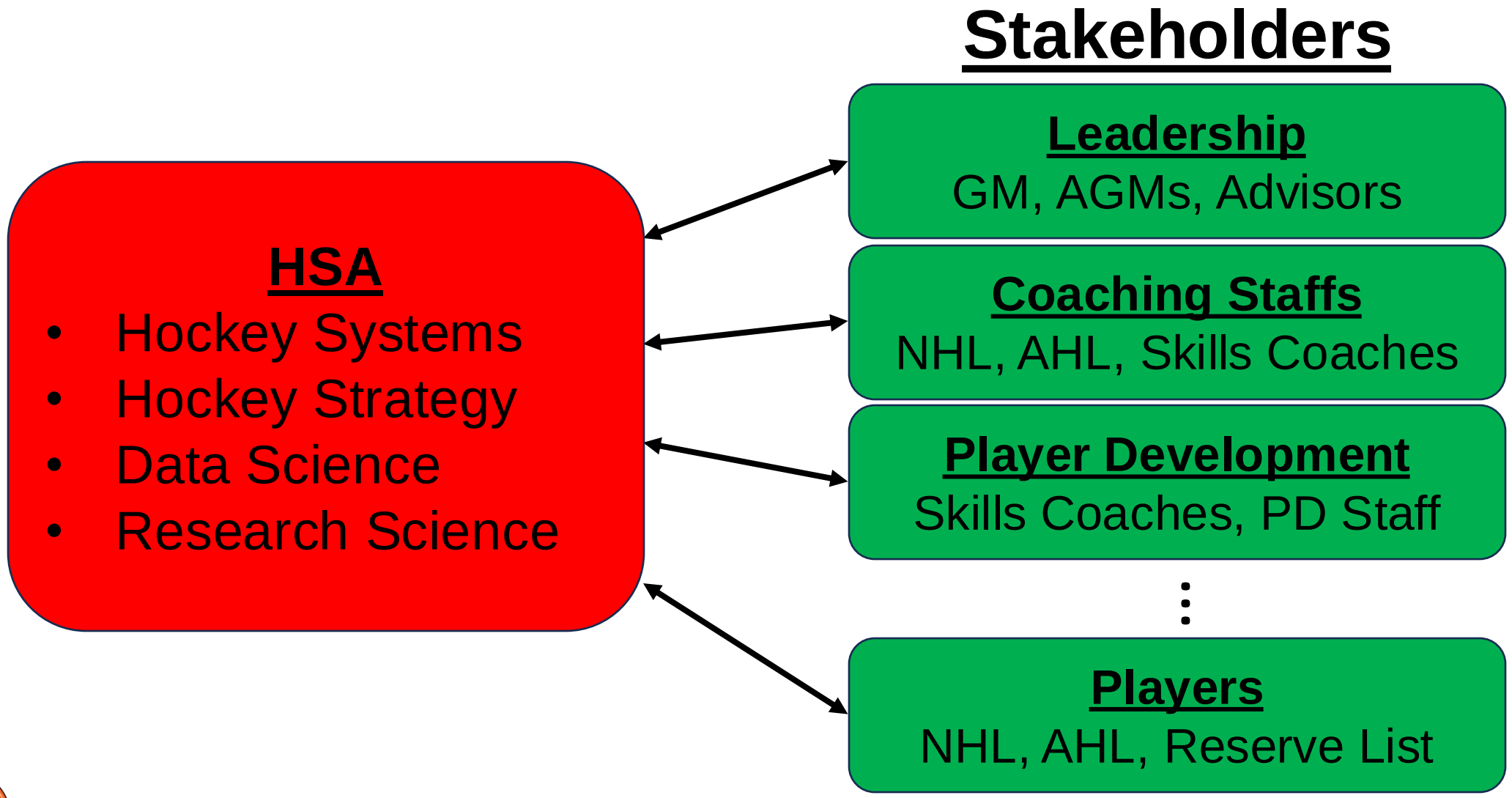

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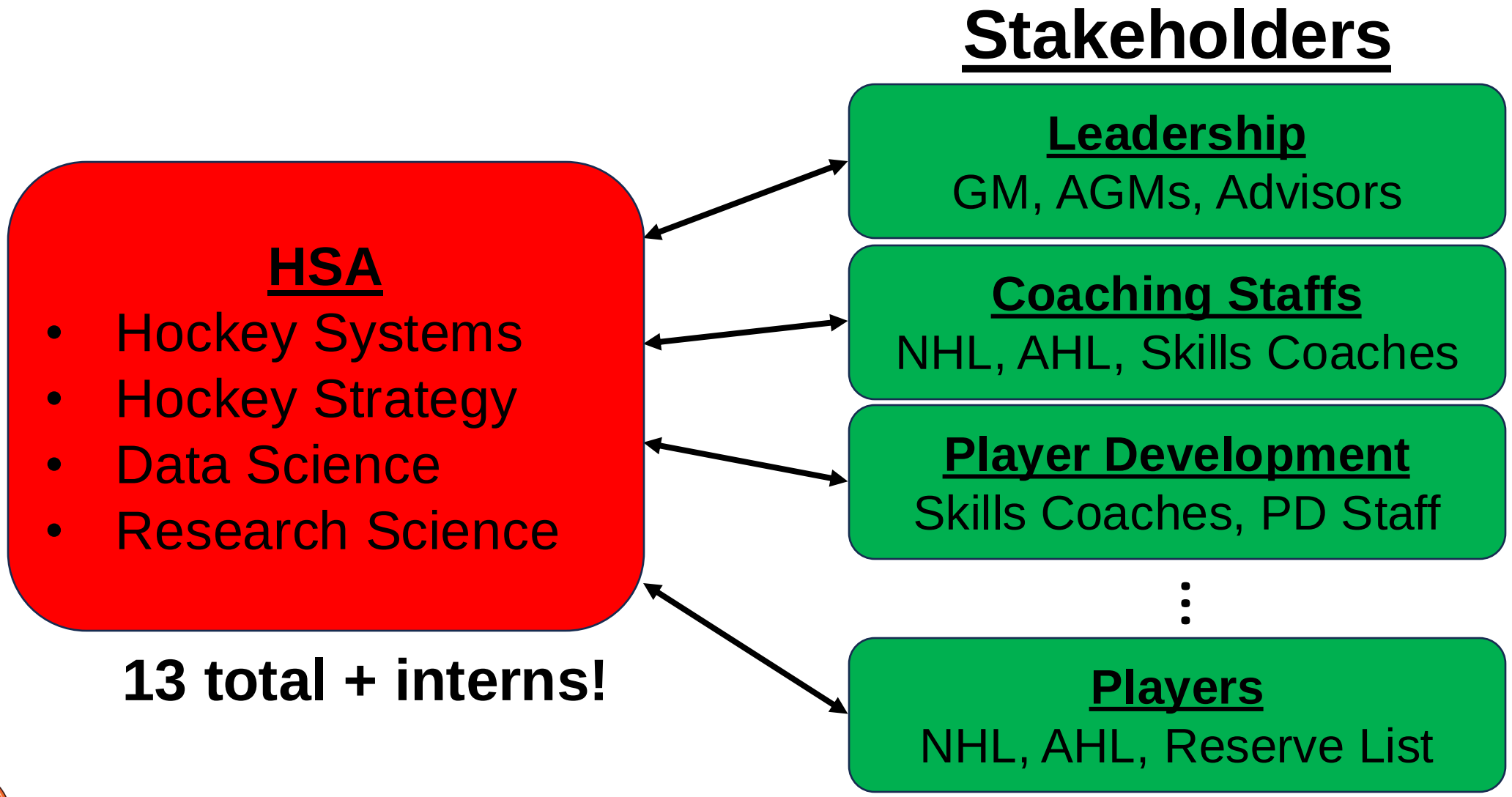

Overview

AI and Games

Multiagent Challenges

Example Projects

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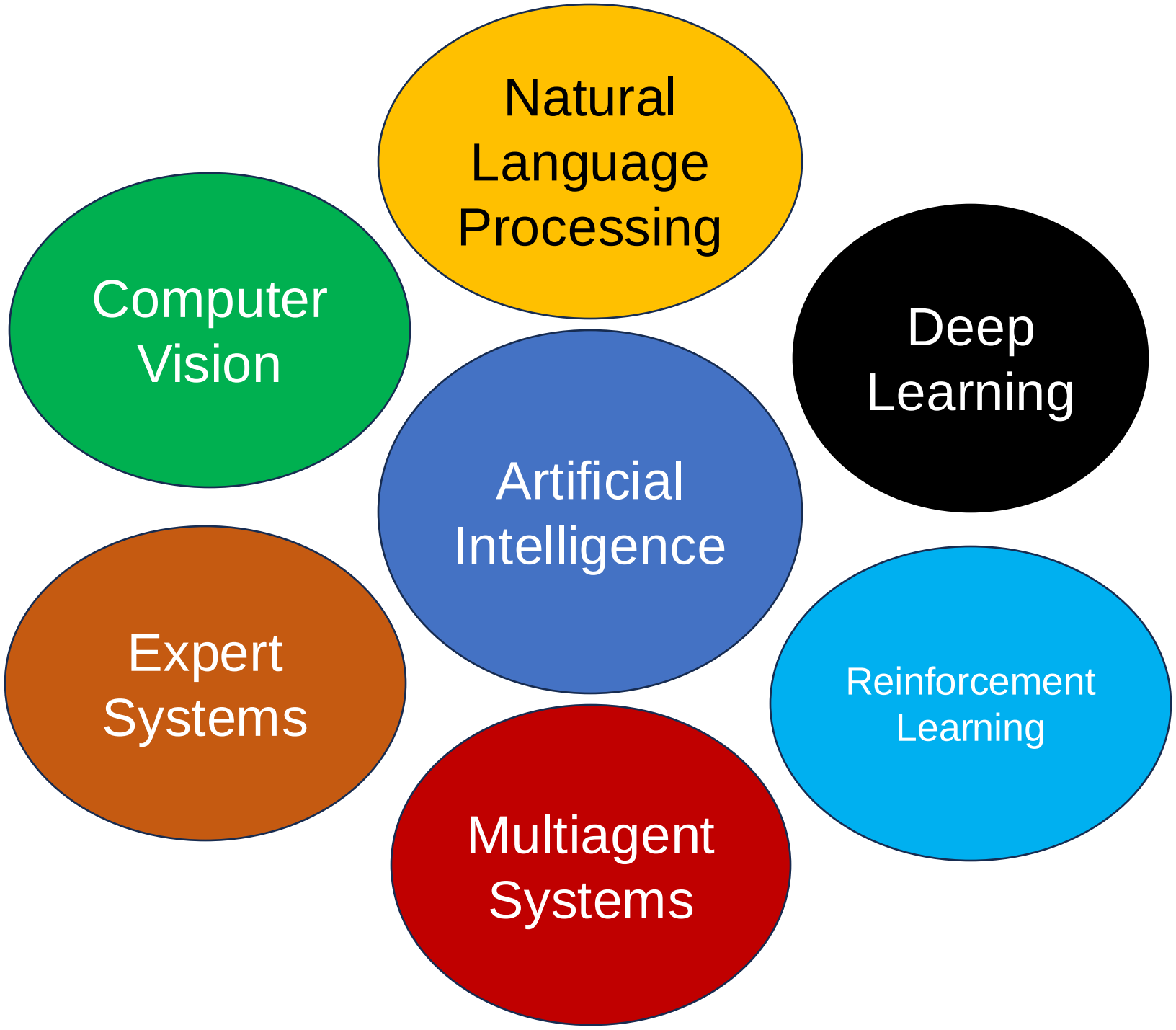
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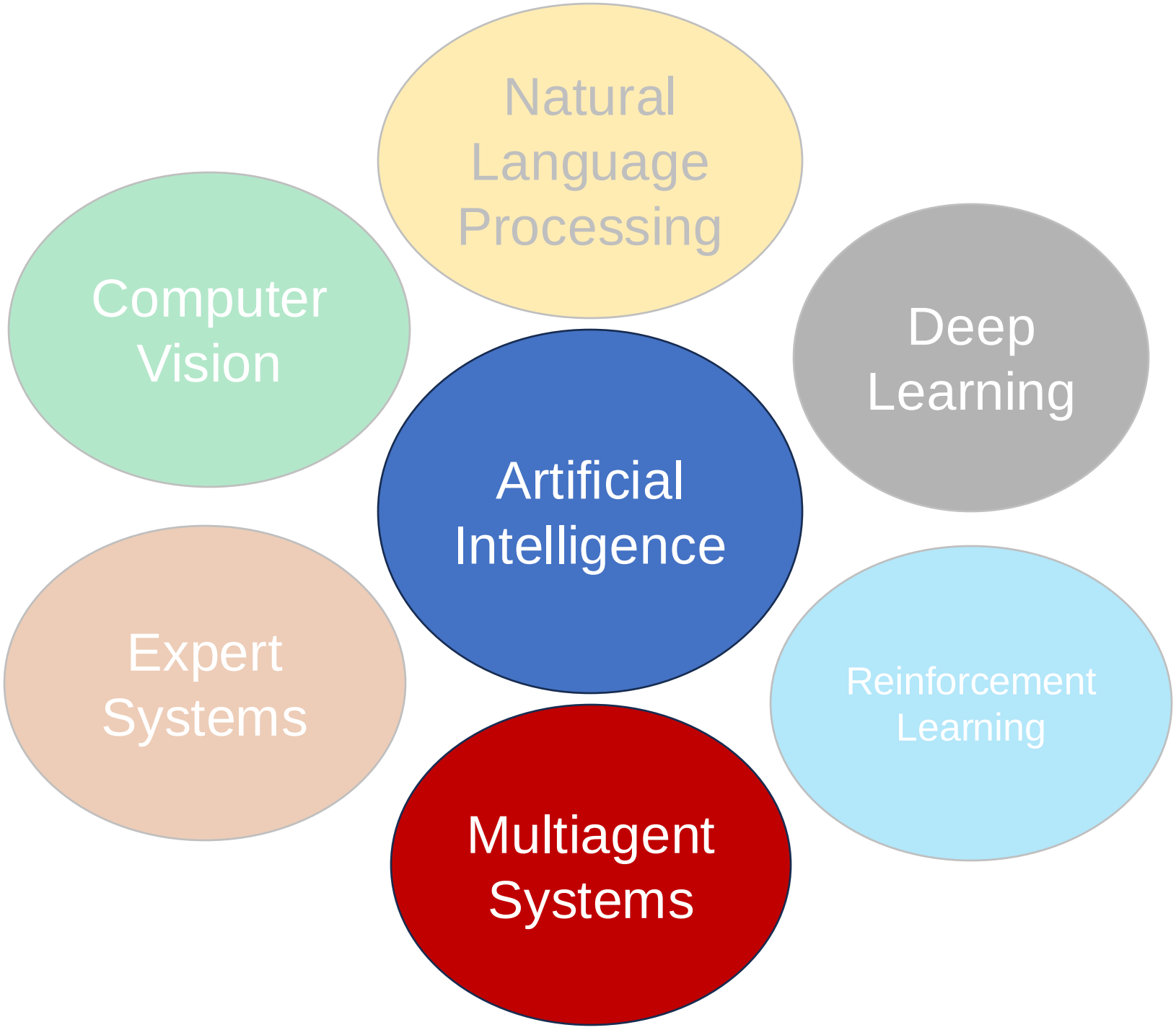
Computer Vision
Deep Learning
Artificial Intelligence
Expert Systems
Reinforcement Learning
Multiagent Systems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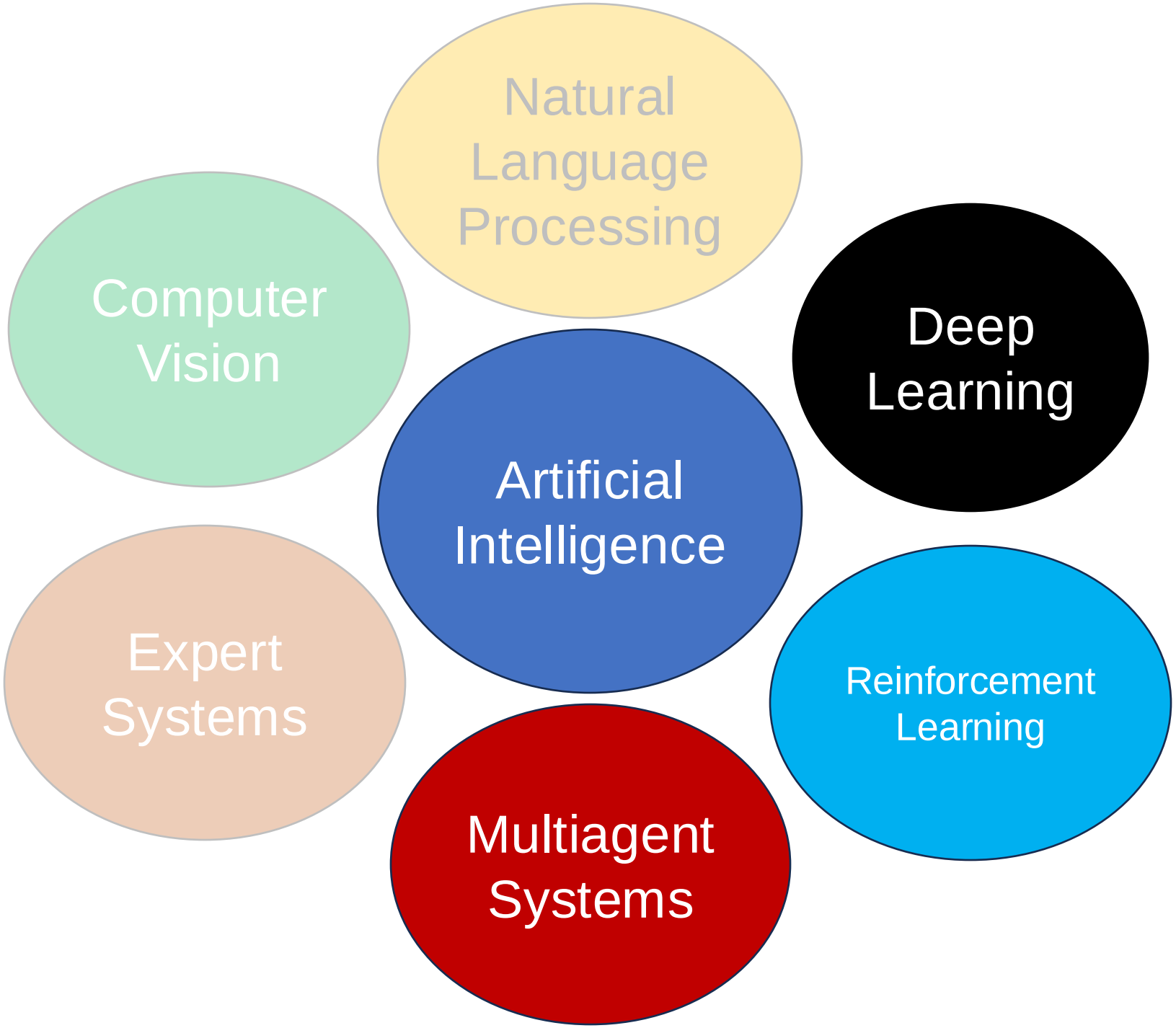
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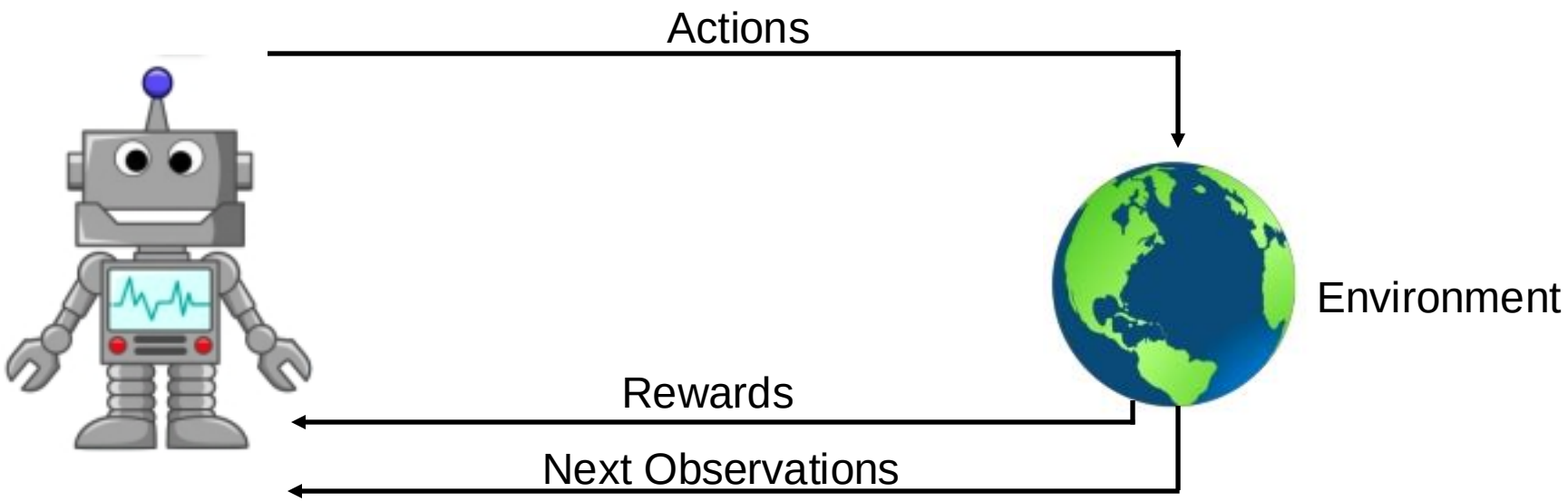
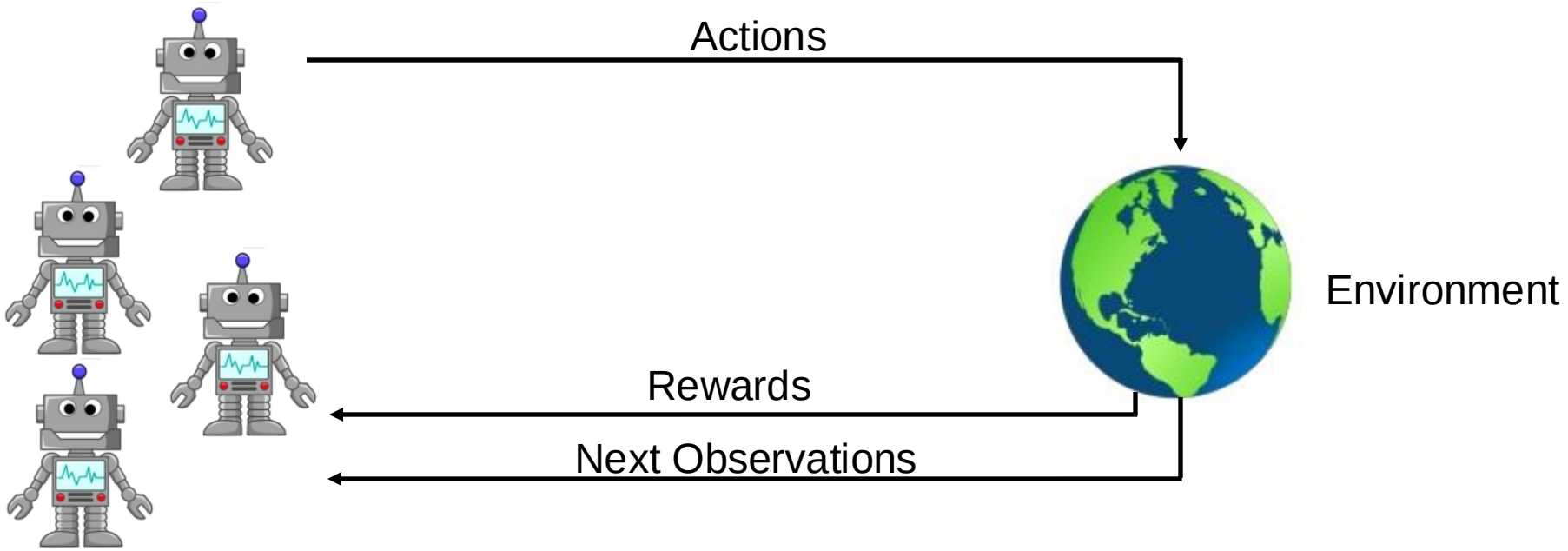
Reinforcement Learning

- Machine learning technique where **agents** take actions to maximize **reward**
- Temporal decision making, Markov Decision Processes
- Function approximation with neural networks



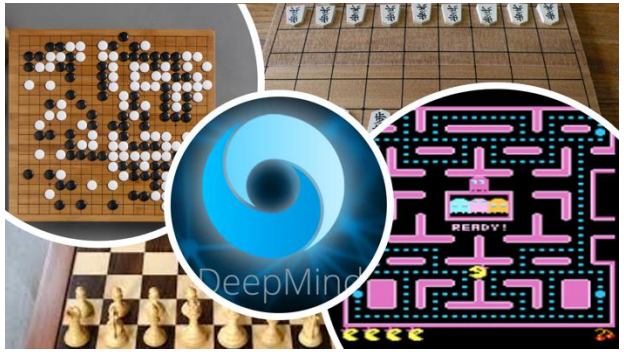
Multiagent Systems

- The study of **multiple** interacting intelligent **agents** within an **environment**
- **Interconnectivity** and many **types** of environments
- Relevant areas: Game Theory, Economics, and Marketplaces



AI's Relationship With Games

- Games are often used as **yardsticks** to **benchmark** progress



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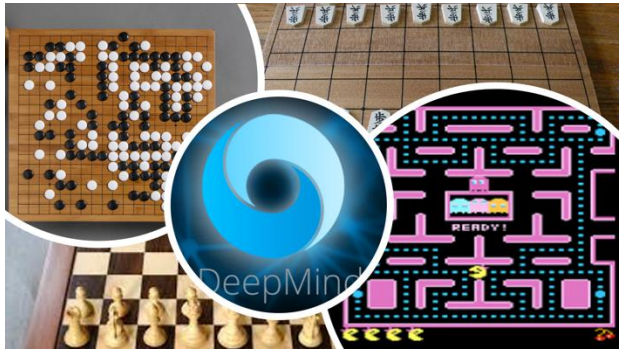
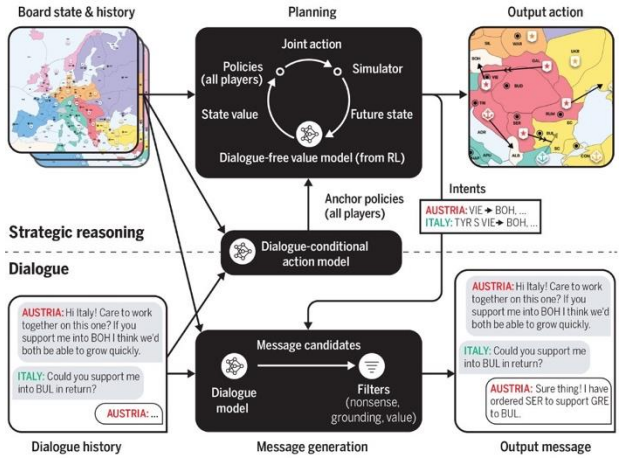
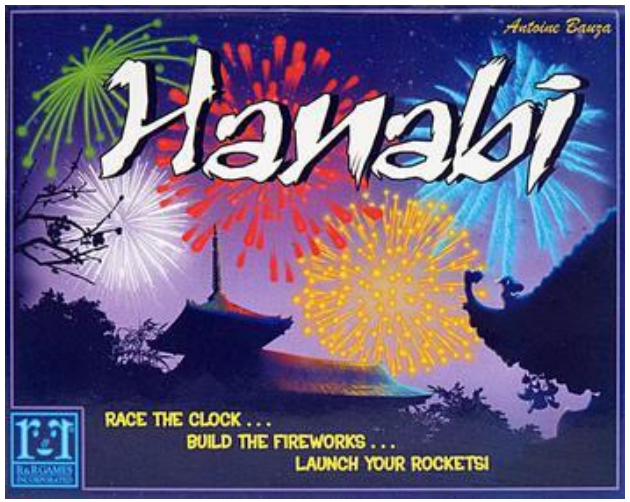
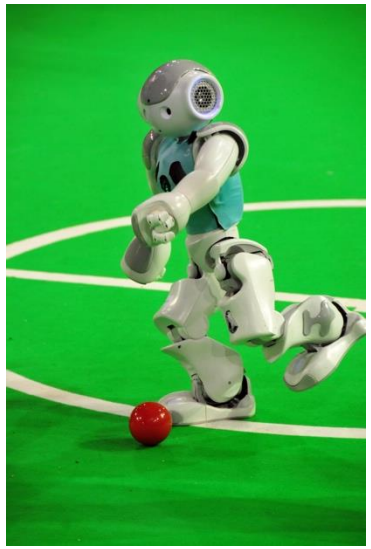






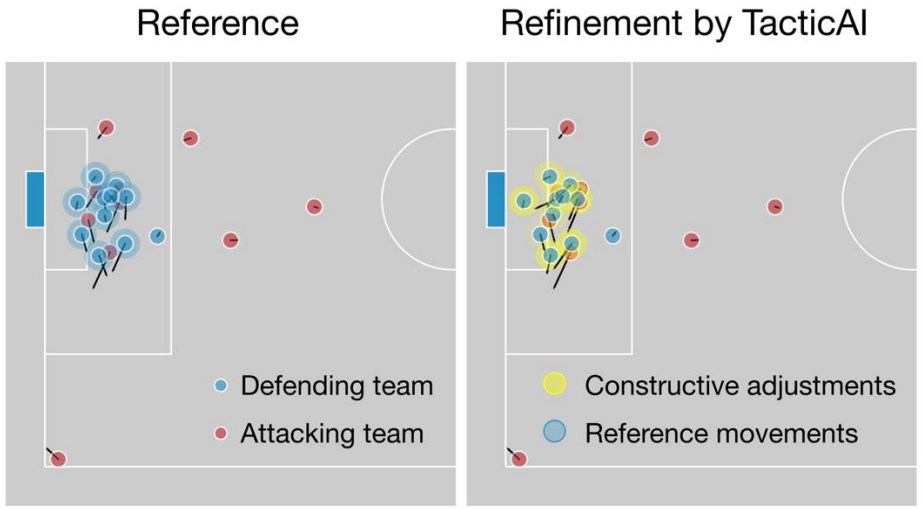
AI's Relationship With Games

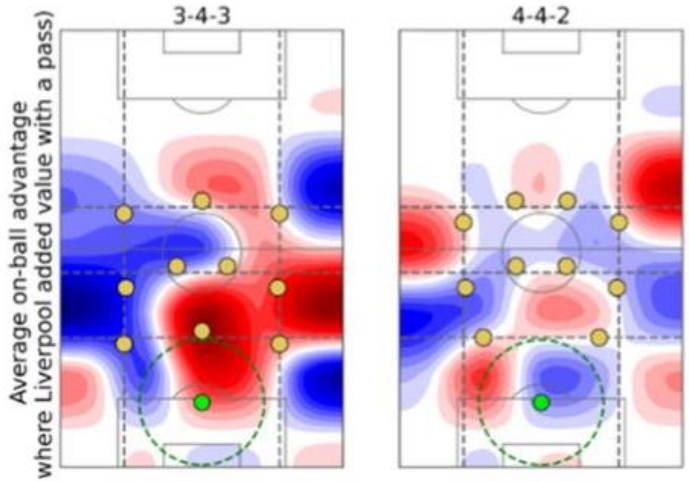
- Learning in simulated environments, sometimes sports related



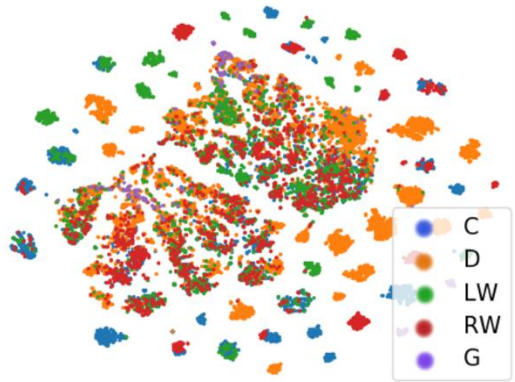
AI in Sports

- Lots of computer vision problems
- Analyses formations and performance
- DeepMind-Liverpool FC





Fernandez *et al.*, 2020



Liu *et al.*, 2020

Overview

AI and Games

Multiagent Challenges

Example Projects

Types of Games (Sports), Ellis [1983]

- **Striking games:**
  - *Players strike objects into open spaces and place fielders strategically to prevent runs from being scored*
  - Baseball, Cricket

- **Invasion games:**
  - *Teams intermingle and attempt to outscore the opponent by invading the opponent's territory*
  - Ice Hockey, Football (soccer), and Basketball

Analytics in Baseball, a Striking Game

- Sabermetrics (i.e., Moneyball [James, 1985; Lewis, 2003])
  - Using empirical **statistics** as a basis for roster management
  - On base %, slugging percentage, and batting average

Types of Games (Sports), Ellis [1983]

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Why Invasion Games Are Different

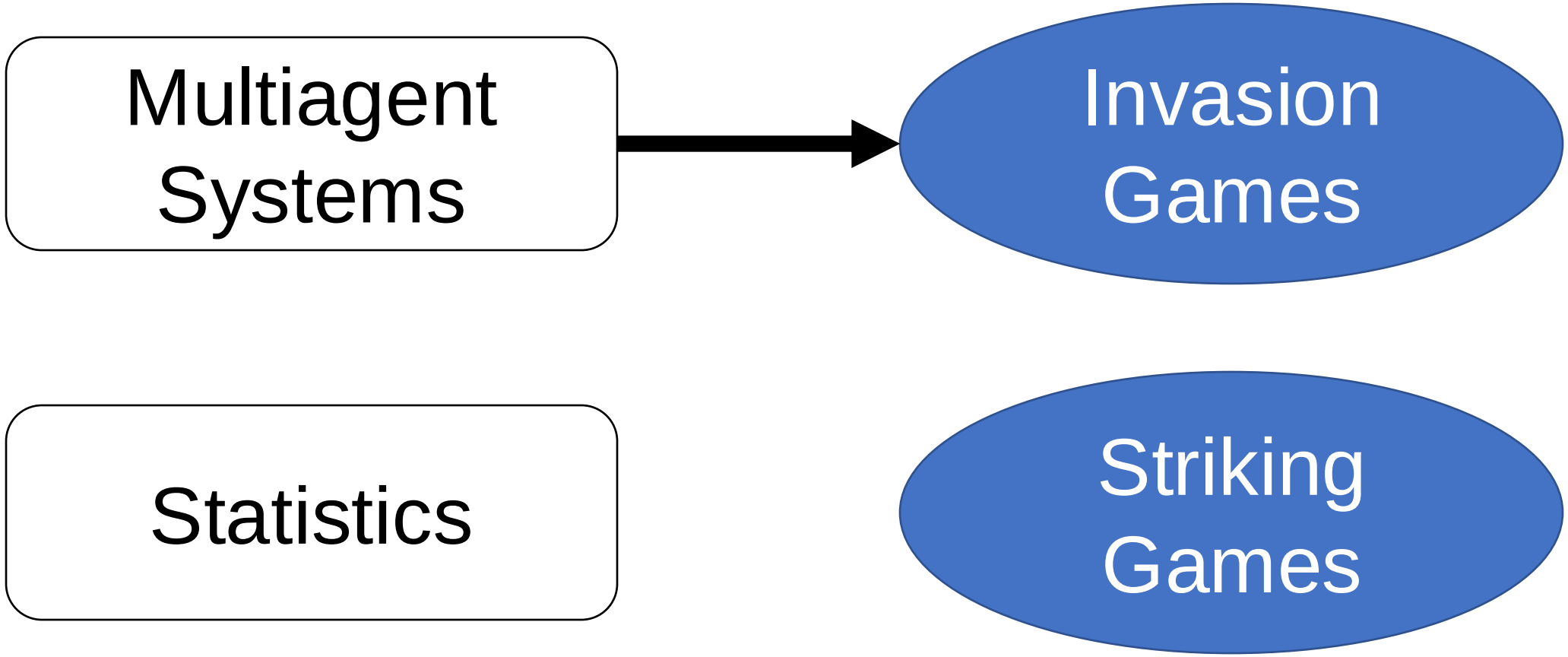
- More interaction, coordination, and teamwork
- Data is complex, more actions, more strategic freedom
- Not just **who** is good, but **good together** and **in what scenarios**

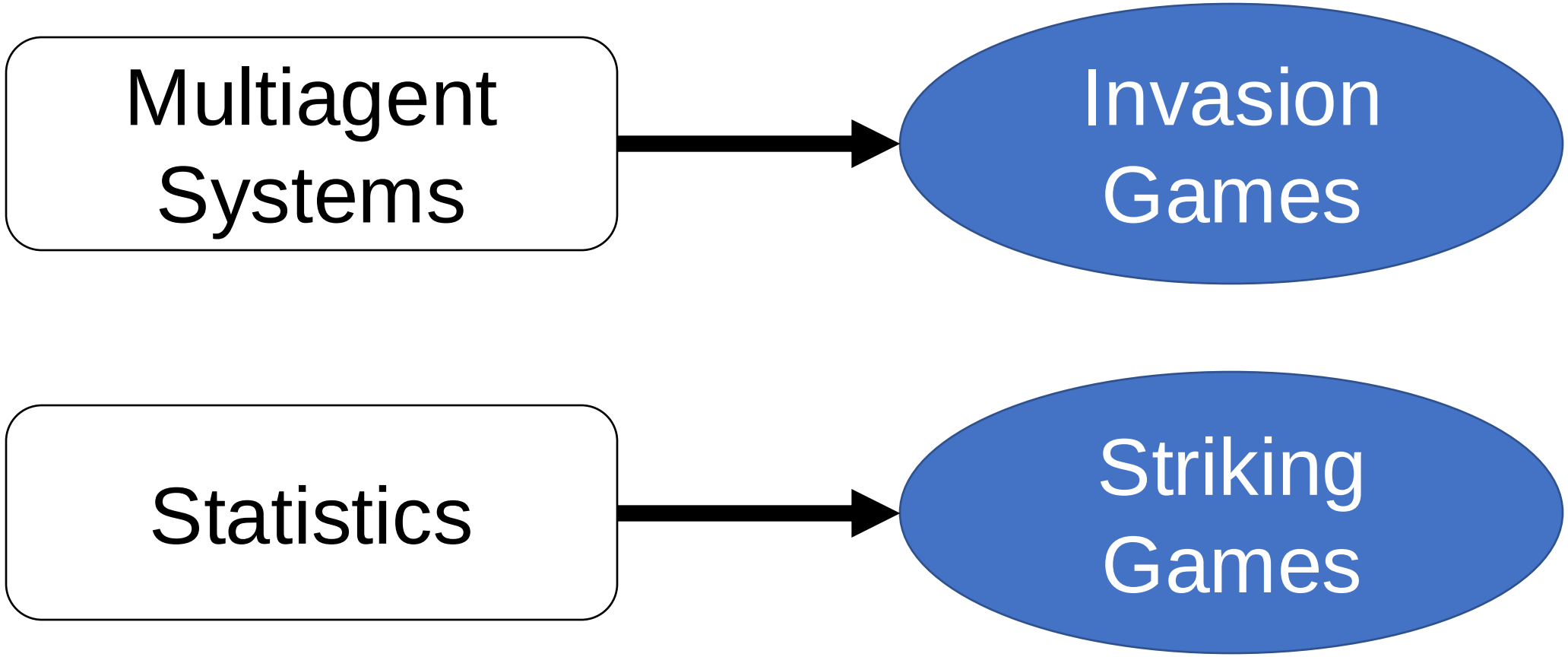
Multiagent Systems

Statistics

Invasion Games

Striking Games


Multiagent Systems
Statistics
Invasion Games
Striking Games


Multiagent Systems
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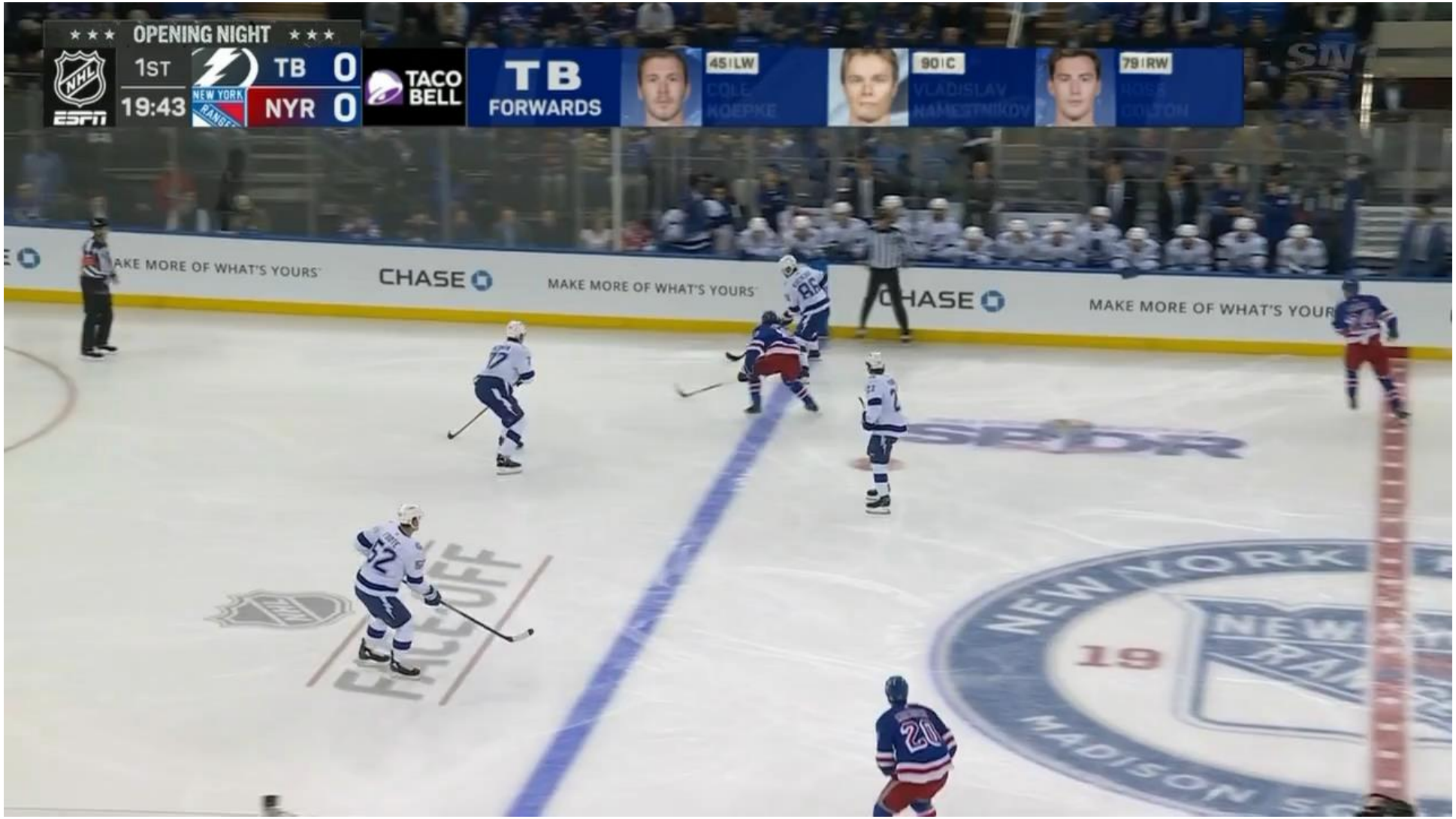
Striking Games

Why Multiagent Systems and Invasion Games?

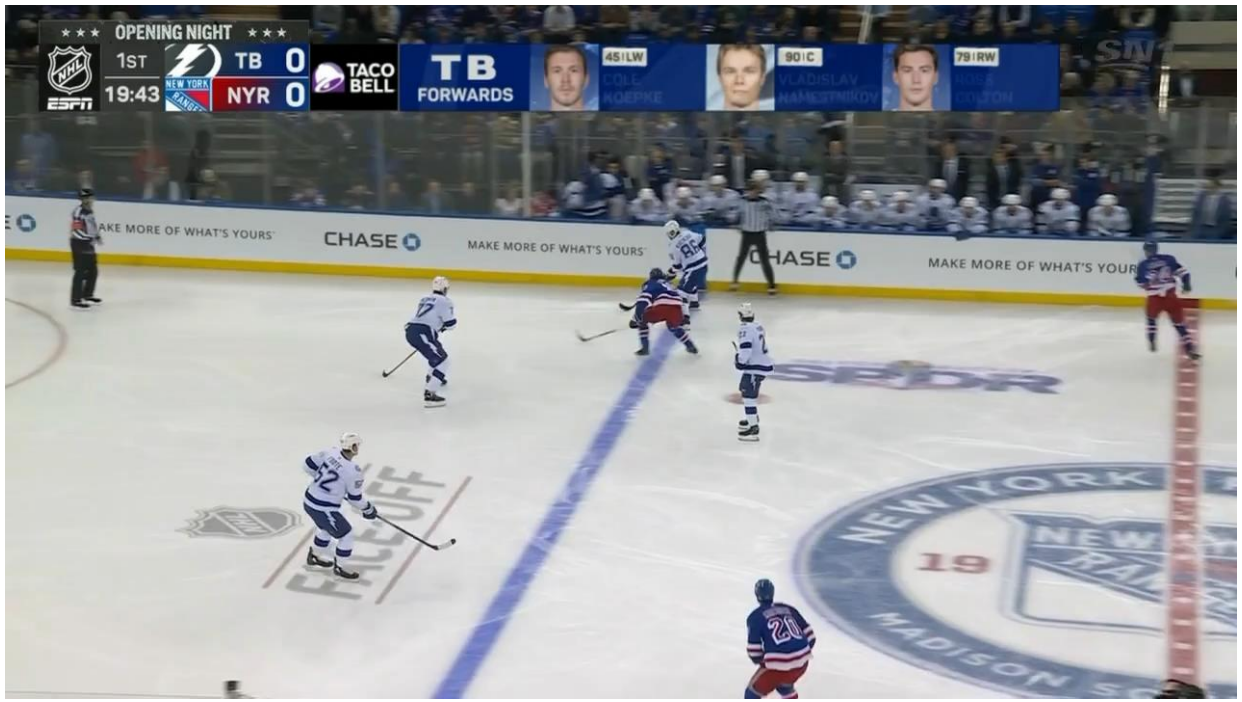
- Enclosed **environments** governed by **rules**
- Examples of **cooperation** and **coordination** (both good and bad!)
- **Team structures** and hierarchies
- Multiple timescales (i.e., coaching vs. management)
- **Marketplaces**
- **DATA**
  - Event data
  - Tracking data

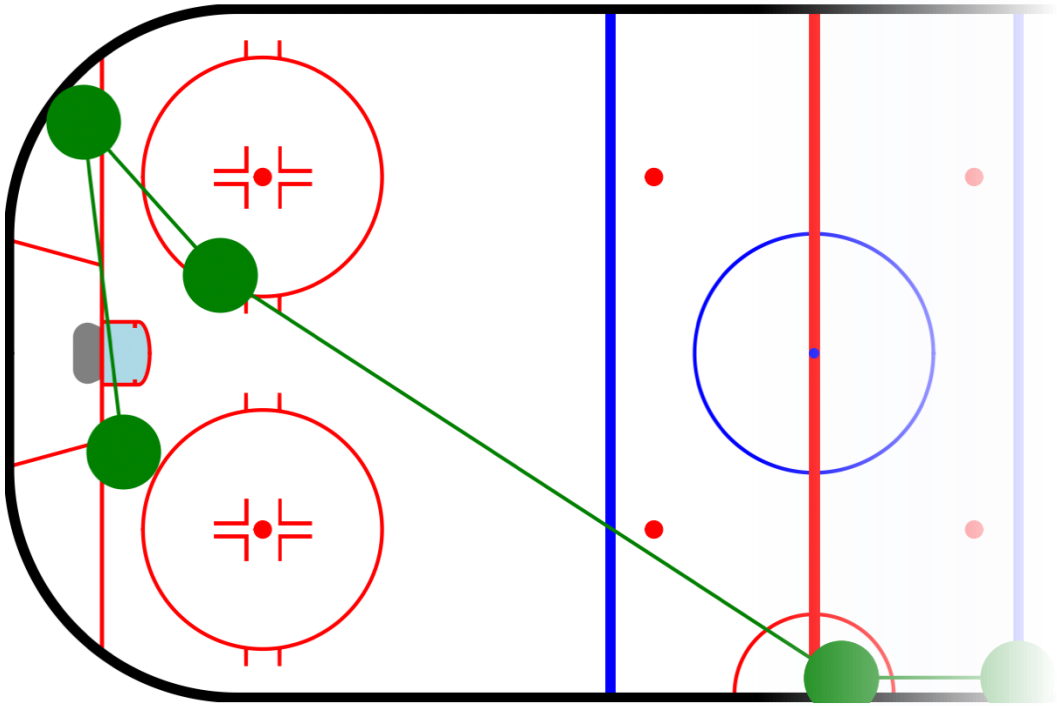
Example Play



Event Data

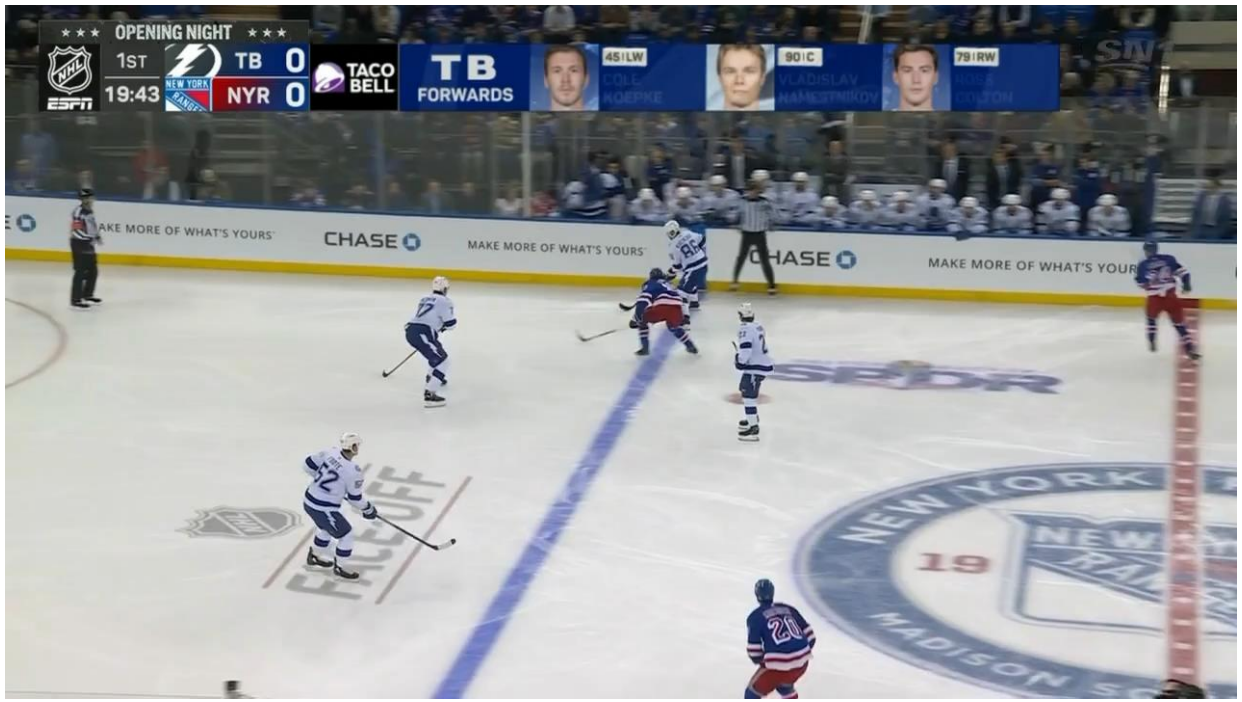
- Shots, passes, carries, possession gain, etc…
  - (x, y) coordinates on surface, players involved, time of game, etc…
- ~3500 events per-NHL game (2022-2023)

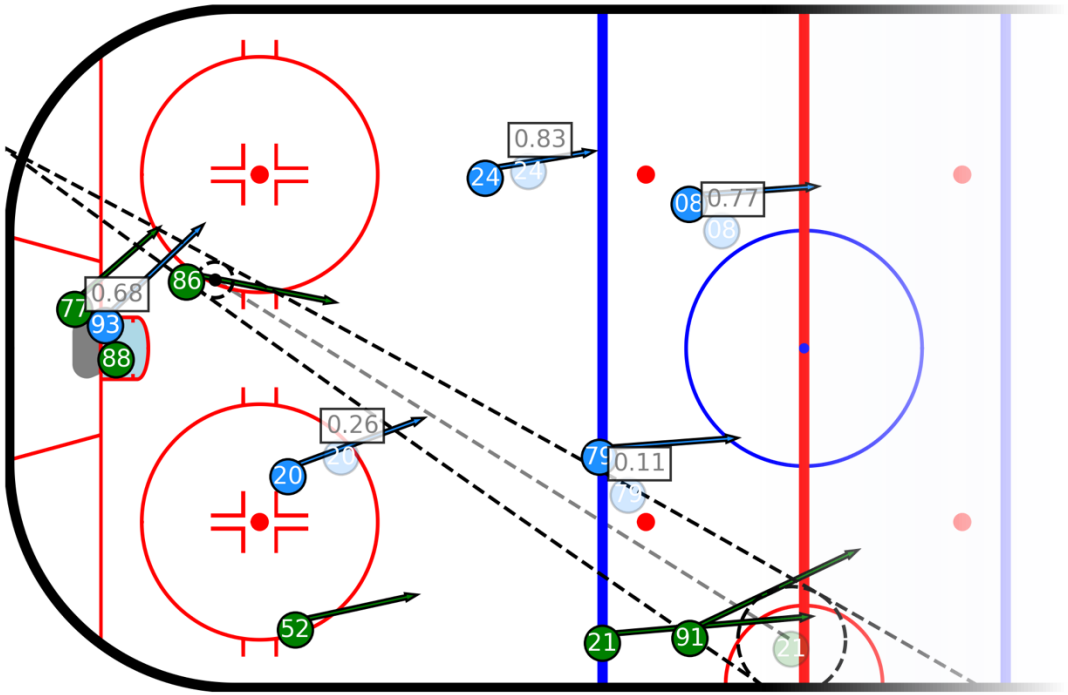




Tracking Data

- Position data for all players (x, y, z), multiple times per-second
- Annotated with event data
- Hardware or computer vision systems



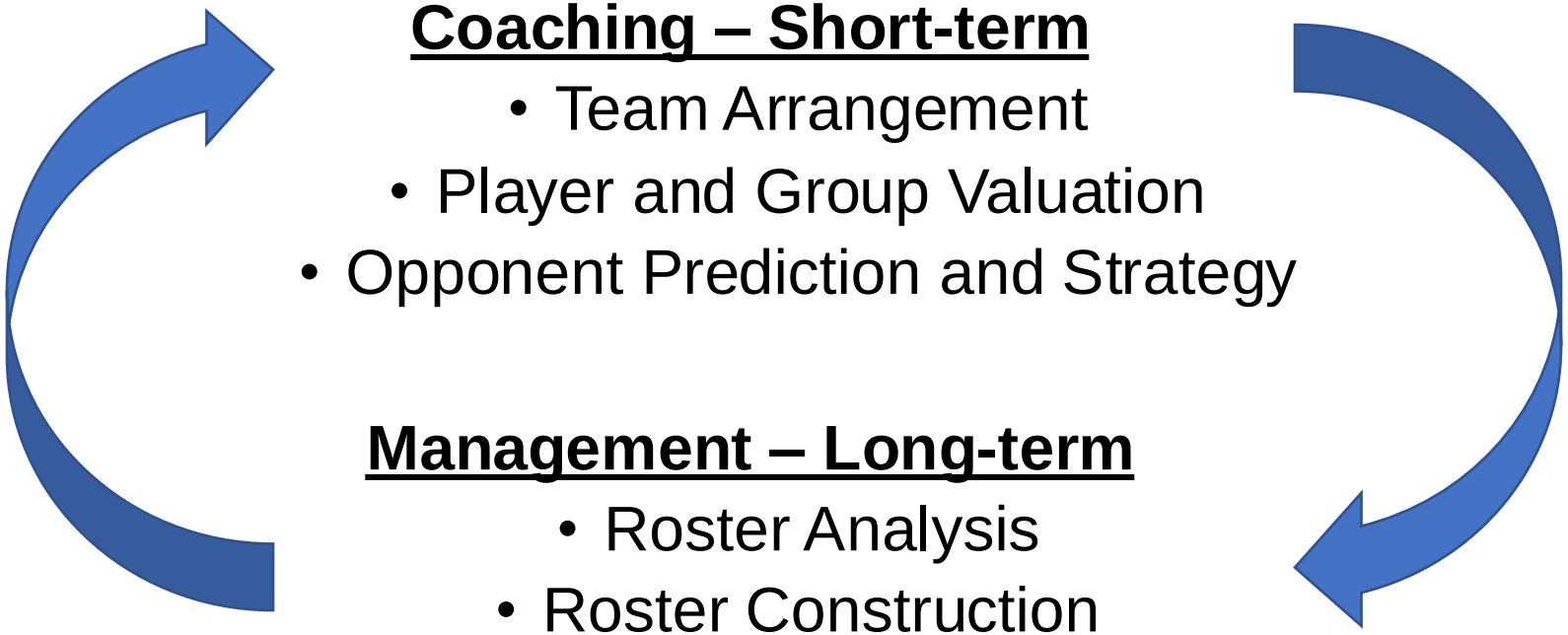


Coaching – Short-term

- Team Arrangement
- Player and Group Valuation
- Opponent Prediction and Strategy

Management – Long-term

- Roster Analysis
- Roster Construction
- Economic Strategies



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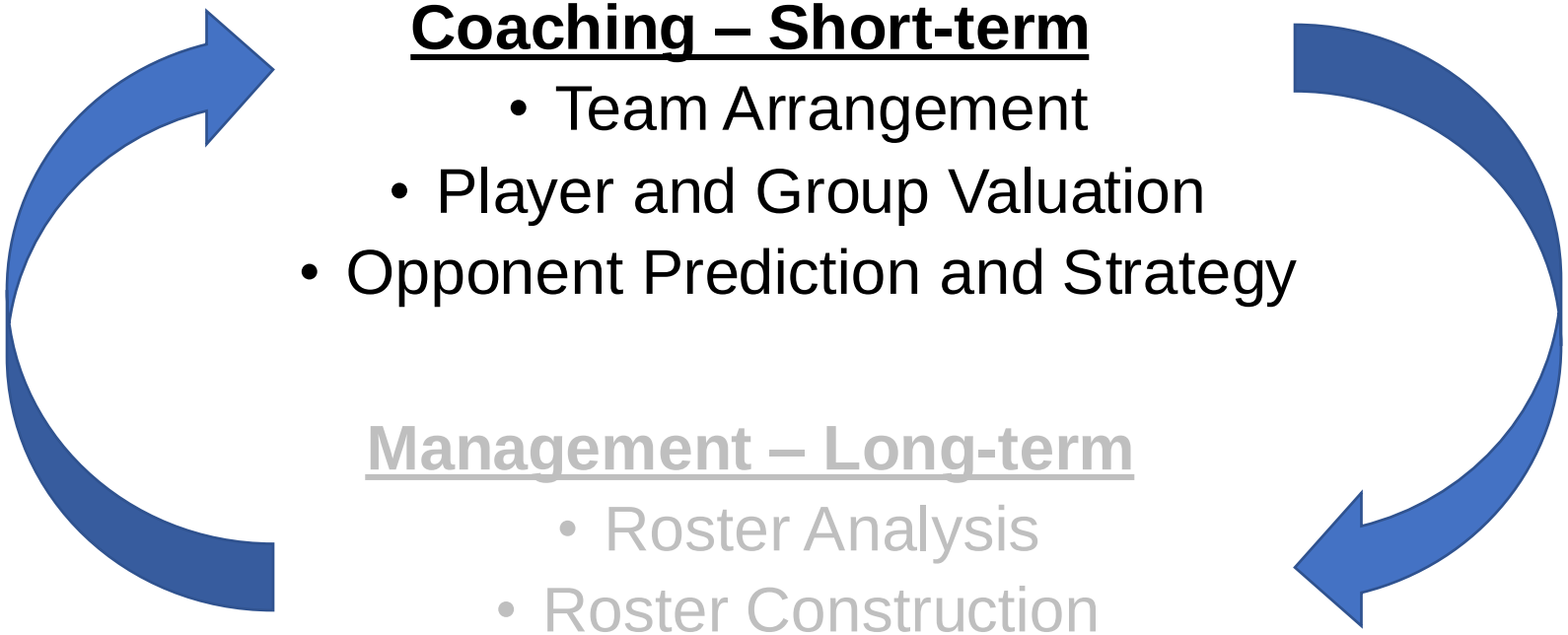

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- Timescale: Before/within match
- Common problems:

Which players play well together?

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How much do players/groups contribute?

Coaching – Short Term

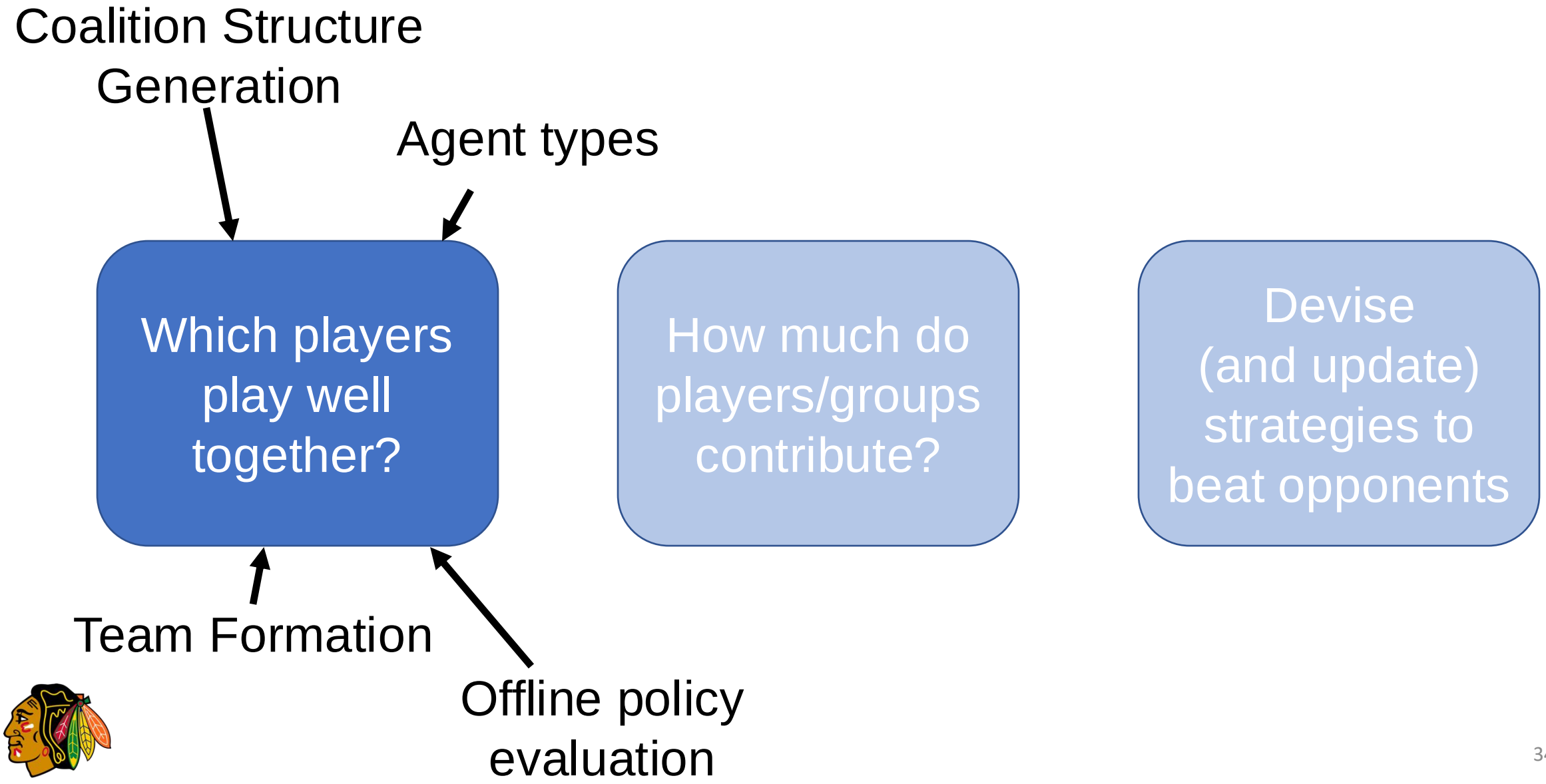
- Timescale: Before/within match
- Common problems:

Which players play well together?

How much do players/groups contribute?

Devise (and update) strategies to beat opponents

Coaching – Related Multiagent Topics



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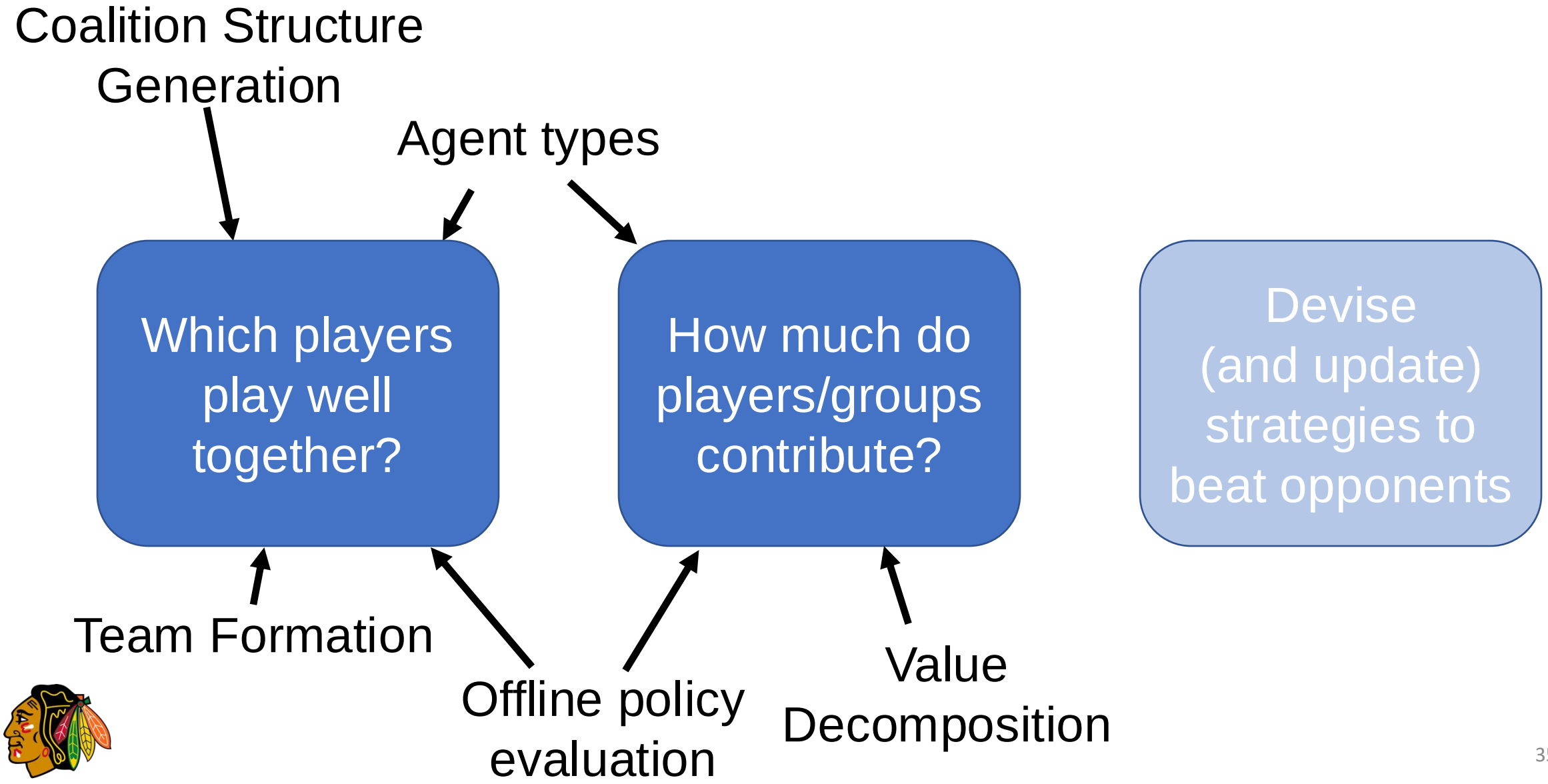

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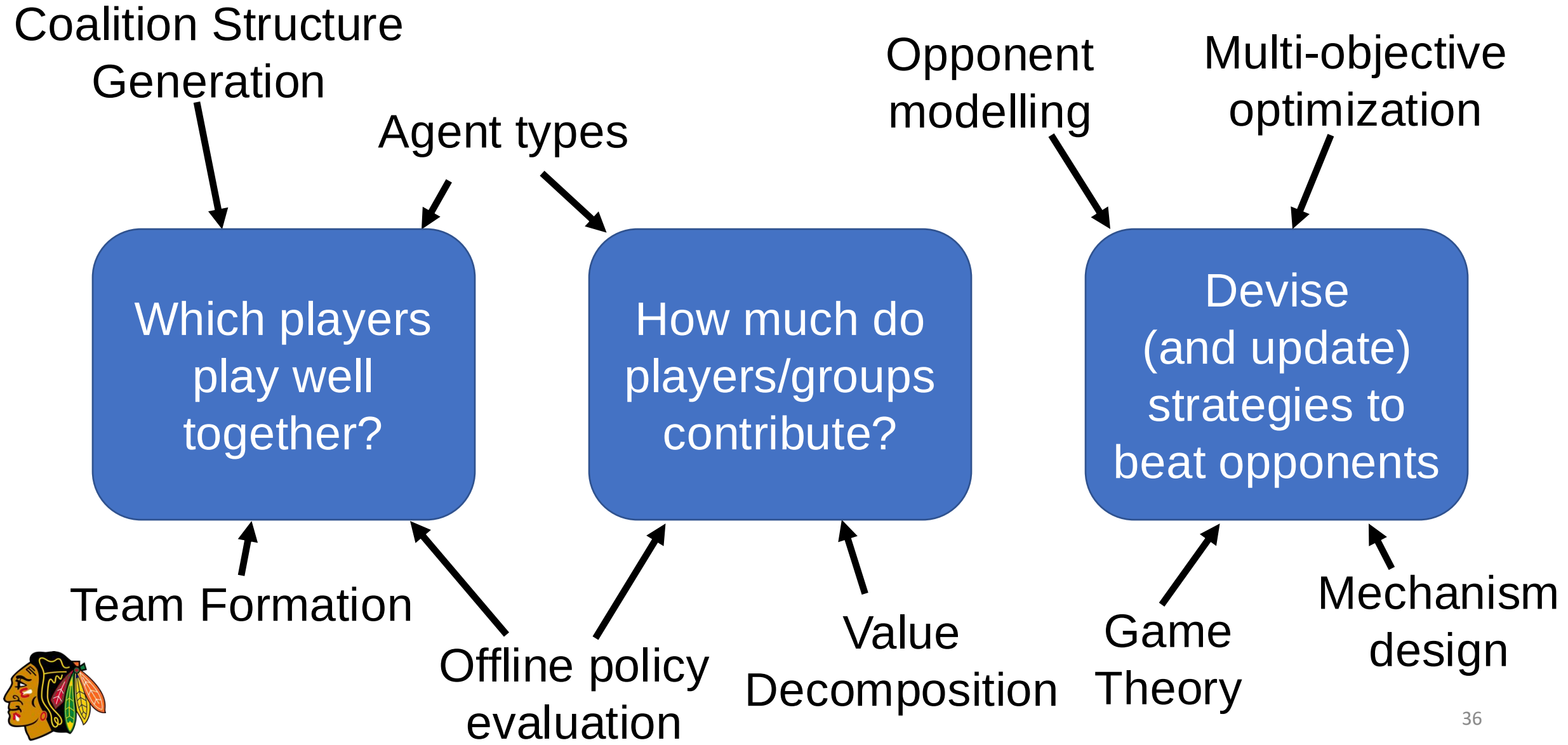

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Management – Long-term

- Roster Analysis
- Roster Construction
- Economic Strategies

Management – Long Term

- Timescale: Across an entire season/multiple seasons
- Common problems:

Analyze a roster and identify areas for improvement

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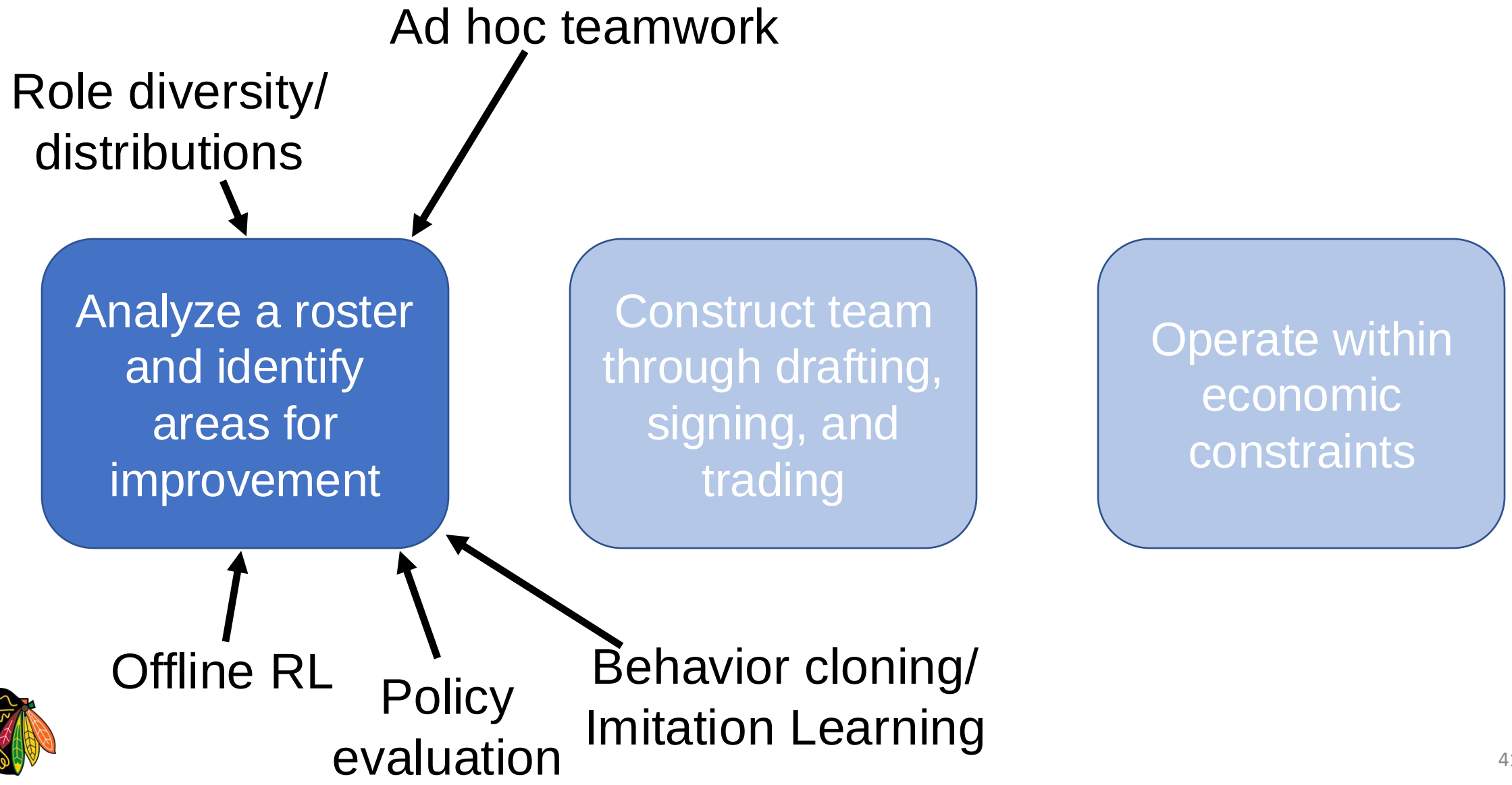
Construct team through drafting, signing, and trading

Operate within economic constraints

Management – Related Multiagent Topics



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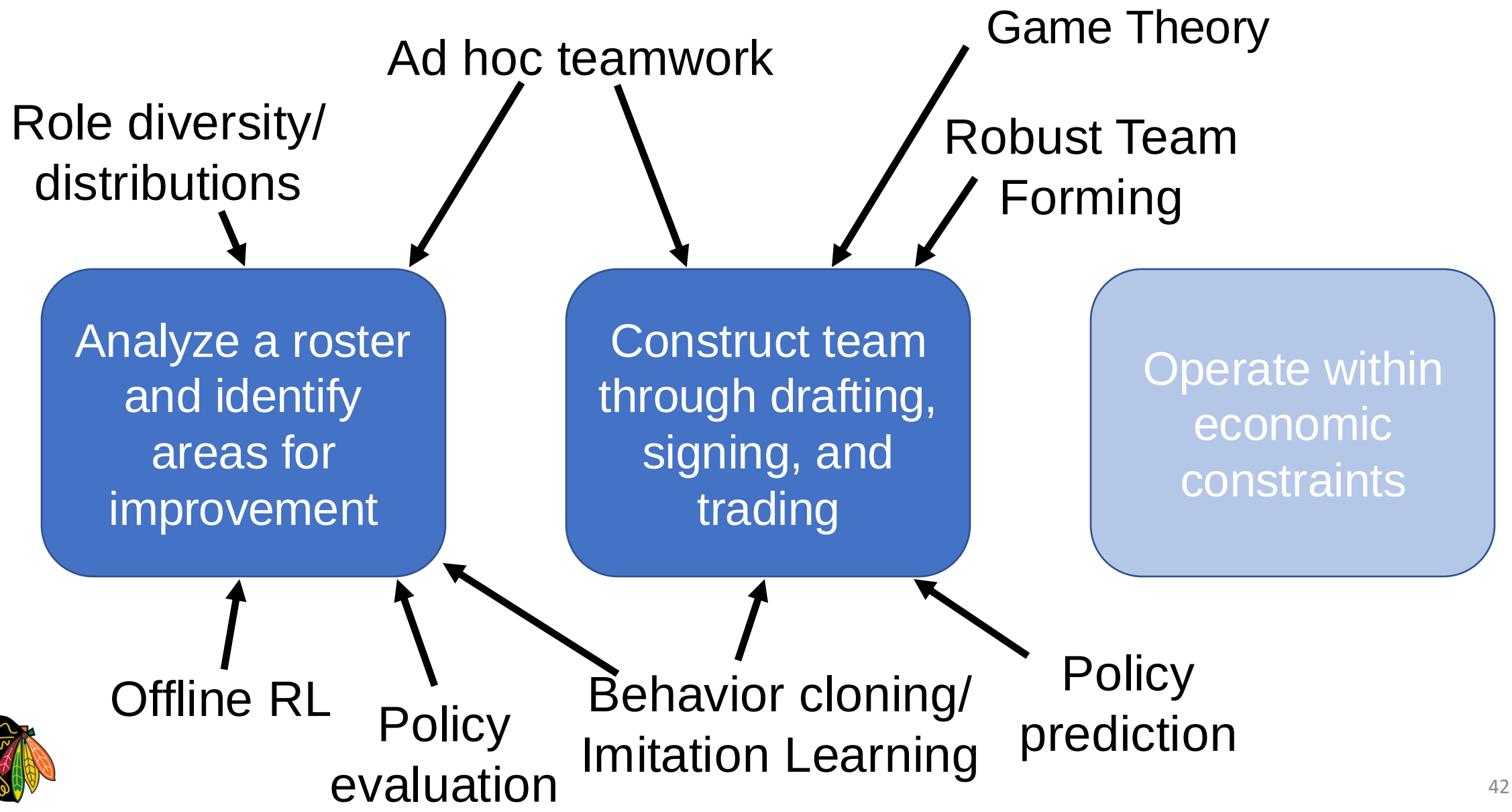

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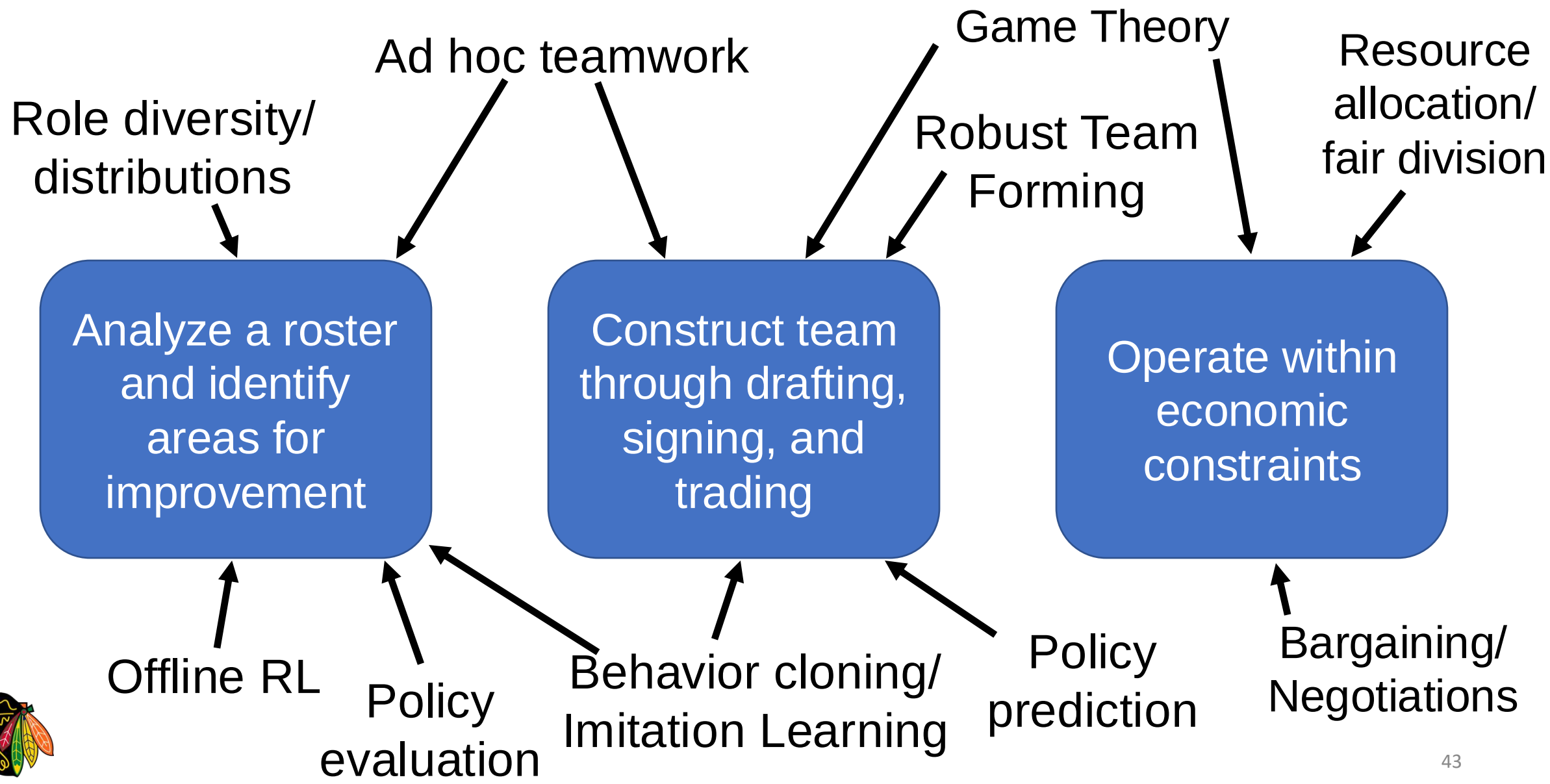

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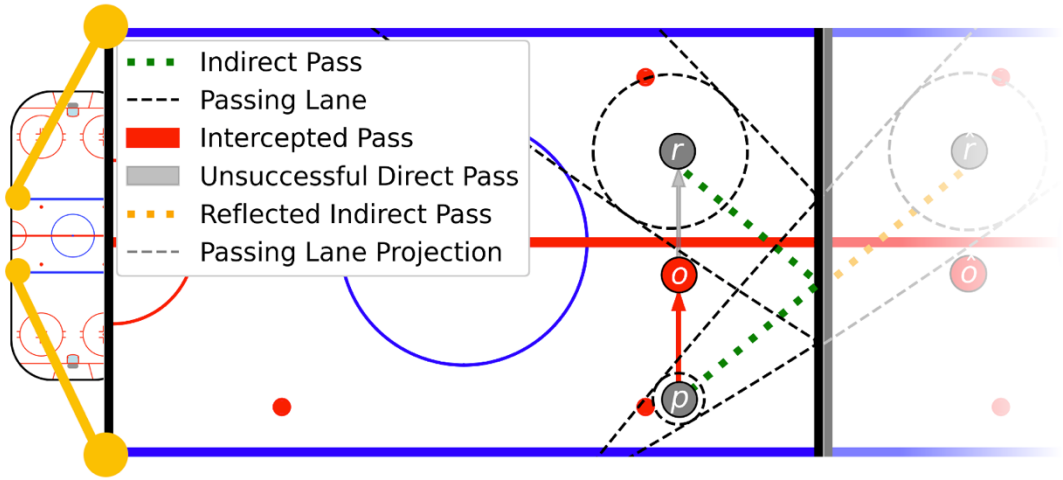
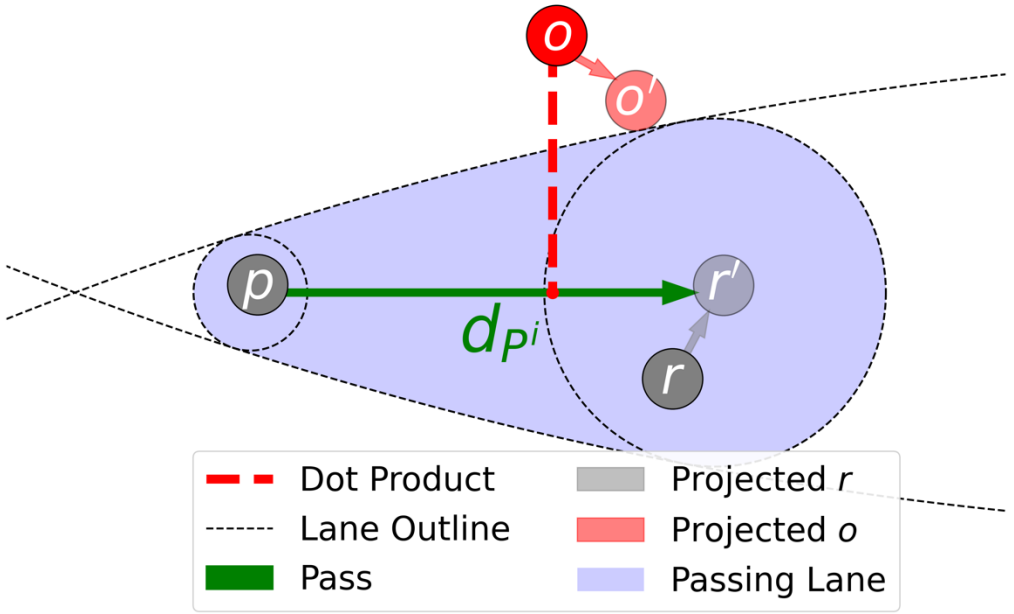
Multiagent Challenges

Example Projects

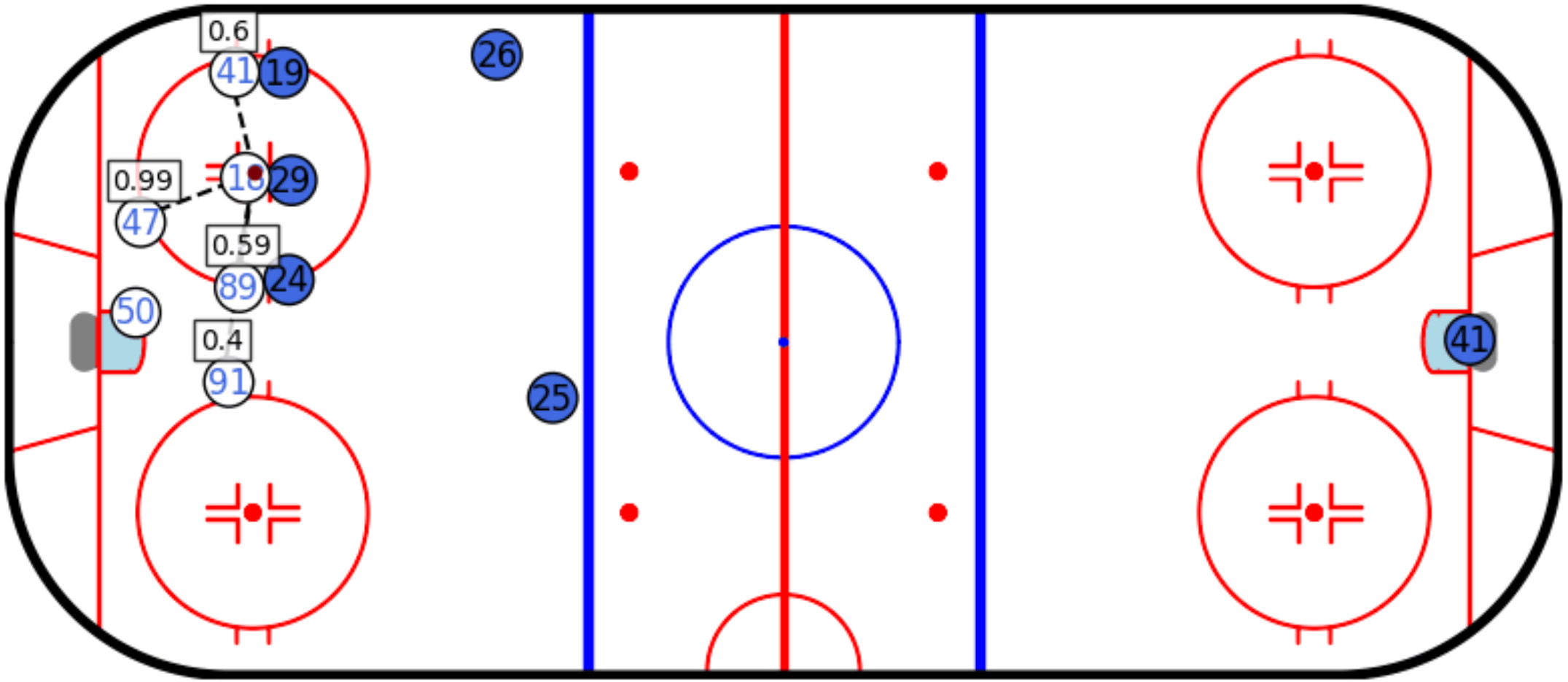
Passing Lanes in Ice Hockey

- Goal: Measure the available space between a passer *p* and receiver *r*
- Insight into players' risk, skill level, and decisions
- Euclidean Geometry

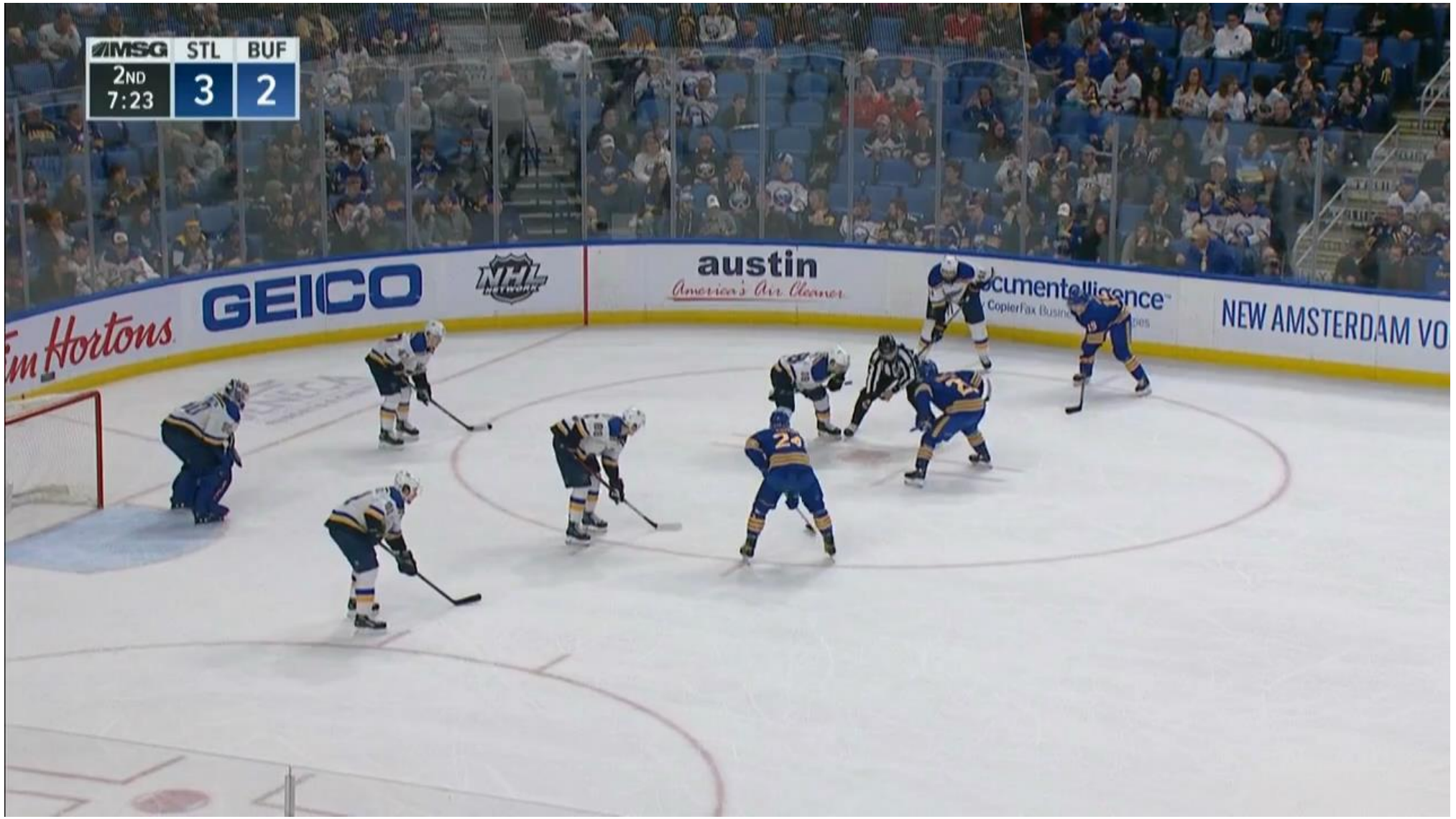




Real Game Scenario



Real Game Video

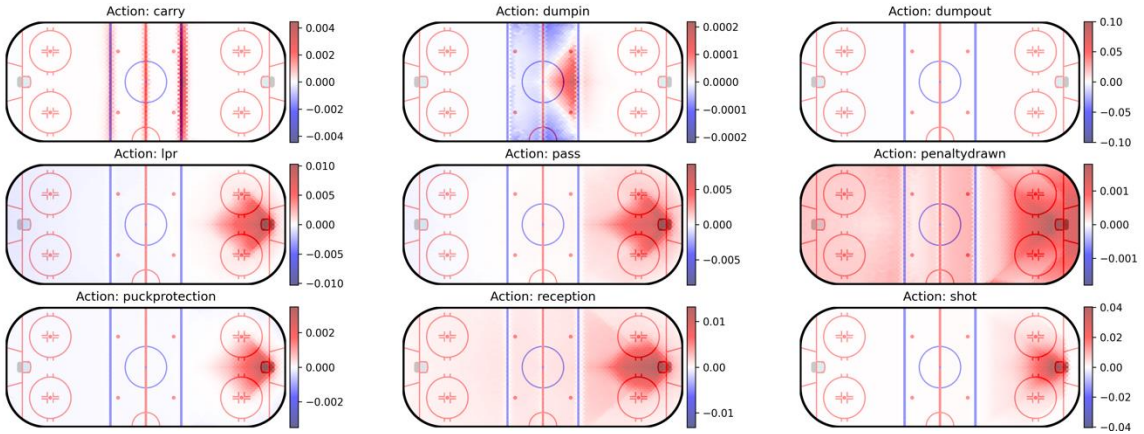


Real Game Video

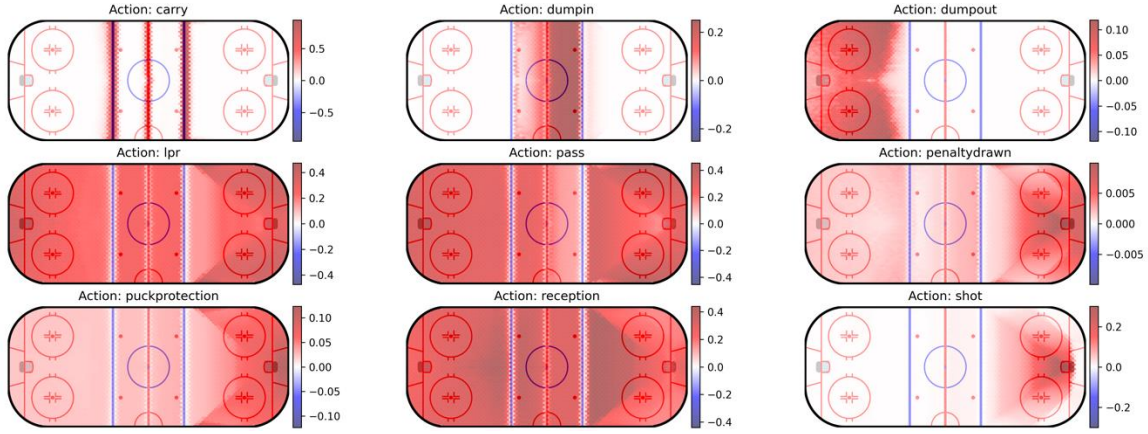
Learning Value Functions in Ice Hockey

- Goal: Learn the value of game states from offline **event data**
- Challenge: Events come from two **adversarial** teams/agents (zero-sum)

Q-Values

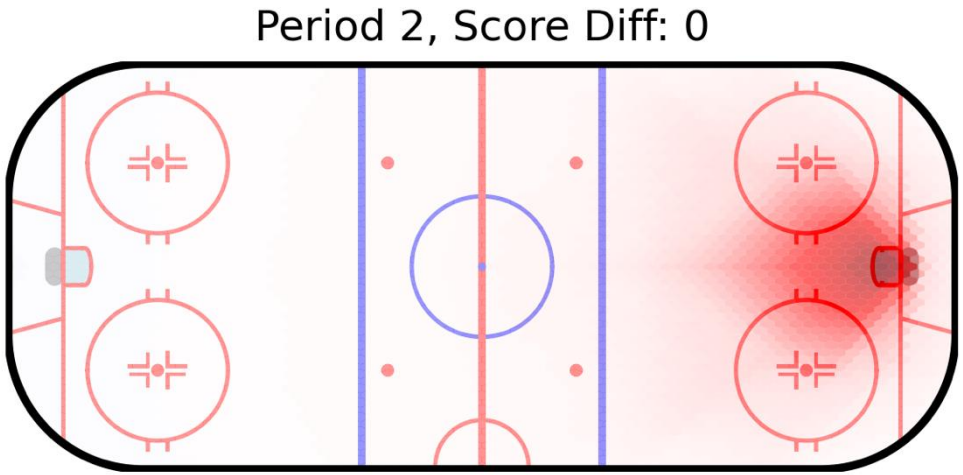


Policy

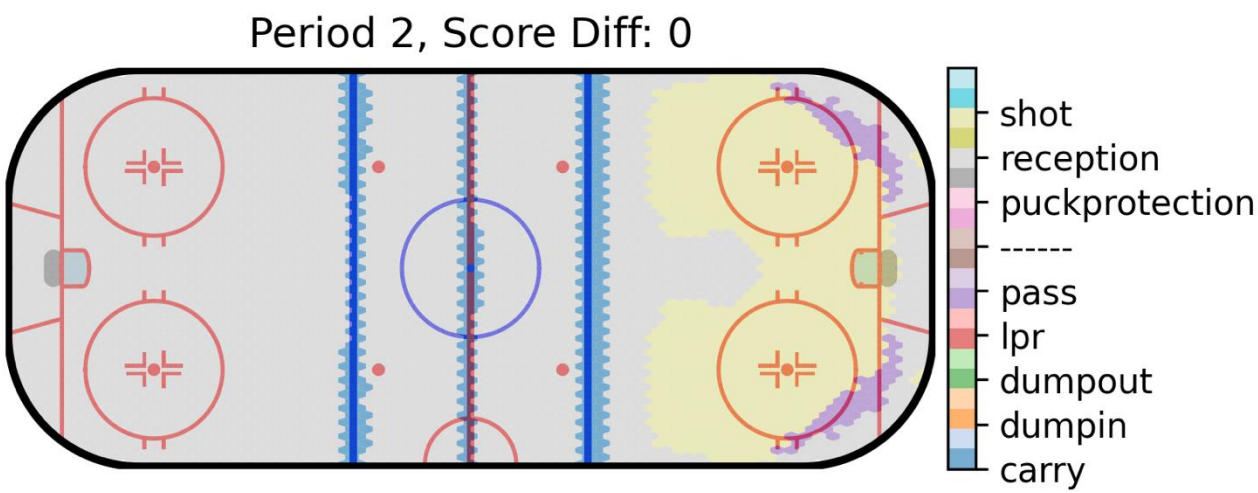


Learning Value Functions in Ice Hockey

V(s)



max Q(a | s)



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Multiagent Challenges

Example Projects

Multiagent Systems for Team Sports Analytics

- No shortage of multiagent problems
- Advancements will improve both domains
- **Real data** for cooperation, development, and financial transactions
- Multi-level planning required for success

Multiagent Systems for Team Sports Analytics

- No shortage of multiagent problems
- Advancements will improve both domains
- **Real data** for cooperation, development, and financial transactions
- Multi-level planning required for success
- Rewards for success!

Summer 2025 Internships (3 total)

- Software Engineering Intern
  - Supports Hockey Strategy group (salary cap/roster management)

- Data Science Intern
  - Supports Data Science group

- Research Science Intern
  - Supports Research Science group

Research Interests

- Value-based RL in sports
- Policy evaluation for groups
- Player/Agent Types
- Team formation
- Empirical Game Theory

Multiagent Challenges

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