

Designing Consensus: Gamified Modeling and Simulation of Collaborative Decision-Making

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IAP 2025 (Non-Credit)

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Course Roadmap

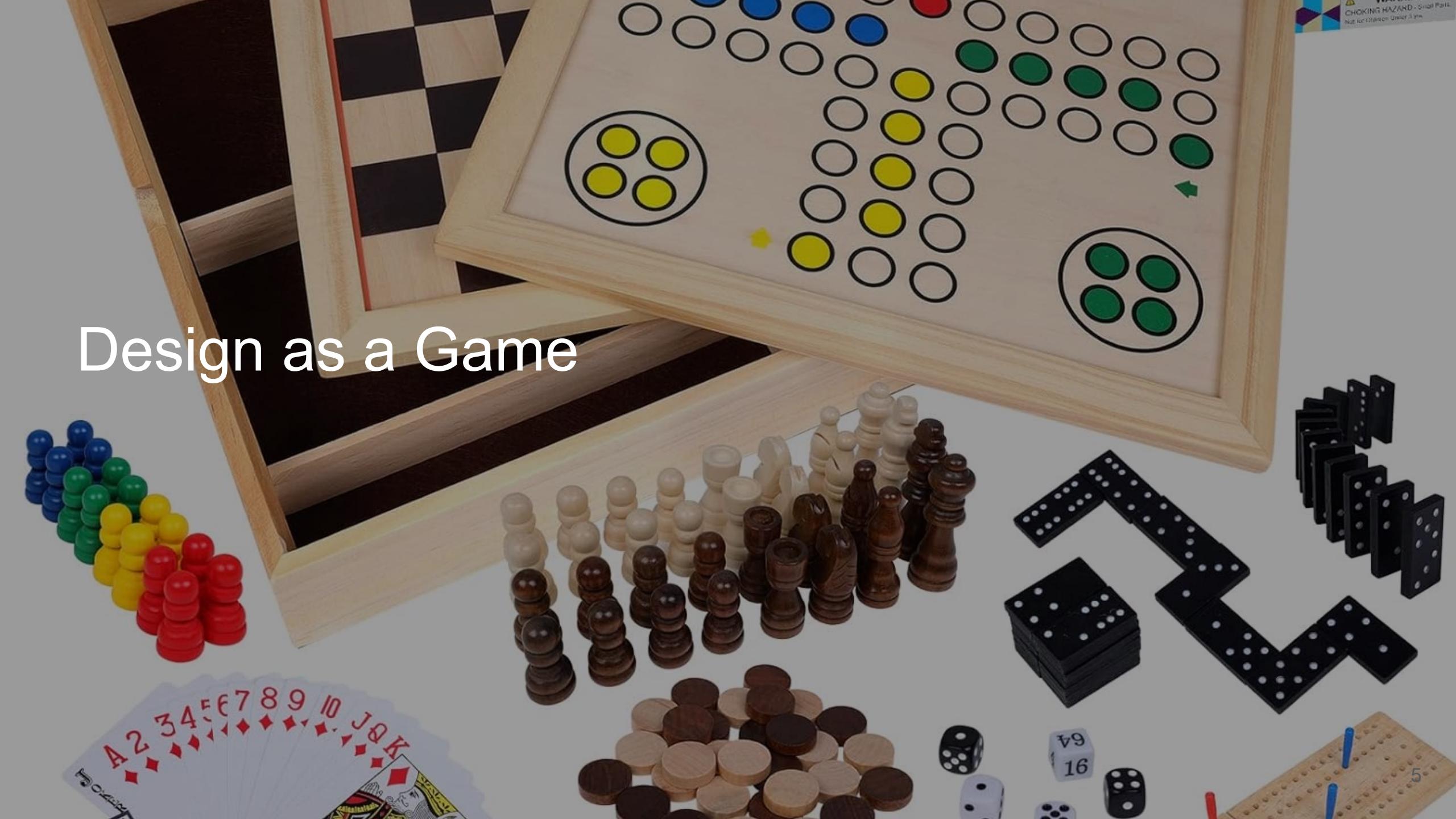
Date	Topic	Contents
Jan 16	Design as a Game	<ul style="list-style-type: none">● Overview and introduction of core concepts.● Introduce classical physical board games and their mechanisms, including Monopoly, Tiny Towns, and Small City.
	Workshop	<ul style="list-style-type: none">● Brainstorming and conceptualization
Jan 21	Modeling and Collaborative Decision-Making	<ul style="list-style-type: none">● Further introduction to game theory and decision-making from a computational perspective.● Explore how we can turn a game (like Go) into a format the computer can recognize, play, and learn with. A touch on PettingZoo as a standard for creating digital environments.● A brief introduction to traditional decision-making modeling approaches, such as behavioral trees, finite state machines, and rule-based systems.
	Workshop	<ul style="list-style-type: none">● Group formation, mockups, playtesting, and refinement of your conceptual board game.● Free food will be provided to celebrate my birthday!
Jan 23	System Dynamics and Simulation Games (SLG)	<ul style="list-style-type: none">● From a macro perspective, introduction to system dynamics as an approach for modeling complex systems.● Introduction to the core mechanisms behind classical SLGs that utilize system dynamics concepts, such as SimCity.
	Workshop	<ul style="list-style-type: none">● Sketch out the system's dynamic loops and diagrams of your game.● Share your game design with the class, play others' board games, make suggestions, and refine your design.● Develop and build your game at home (physical or digital)

Course Roadmap

Date	Topic	Contents
Jan 28	Swarm Intelligence and Emergent Intelligence	<ul style="list-style-type: none">From a micro perspective, introduction to agent-based approaches as another method for performing simulations.Introduction to swarm intelligence, inspired by real-world examples (e.g., ants), and their simulation through collaborative and competitive agents.Guest Lecture: Introducing current advances in emergent intelligence with Large-language-Model agents and their limitations.Introducing the application behind modern simulation games such as Cities: Skylines, Civilization, and Anno.
	Workshop	<ul style="list-style-type: none">Experiment with GAMA to simulate pedestrian behavior in a small town.Prepare your presentation
Jan 30	Multi-Agent Learning	<ul style="list-style-type: none">Step from the concept of game theories we built from the previous lectures, we explore methods to train agents to make decisions in the environment we created. Starting from reinforcement learning (RL), we will introduce multi-agent RL and explore the pros and cons of a variety of methods.Overview of advances in this field, including Deep Blue, AlphaGo, and Cicero.
	Workshop	<ul style="list-style-type: none">Present your final game design to the class (game rules, competition or collaboration mechanisms, balancing, strategies, etc.).
	Wrap up and conclude.	

Jan 16	Design as a Game	<ul style="list-style-type: none">● Overview and introduction of core concepts.● Introduce classical physical board games and their mechanisms, including Monopoly, Tiny Towns, and Small City.
	Workshop	<ul style="list-style-type: none">● Brainstorming and conceptualization

Design as a Game





Design is a process to reach consensus

Q: How are decisions made in “actual” designs?

Example: How are decisions made in cities



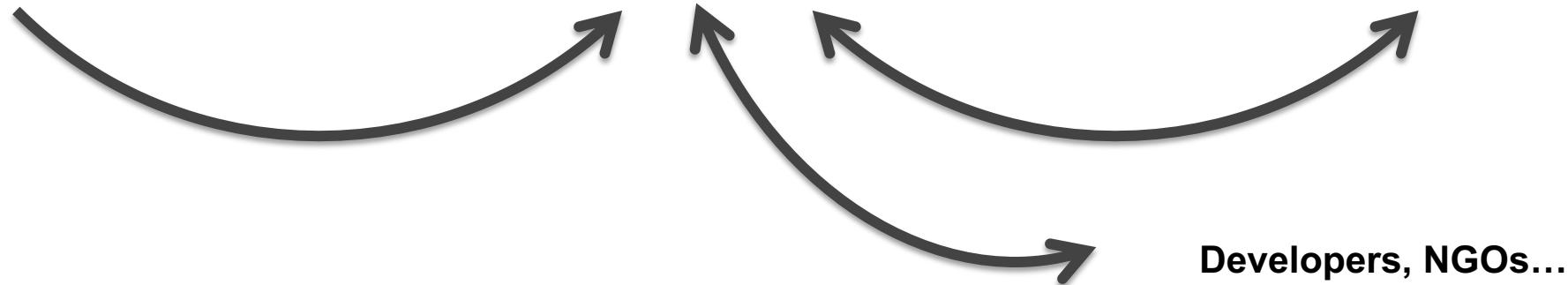
Public Events



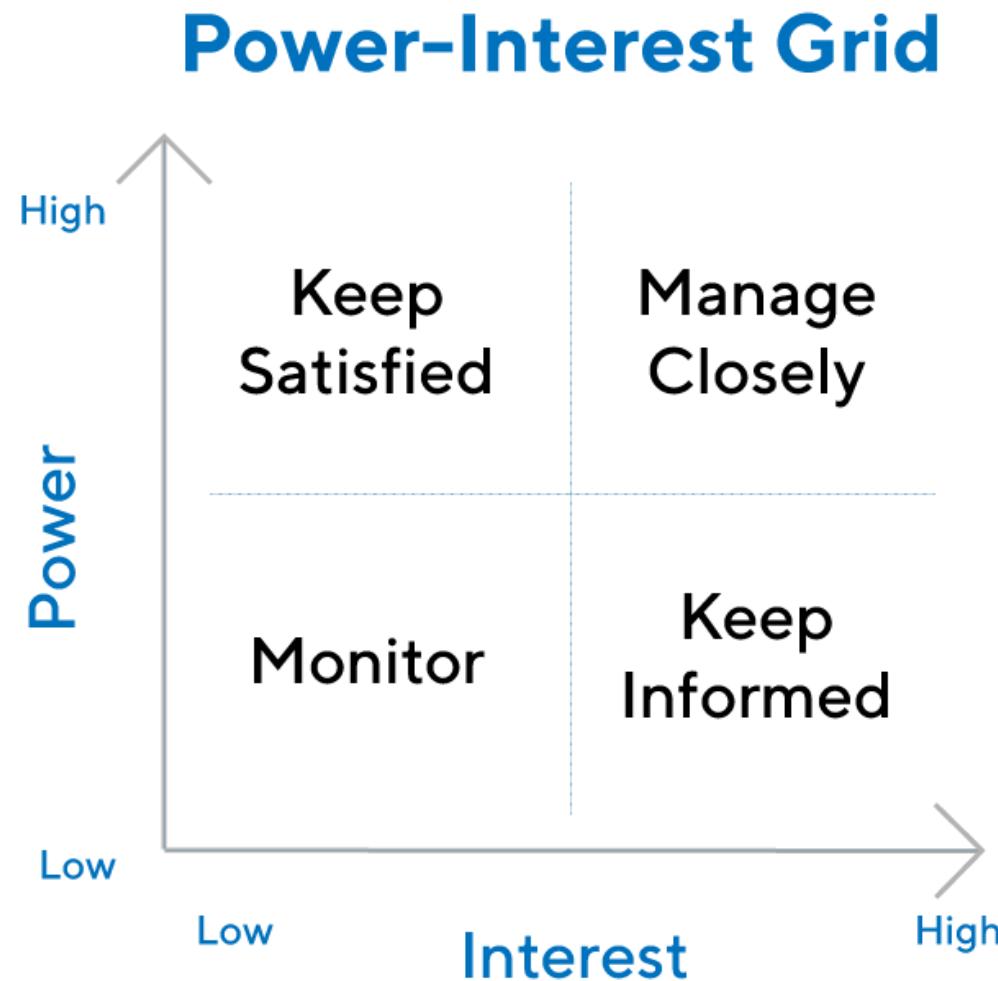
City Council Meetings & Hearings



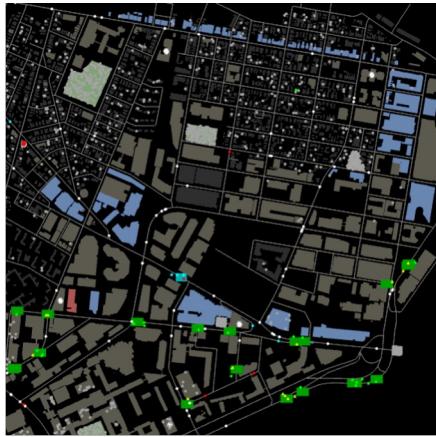
Planning Contractors



Exercise: Identifying Players (stakeholders)



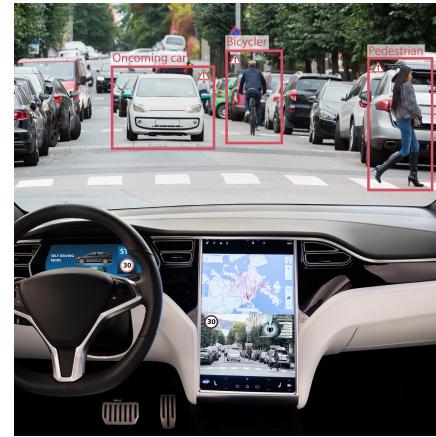
Intuition of Problem Scale



Urban Mobility Network



Texas Poker



Self-Driving

Agent Count

1000+

2-10

1

Computing Resource
for Each Agent



Update Time

0.1s – 1s

0.1s – 10s

<0.1s

Agent Strategies

Collaborative

Competitive

Safety-first

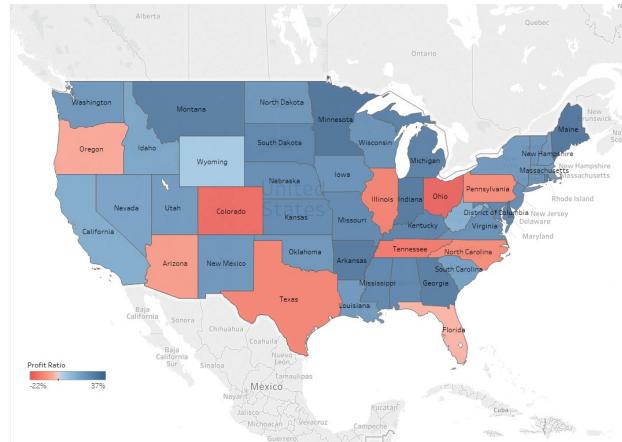
Intuition on Decision Making



Before making a decision, what info do we need?

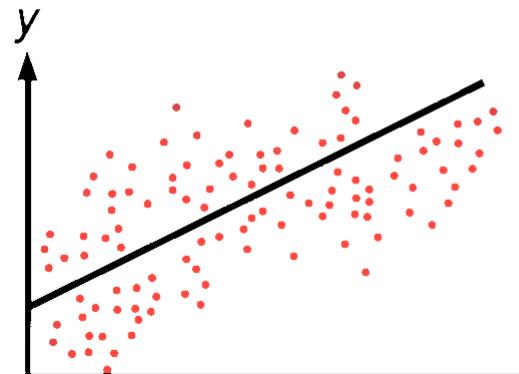
Descriptive

What happened?



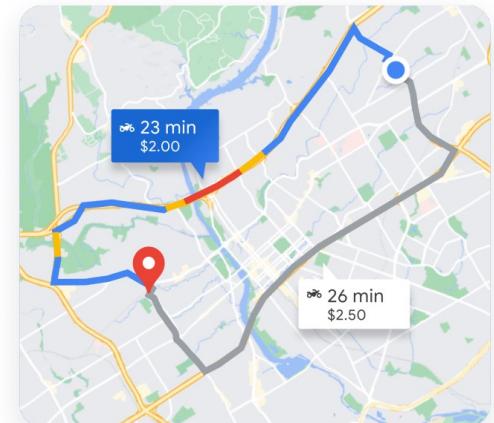
Predictive

What will happen?



Prescriptive

What should I do?



Data Management

Data Visualization

Forecasting

Machine Learning

Types of Analysis

Optimization

Simulation

One person decision making



One person decision making – Strategies?

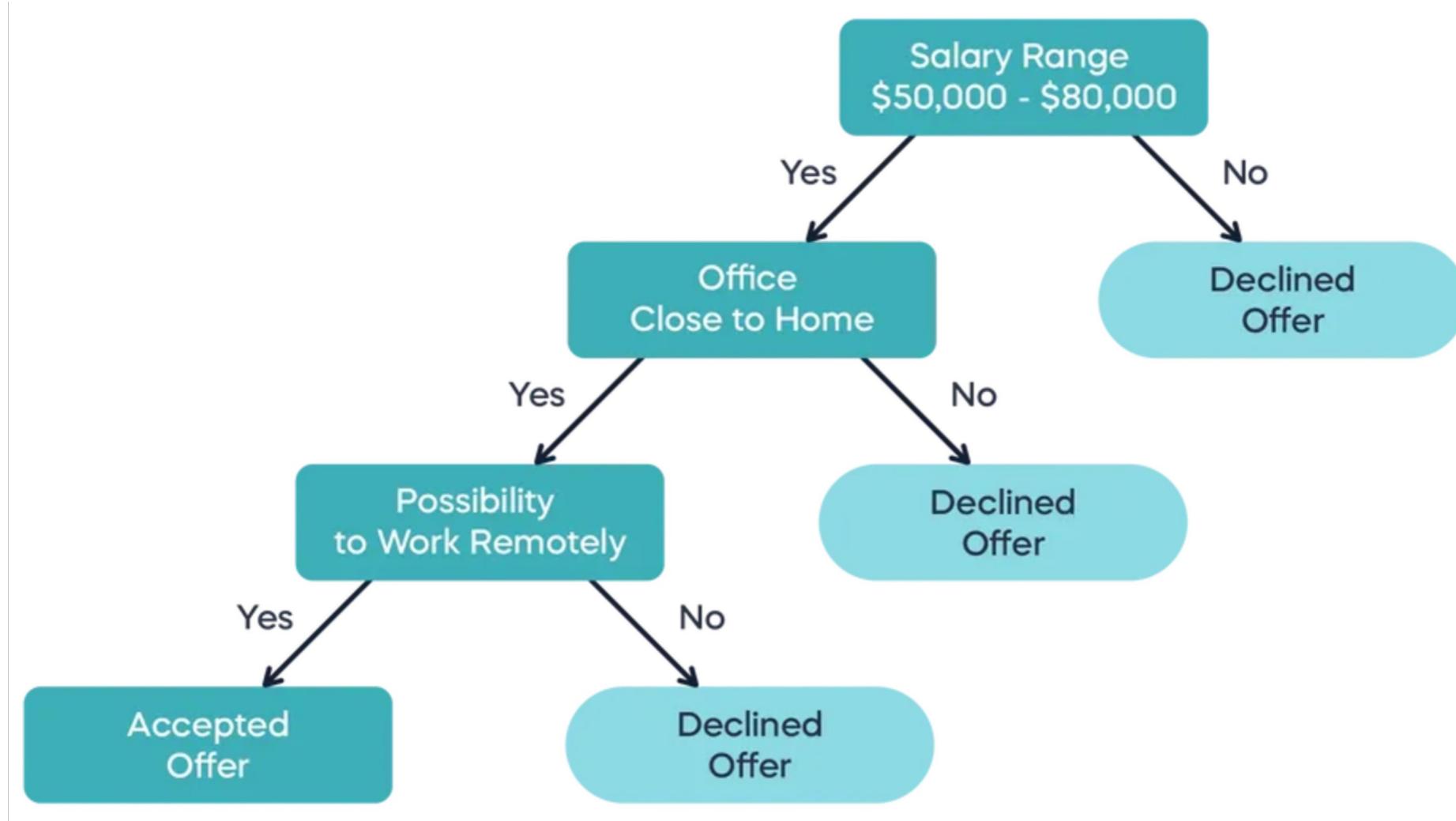


Guess the answer:
Heuristic Decision Making

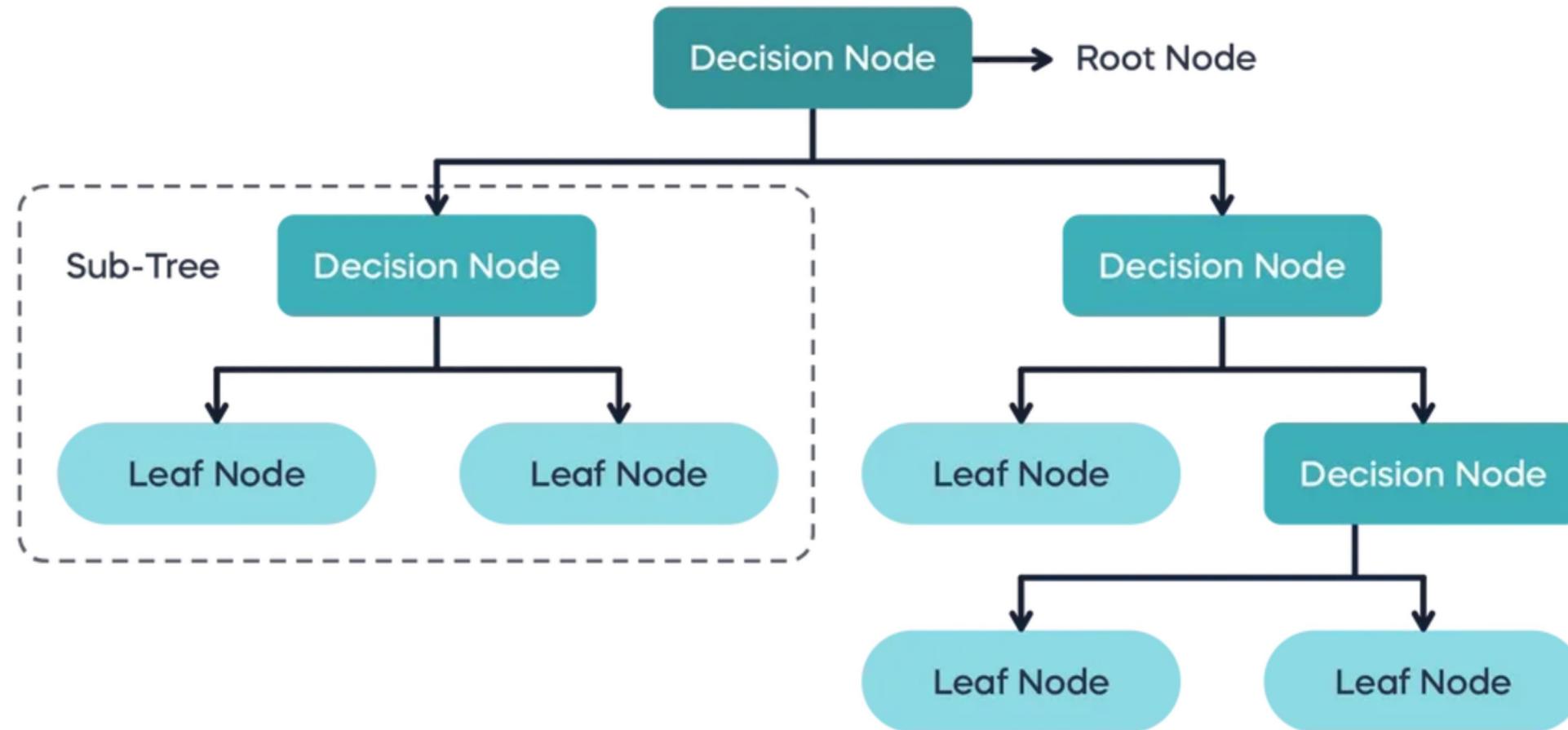


Greedy :
Rational (Analytical) Decision-Making

Decision-Making 101



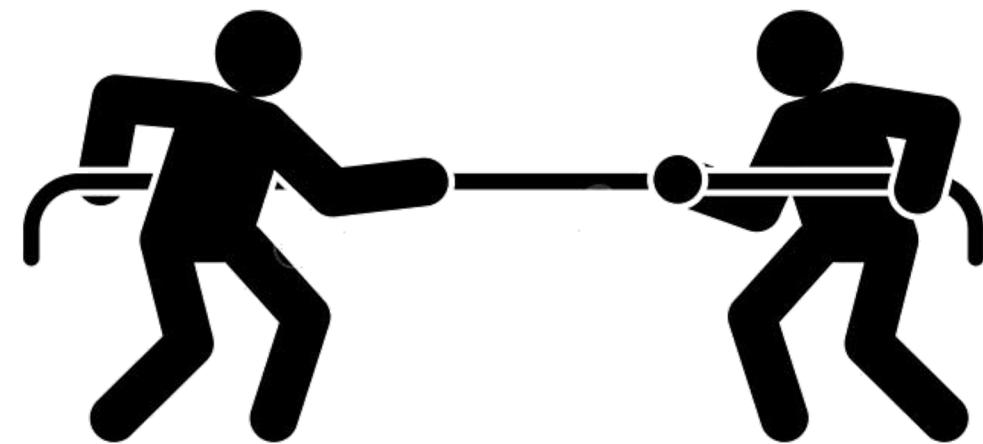
Decision-Making 101



More than just yourself?

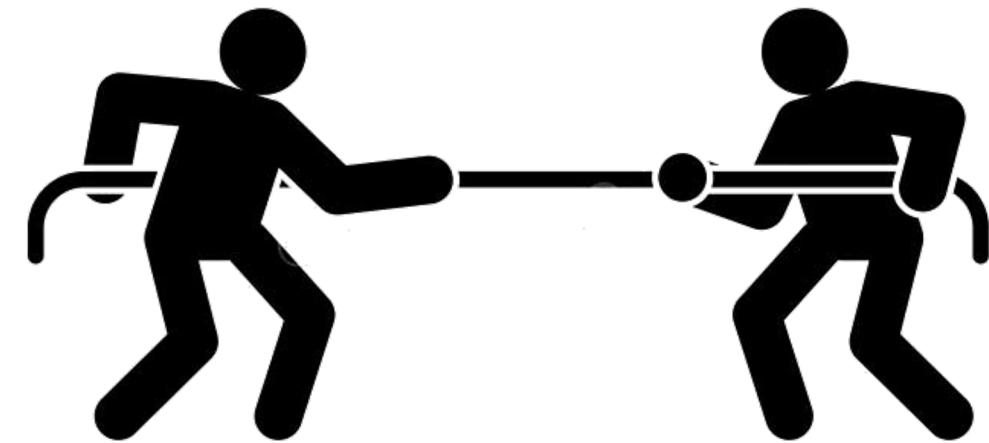
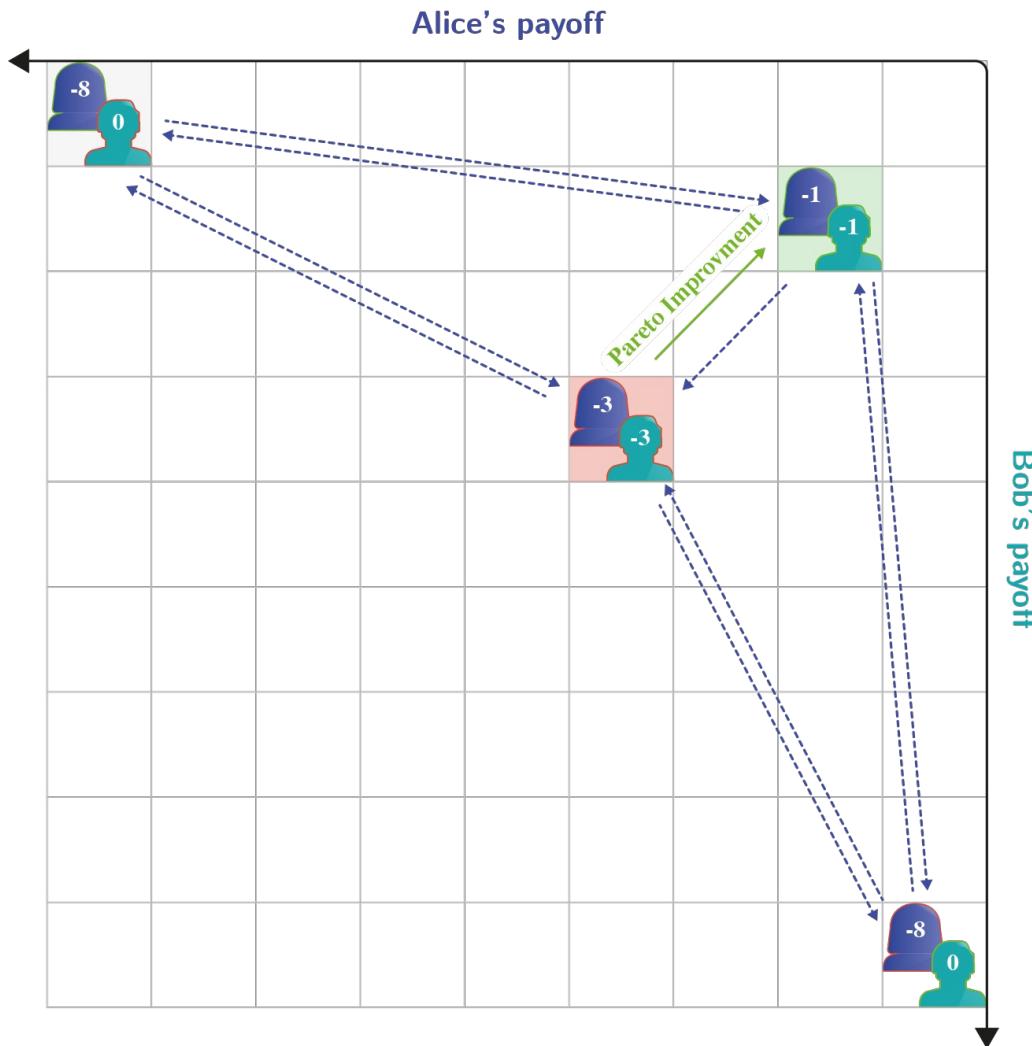


Corporative



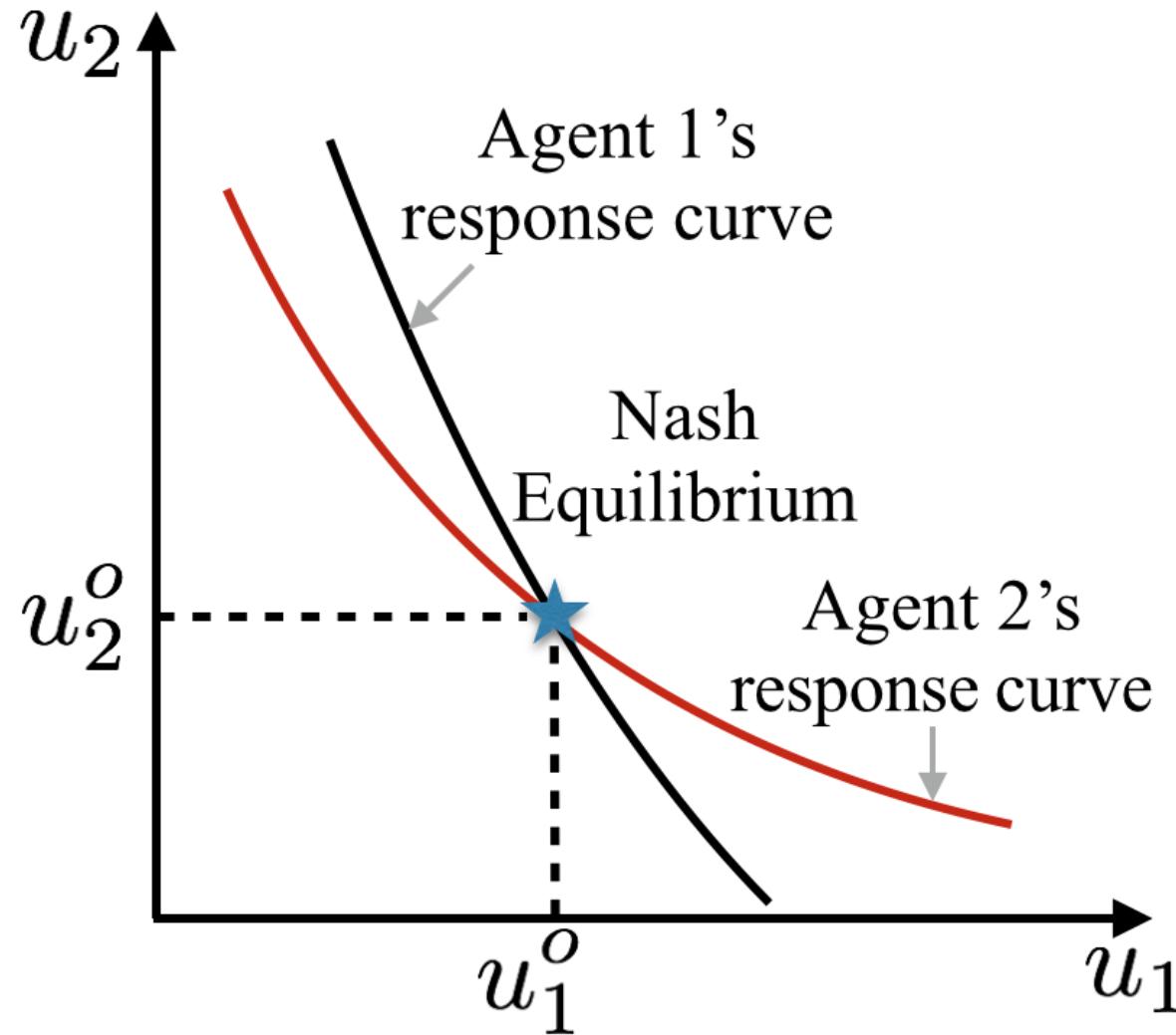
Competitive

Two-person situation – Zero-Sum Game



Competitive

Nash Equilibrium



No player can improve their outcome by changing their strategy

-- the solution of N-player noncooperative games.

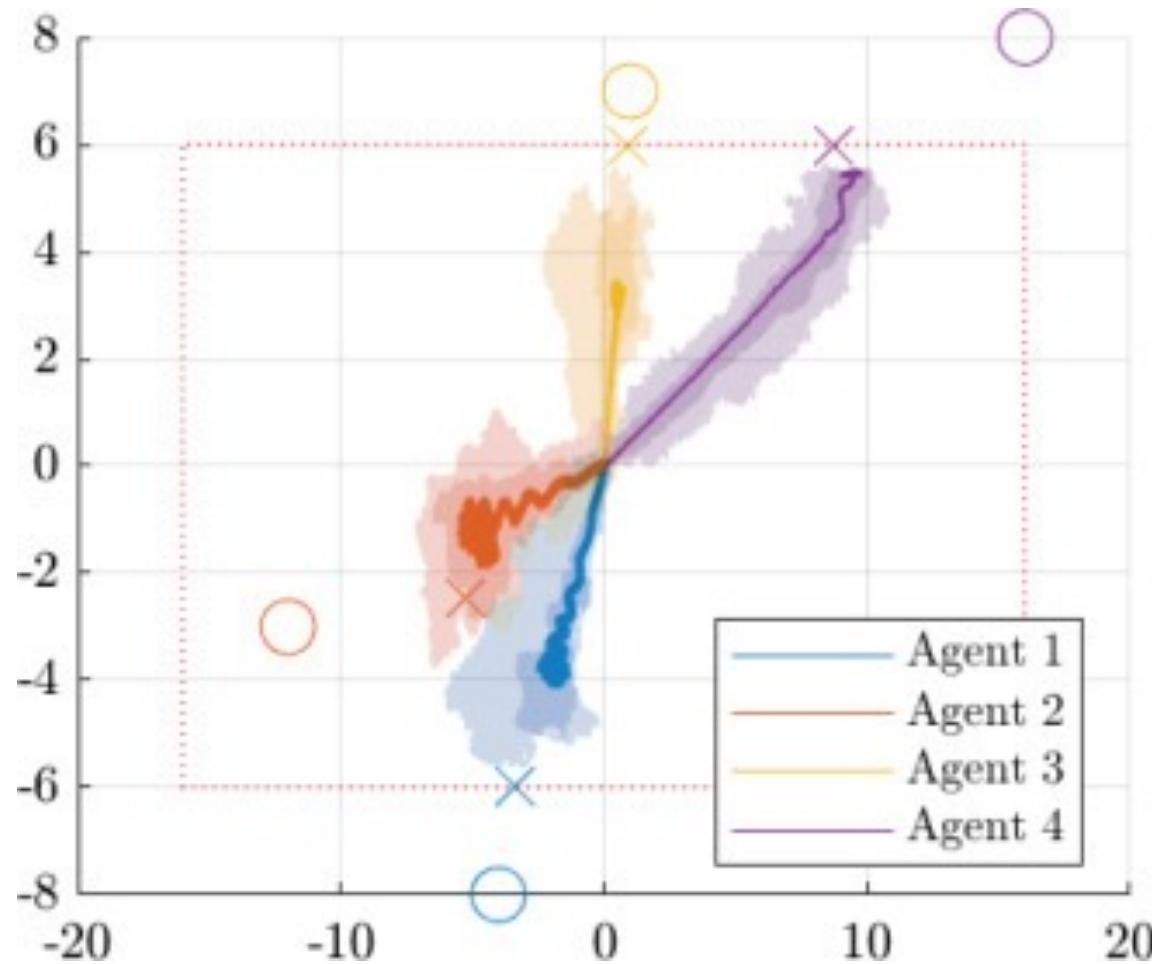
-- hard to compute that *exact* point

I win

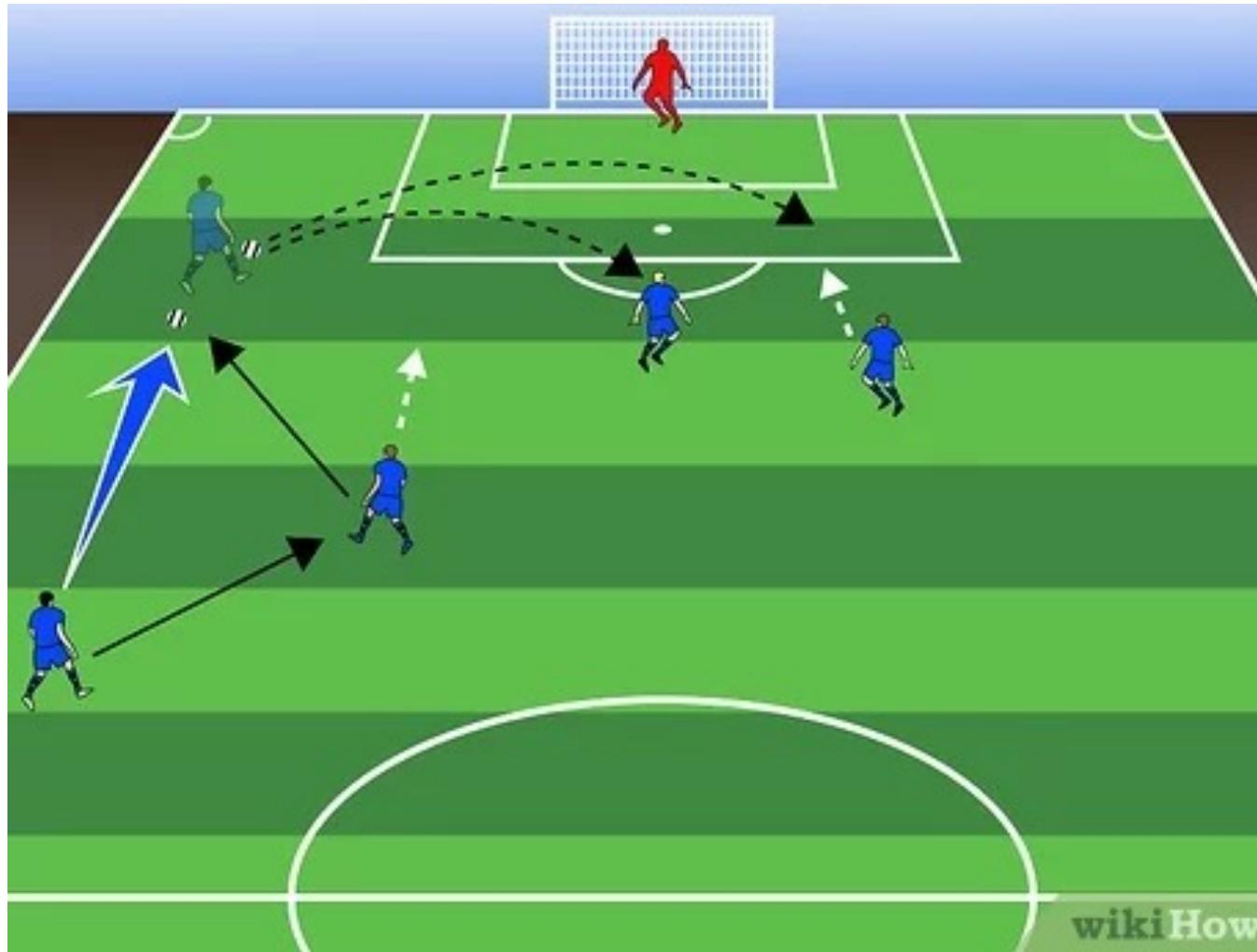
You lose

Other types?

What will happen if there are more than 2 people?

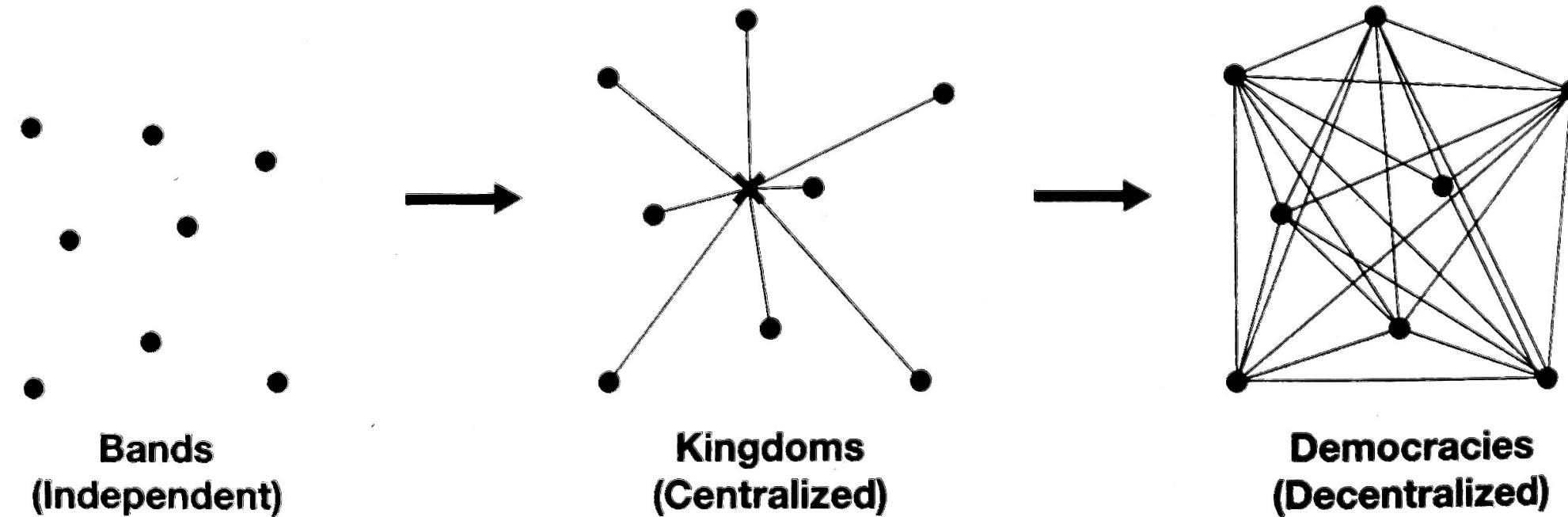


What will happen if the players needs collaborate?



What will happen if the players have hierarchies?

The major ways human societies have been organized throughout history reveal a remarkably simple pattern that foreshadows how businesses are now changing.



Classic Physical Board Games



Board Game Survey



Monopoly

Core rule:
Purchase and upgrade properties.
Random Events and Opportunities.



Tiny Town

Combine resource pieces to form buildings.
Buildings have scores.



Big City

Place building blocks satisfy the adjacency rules.
Buildings have interplay.



Small Town

Building buildings to maximize Citizens benefits.
Please the city council.
Reduce Pollution

Inspirations: Events under Uncertainty

Pieces conversion and transformation

Expandable Game Board

Player Hierarchy Voting



<https://www.hasbro.com/common/instruct/00009.pdf>

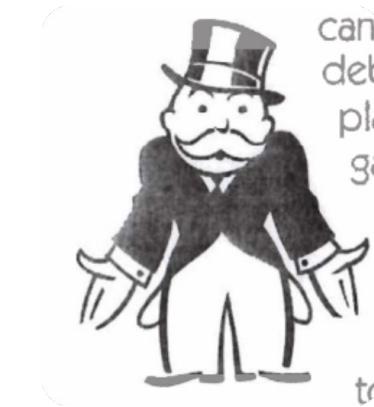




Go



Real Estate

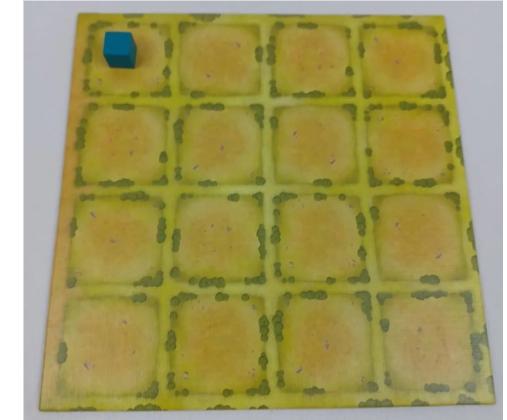
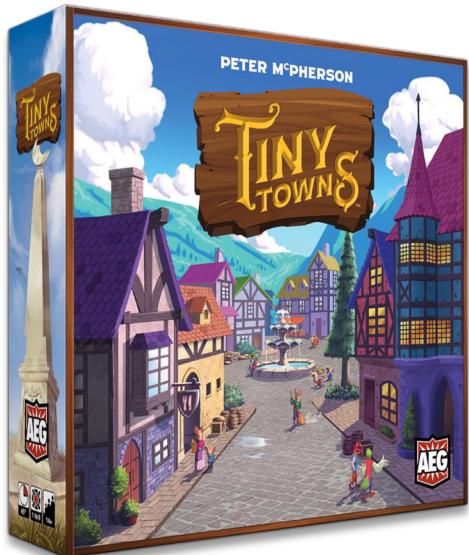


Bankrupt

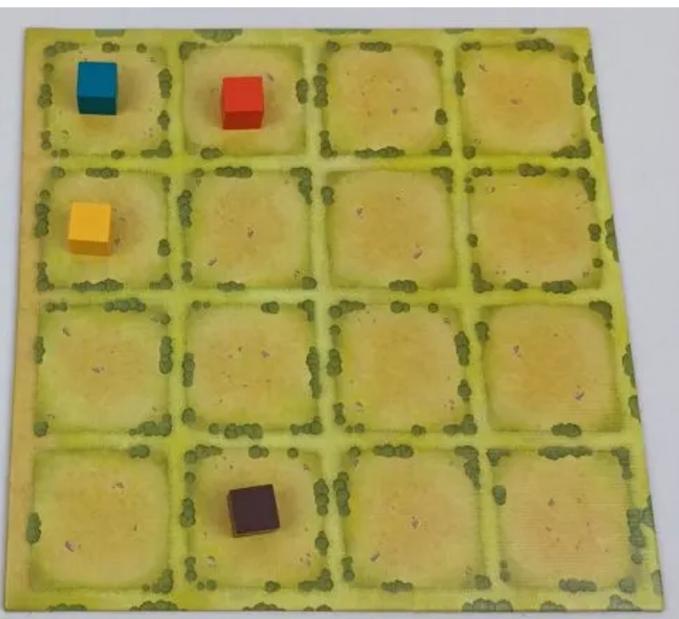
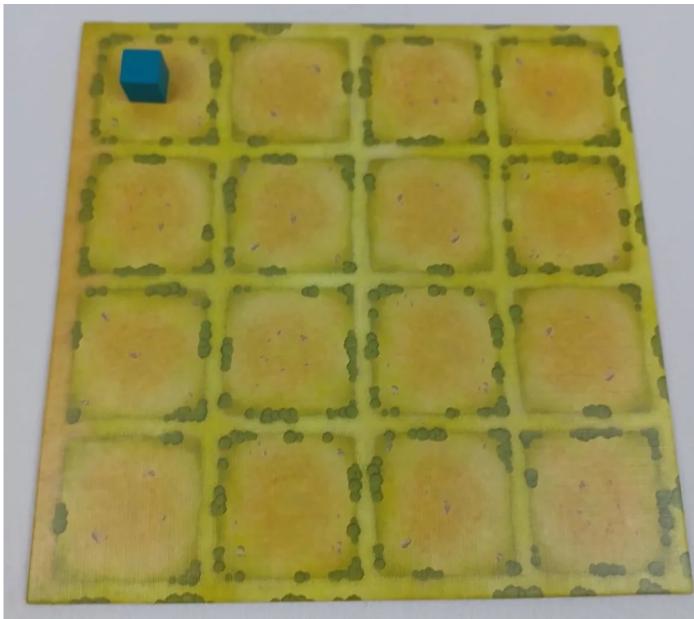
Strategies to win?

- Invest early to build momentum.
- Prioritize red and orange properties for frequent rent collection.
- Secure railroads for consistent income and strategic advantage.
- Avoid utilities; they offer minimal returns.
- Focus on building three houses for optimal income.
- Create a housing shortage to hinder opponents' progress.
- **Use statistics to make informed decisions on property investments.**
- **In late-game, staying in jail can save you from costly property landings.**

Tiny Towns



Components: 6 player boards, 25 Building cards, 15 Monument cards, 15 Resource cards, 126 wooden buildings, 1 Master Builder hammer, 6 wooden monuments, 90 wooden Resource cubes, scorepad, instructions



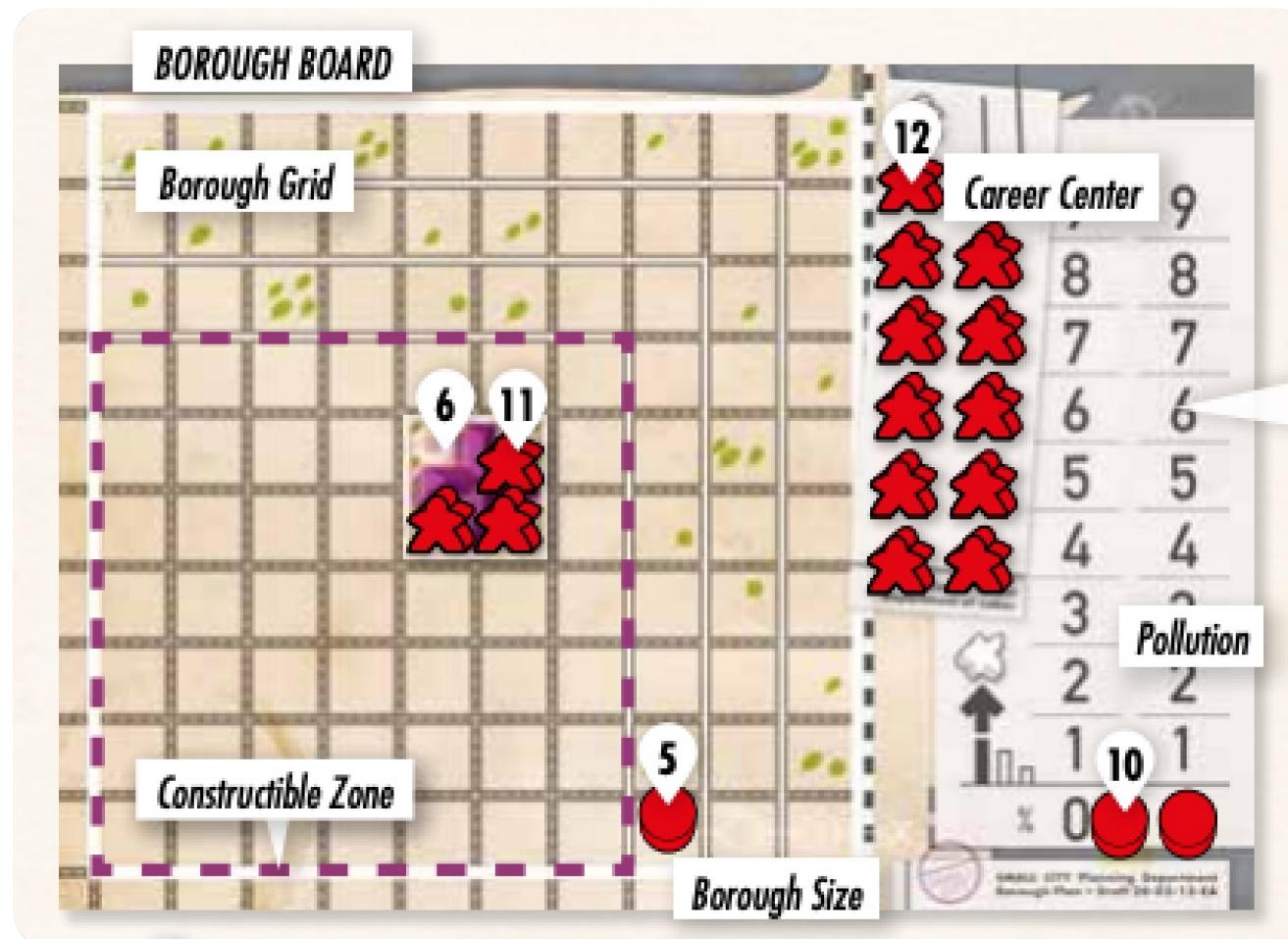
Winning Strategy?

“After 3rd play we realized we are **only building cottages** and occasionally Monuments combining with some green and grey buildings to utilize stone and wood. We literally **never use other types of buildings** as it seems **less rewarding** (takes more resources and effort to build for less points”

SMALL CITY

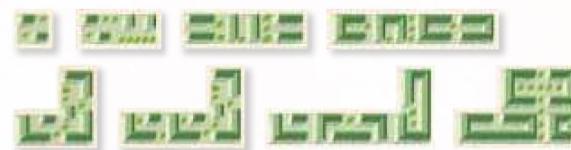
PLAYERS: 2–4

GAME TIME: 30 MINUTES / PLAYER



This work by

Residential Zones



Commercial Zones



Factories



Refinery, Harbor and Warehouse



Parks



Police Station and Fire Station



Cultural buildings



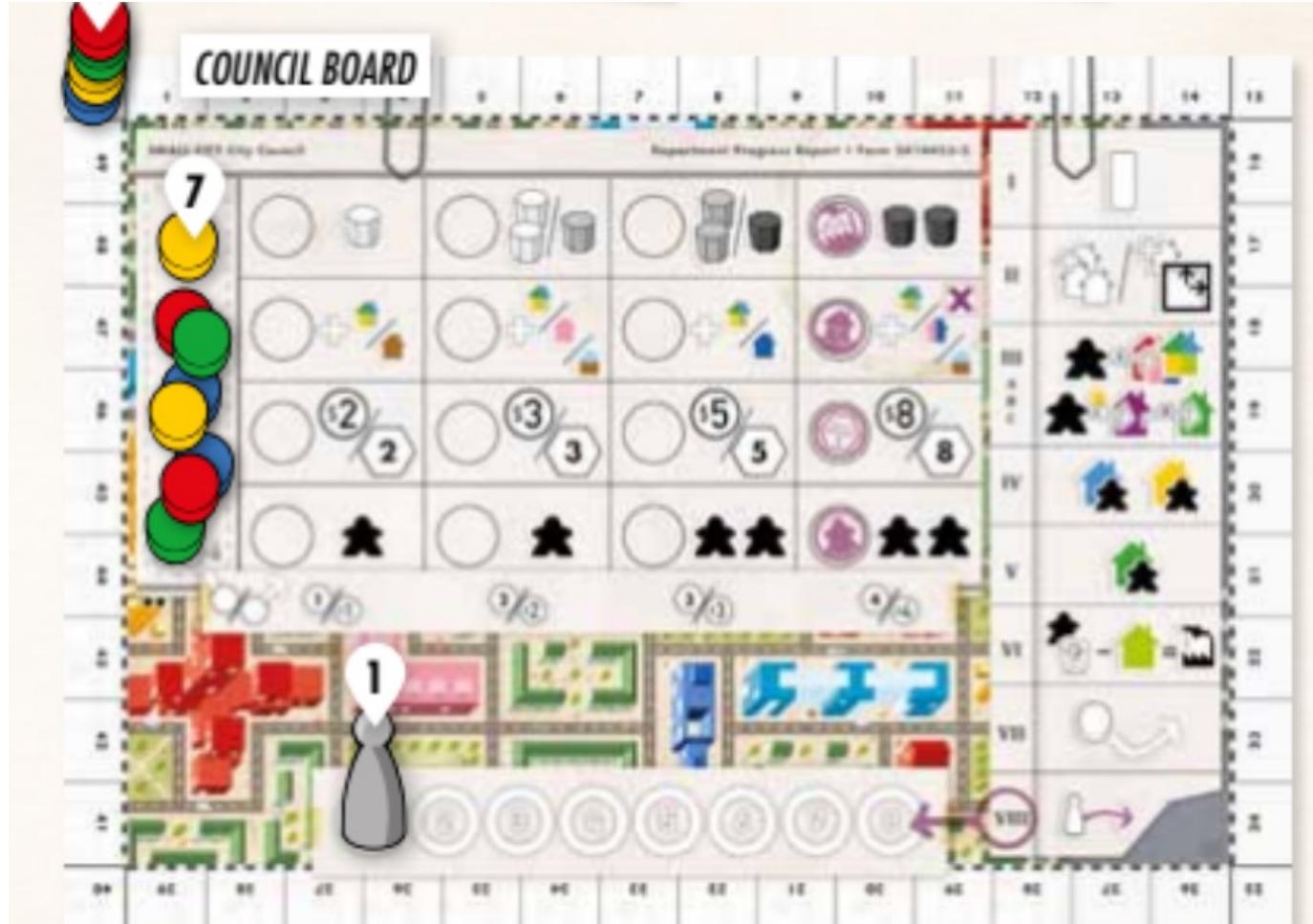
City Hall



SMALL CITY

PLAYERS: 2-4

GAME TIME: 30 MINUTES / PLAYER



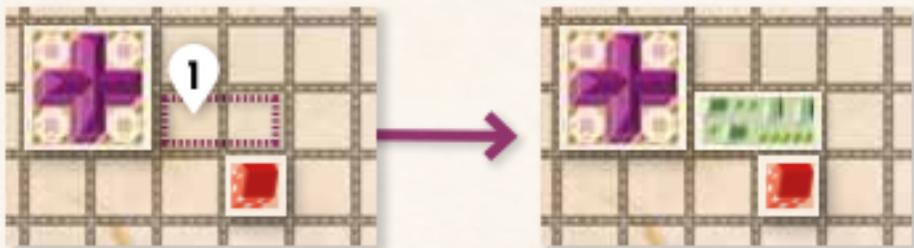
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SMALL CITY

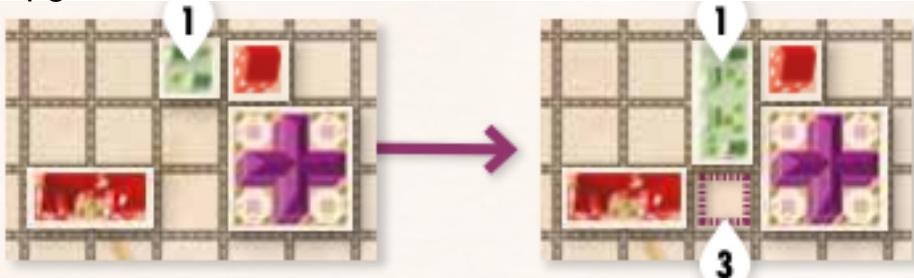
PLAYERS: 2-4

GAME TIME: 30 MINUTES / PLAYER

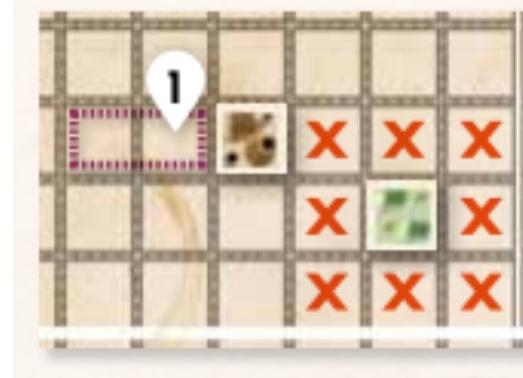


Example 1: You can build a Residence 2 that overlaps the marked space (1) for \$2.

Upgrade



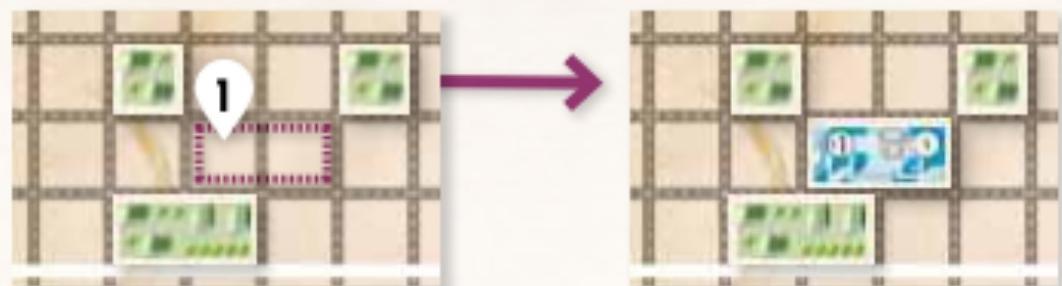
Example 2: Your Residential 1 tile (1) is Influenced by 2 Cultural Buildings (School and City Hall), so you upgrade it to a Residential 2 (2). By expanding downward, your newly expanded R2 is Influenced by a 3rd Cultural Building, the Library. So, you can upgrade the R2 to an R3, if you like (3).



Example 2: You cannot build a Factory in any of the spaces marked with an X, because of the Residence 1; however, you could build a Factory 1 elsewhere for \$1, and/or a Factory 2 for \$2 where it is influenced by the Refinery (1).

- **Construction Conditions:**

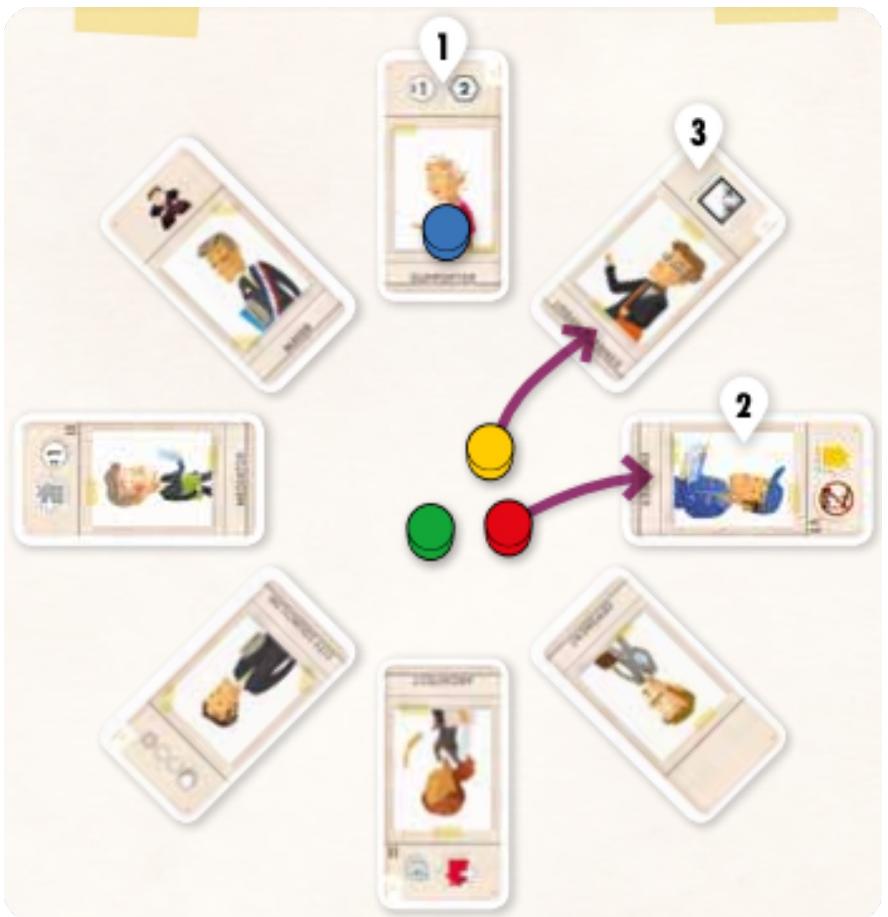
- Level 1: Must be Influenced by 1 Residential Zone.
- Level 2: Must be Influenced by 2 Residential Zones.
- Level 3: Must be Influenced by 3 Residential Zones.
- Level 4: Must be Influenced by 4 Residential Zones.
 - Residential Zones may be of any size.



Example: You can build a Commerce 2 overlapping the marked space (1) for \$2, because that space is influenced by 2 Residential Zones.

SMALL CITY

PLAYERS: 2-4
GAME TIME: 30 MINUTES / PLAYER

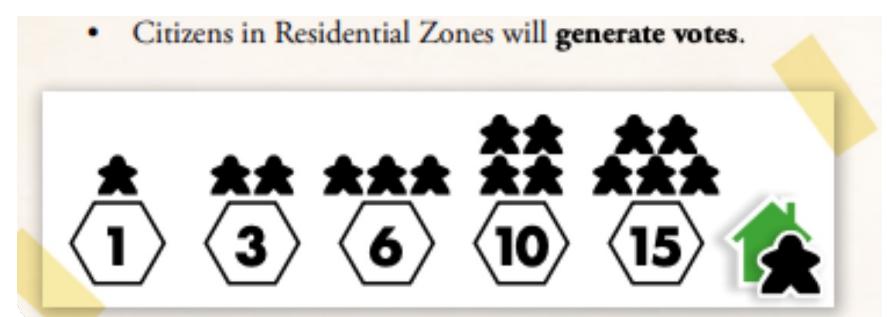


<https://cdn.1j1ju.com/medias/ea/b4/59-small-city-rulebook.pdf>

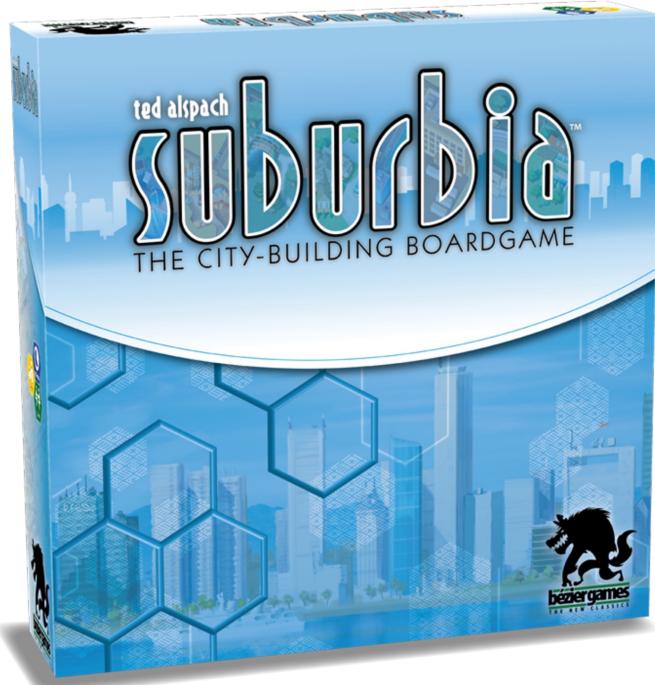


Example: The two full R1s earn 1 vote each. The full R3 earns $1+2+3=6$, and the full R4 earns $1+2+3+4=10$. $1+1+6+10 = \mathbf{18}$.

- Citizens in Residential Zones will **generate votes**.

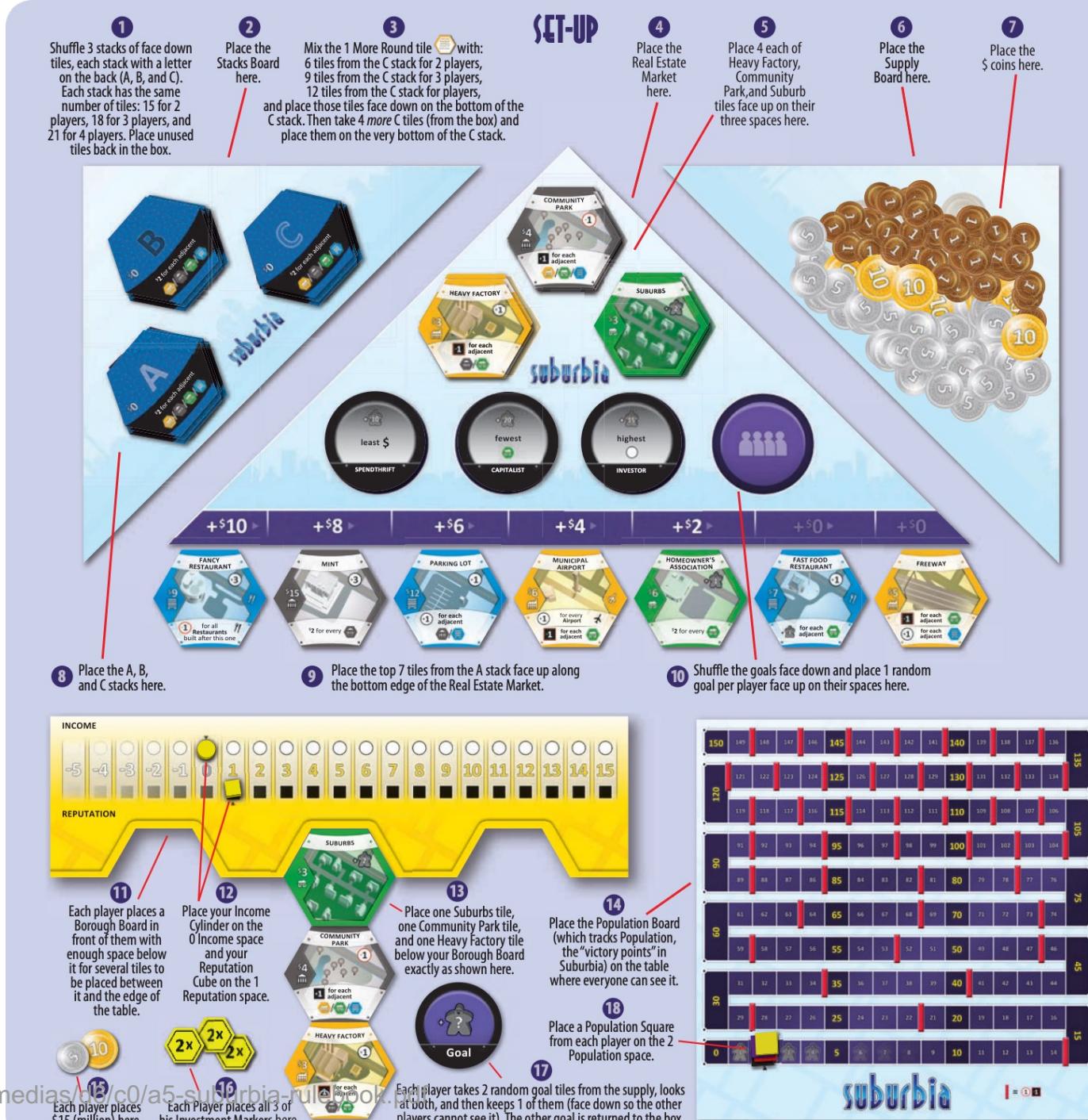


Suburbia

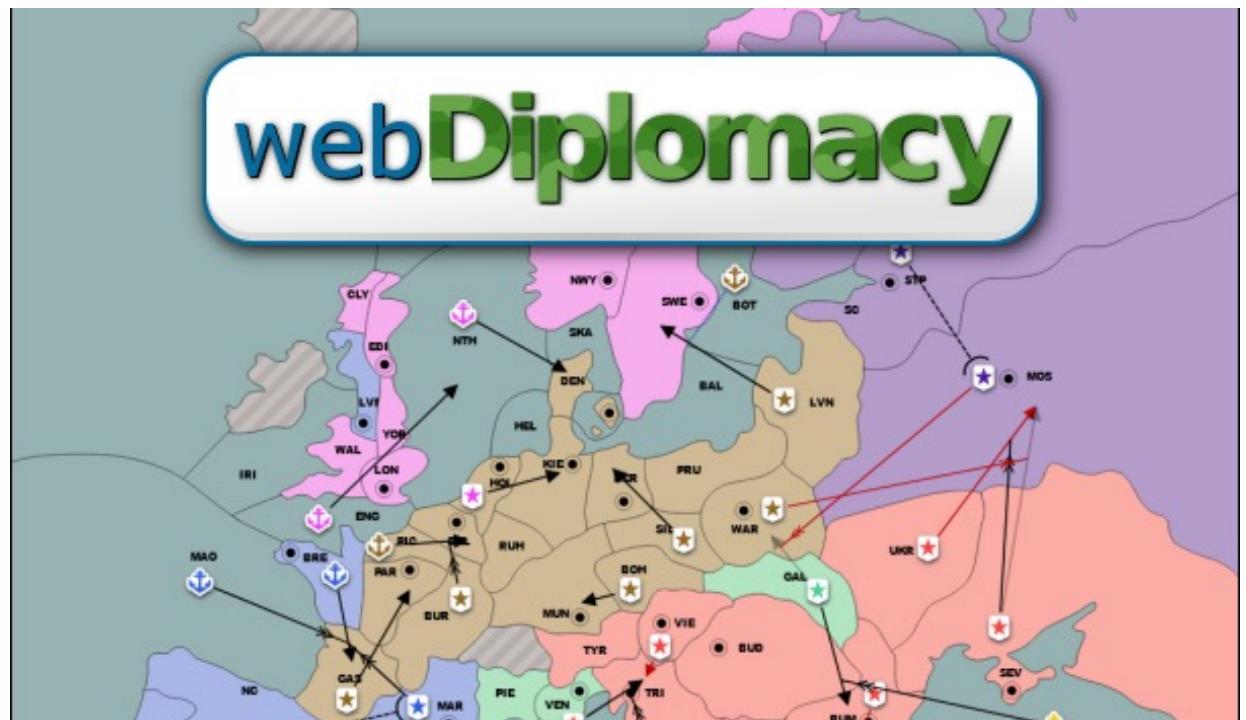
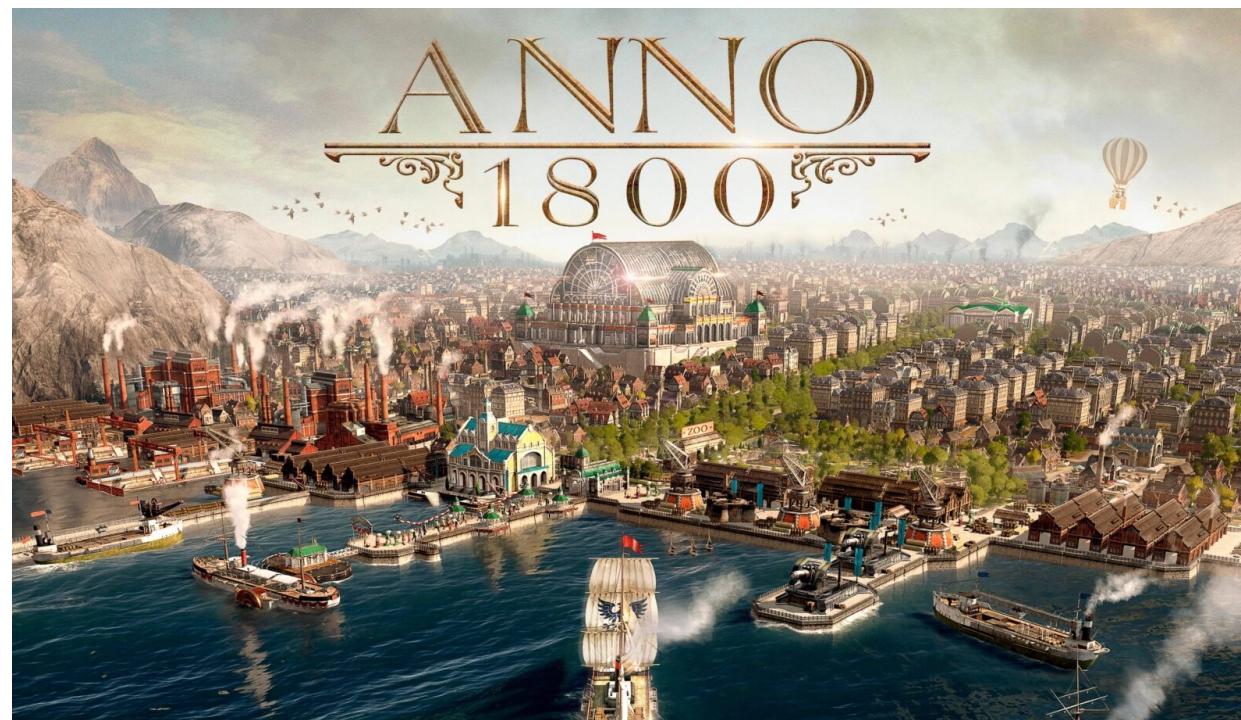




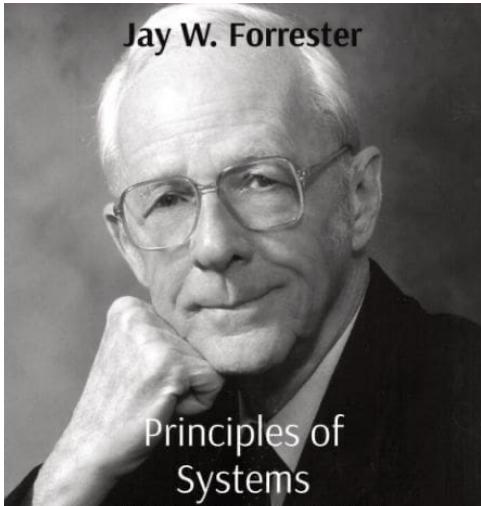




Overview of the following sessions:



Macro-scale: System Dynamics

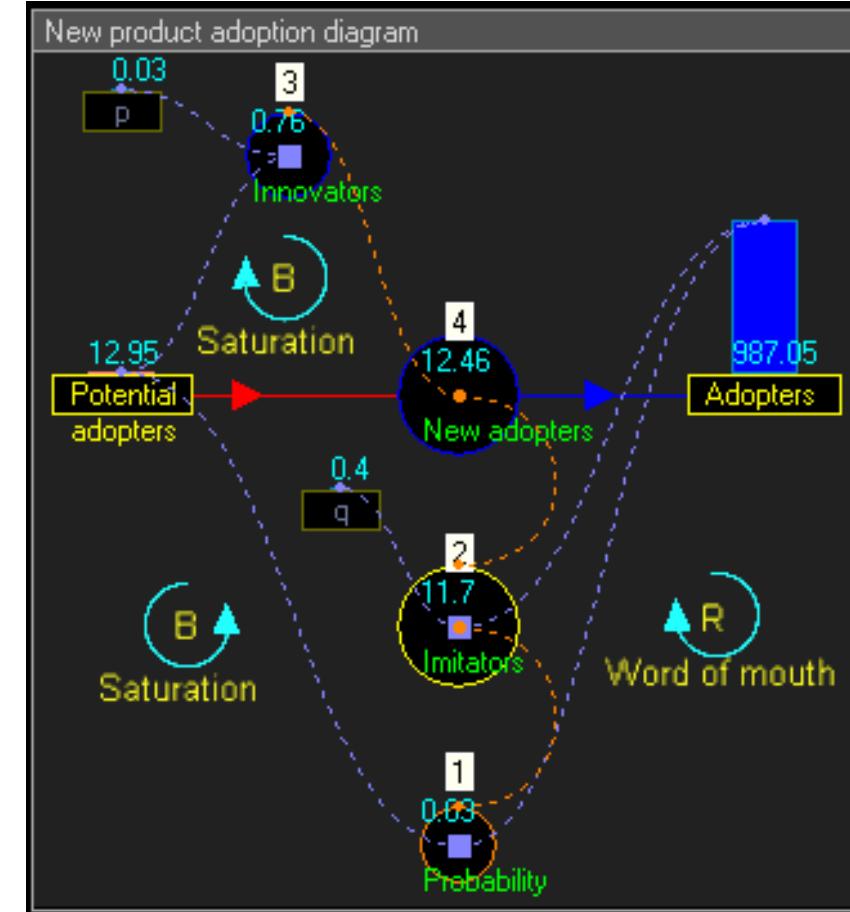


Introduce **System Dynamic Model** to Simulate:

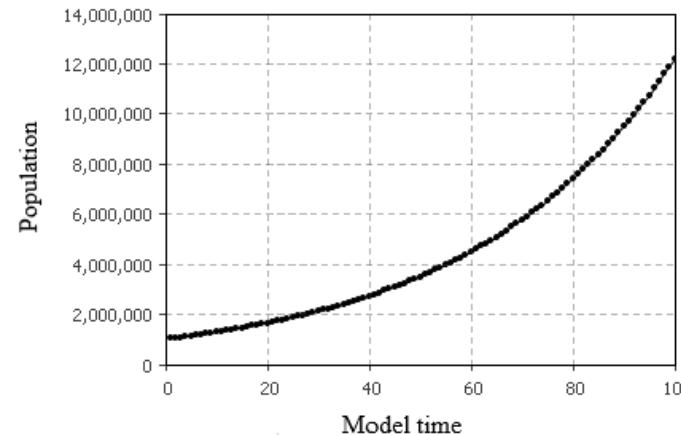
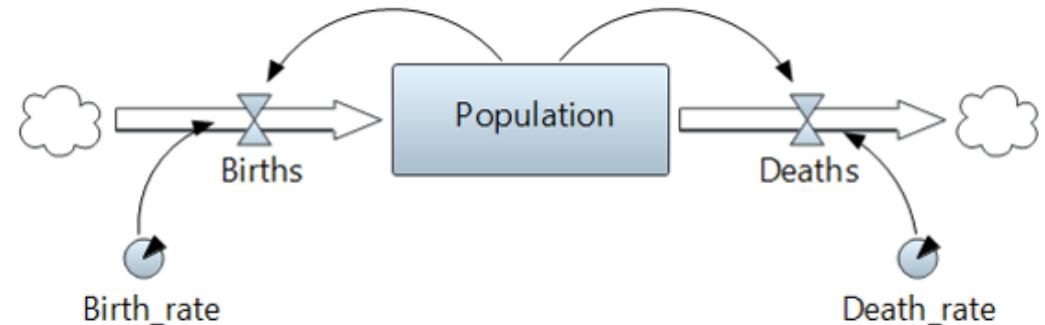
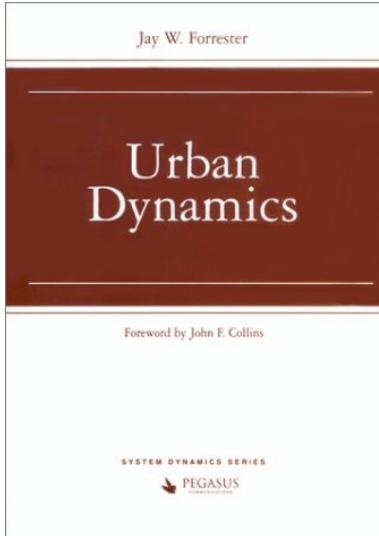
Population Change

Economical Cycles

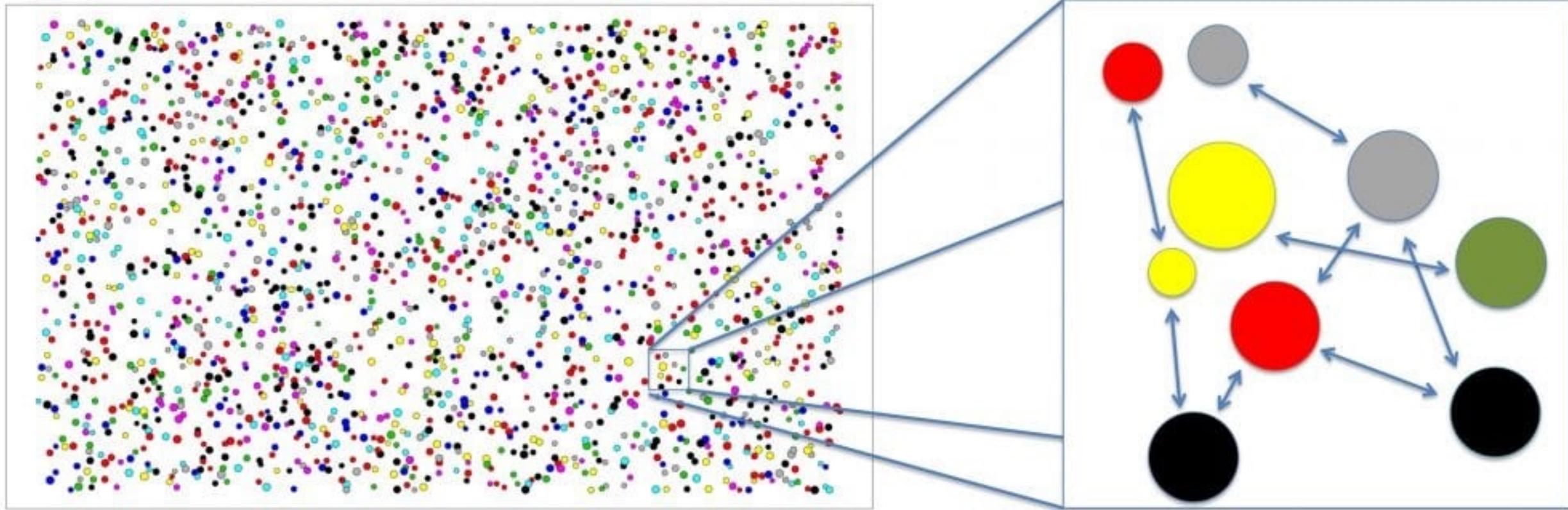
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Macro-scale: System Dynamics



Micro-scale: Agent-Based Models

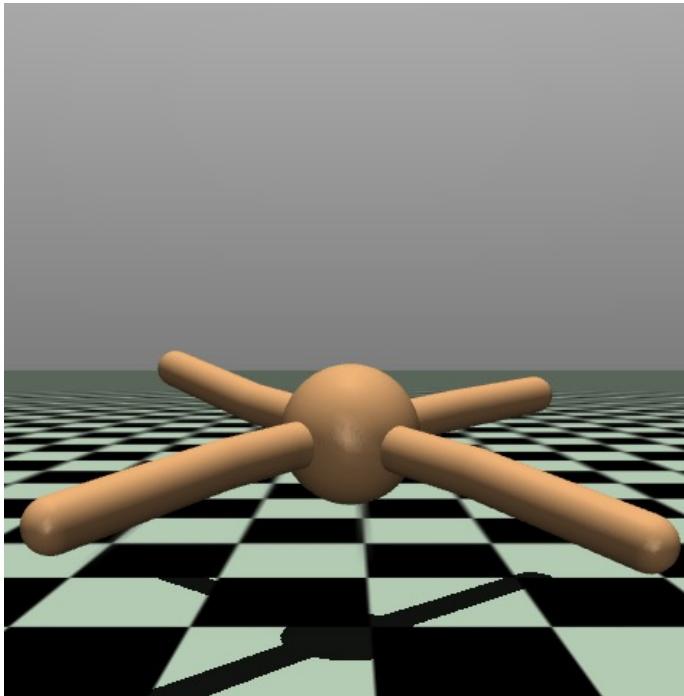


Micro-scale: Agent-Based Models Empowered by LLM



Introduction to Learning

Each leg is an “agent”



Collaborative or Competitive ?

Selfish or Altruistic ?

Hierarchical or Flat?

Workshop time!

Self Introduction

Play & Brainstorming a Game

Conclusions