



Deterministic vs Replicated AI:

The battlefield of For Honor

Xavier Guilbeault

Gameplay Tech Lead – Ubisoft MTL

Frederic Doll

AI Programmer – Ubisoft MTL



MELEE FIGHTING GAME



COMPETITIVE MULTIPLAYER



BELIEVABLE BATTLEFIELD



DETERMINISTIC

VS



REPLICATED

OVERVIEW

FUNDAMENTALS

DETERMINISTIC AI

REPLICATED AI

TAKEAWAYS



A knight in full plate armor, including a helmet with a visor, is shown from the chest up. He holds a longsword diagonally across the frame. The background is a dark, stormy sky with swirling clouds and a few distant lights. The overall tone is dramatic and epic.

FUNDAMENTALS

FUNDAMENTALS

Character diversity



FUNDAMENTALS |

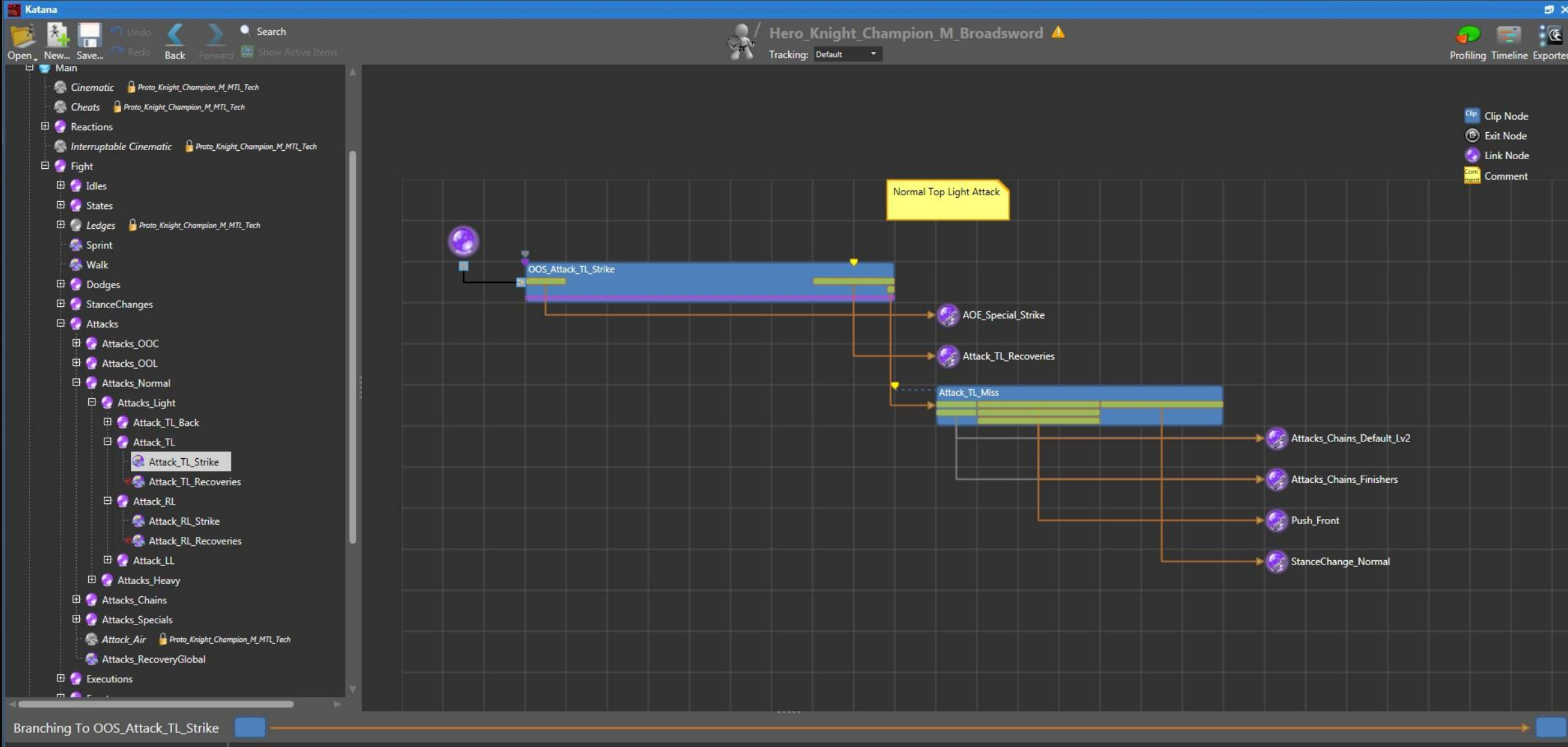
Input driven

Reflect gamepad

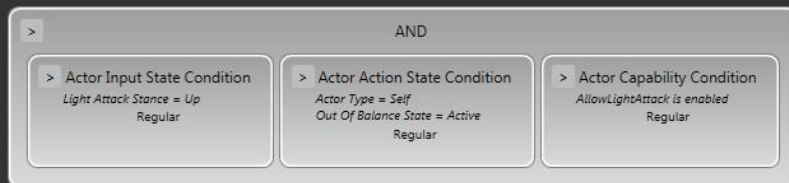
Indirect control

Input Driven AI



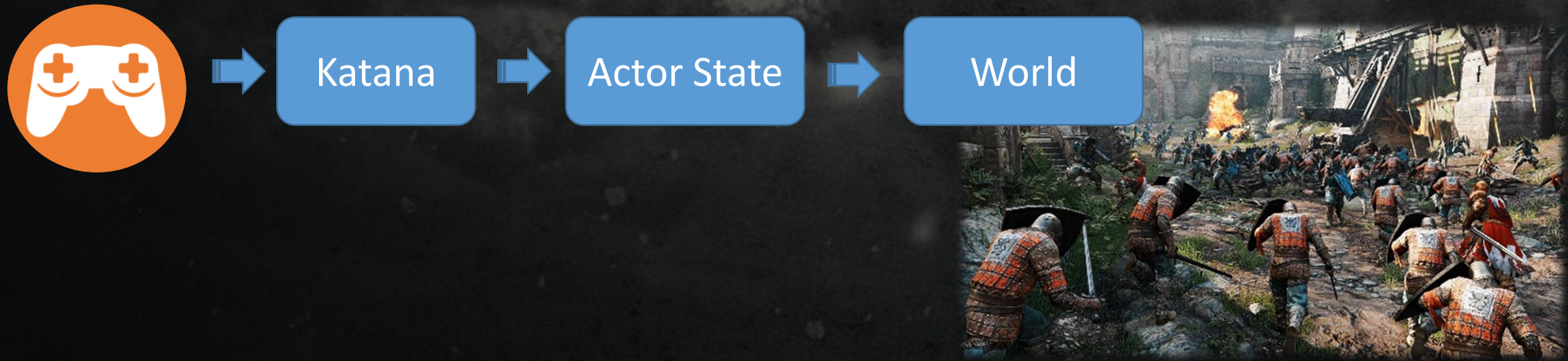


KATANA



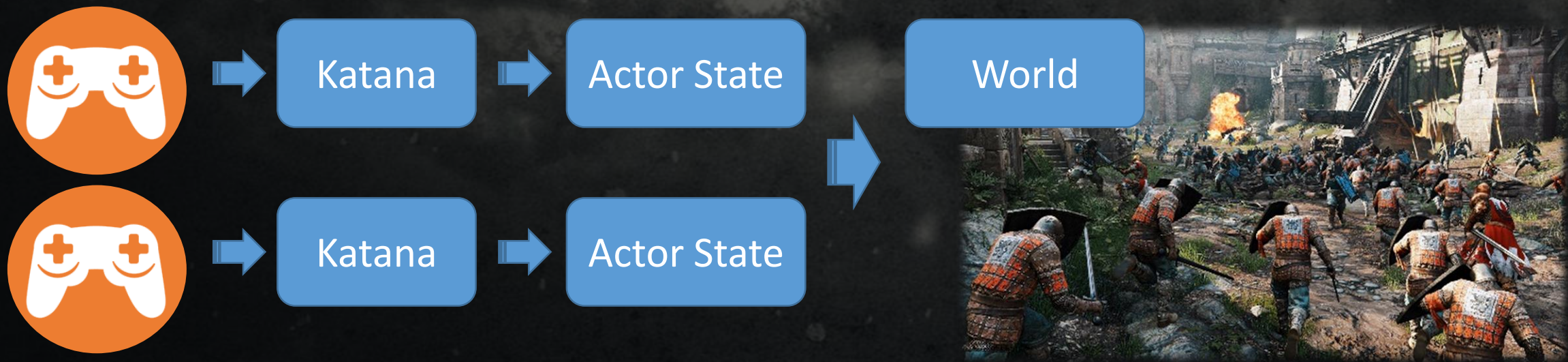
FUNDAMENTALS

Update Loop



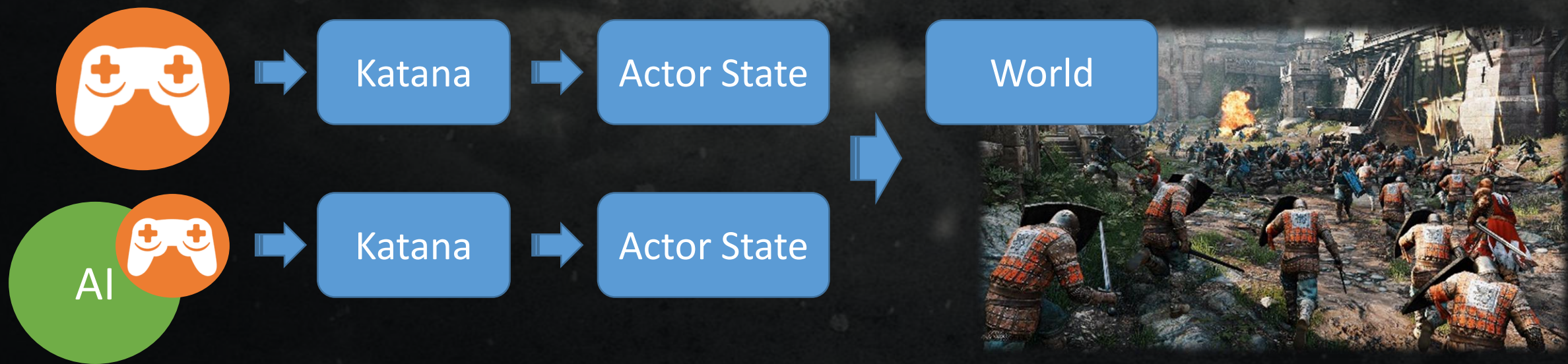
FUNDAMENTALS

Update Loop



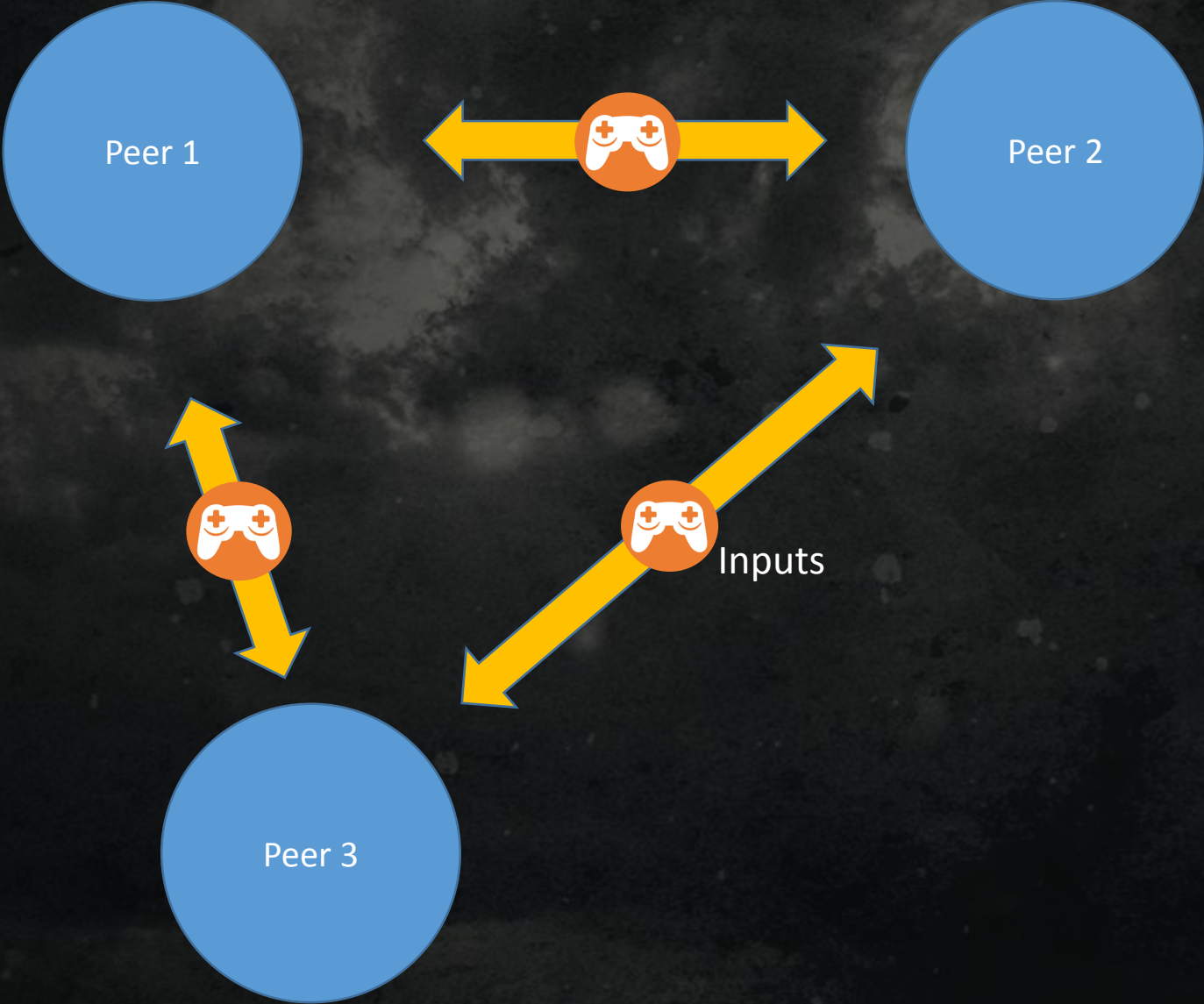
FUNDAMENTALS

Update Loop



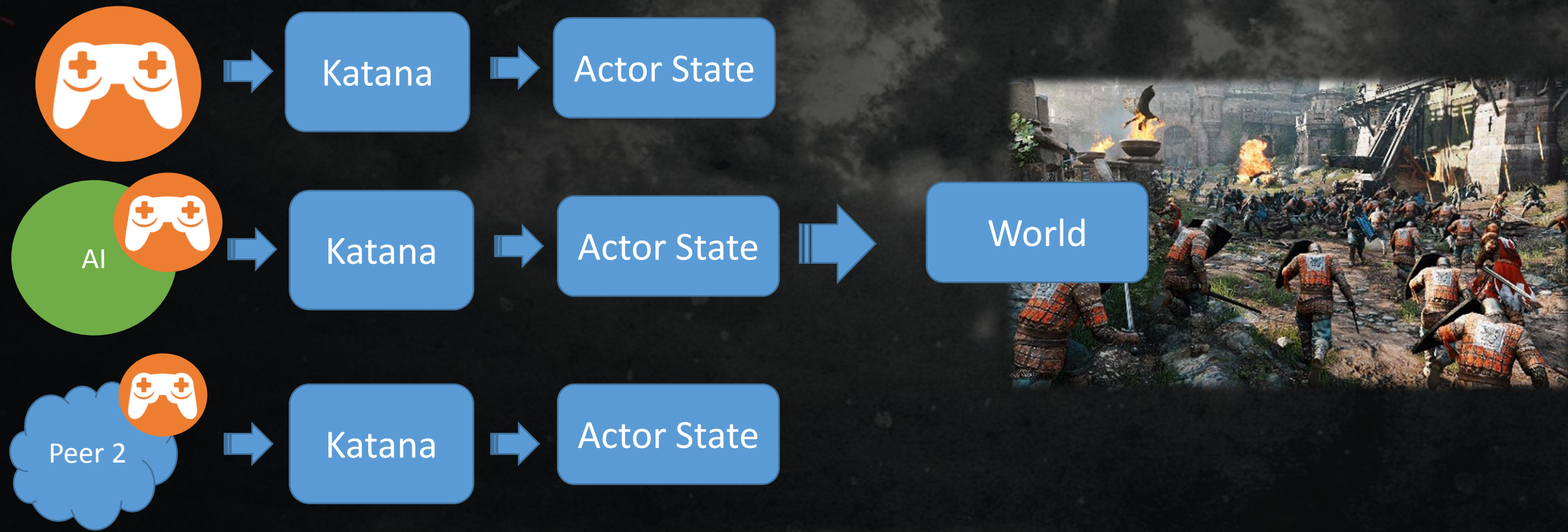
FUNDAMENTALS

Peer to Peer



FUNDAMENTALS

Update Loop



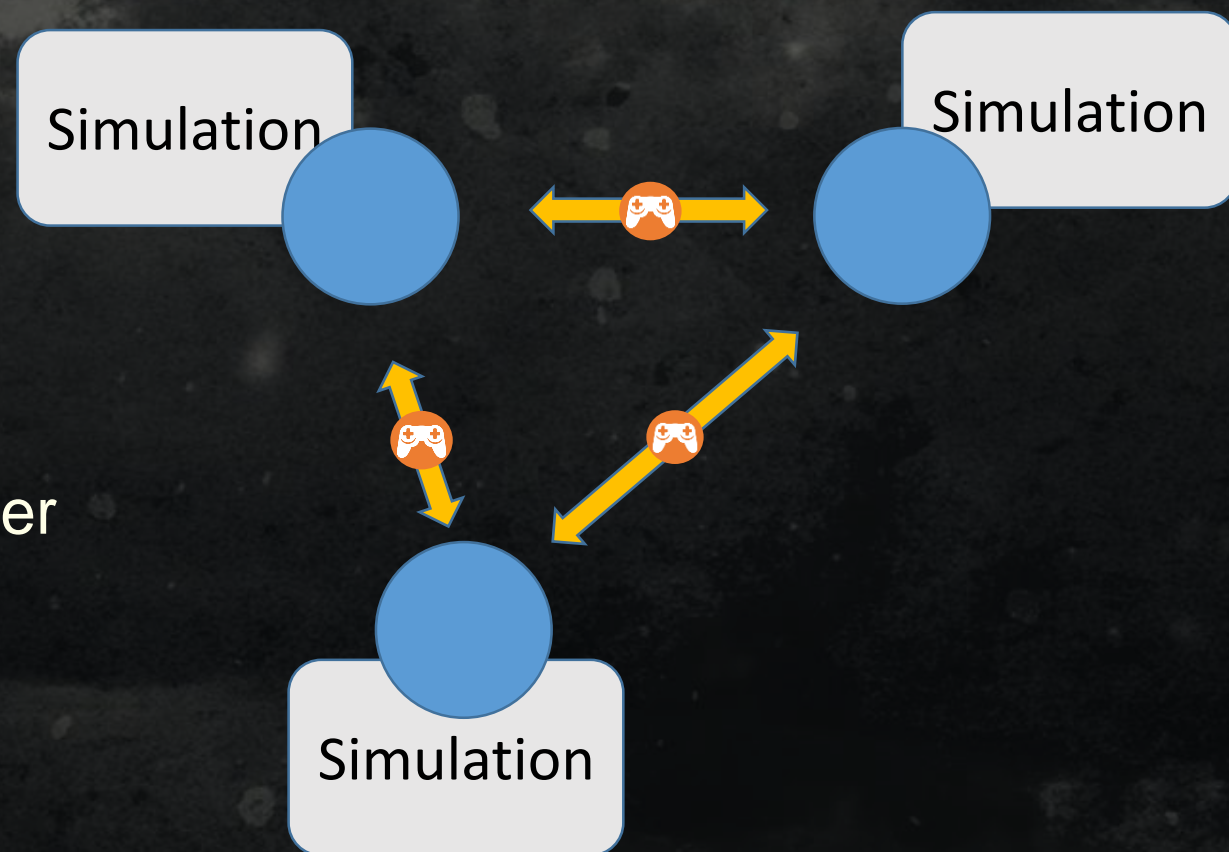
FUNDAMENTALS

LAG... ?

Our solution: a **deterministic simulation**

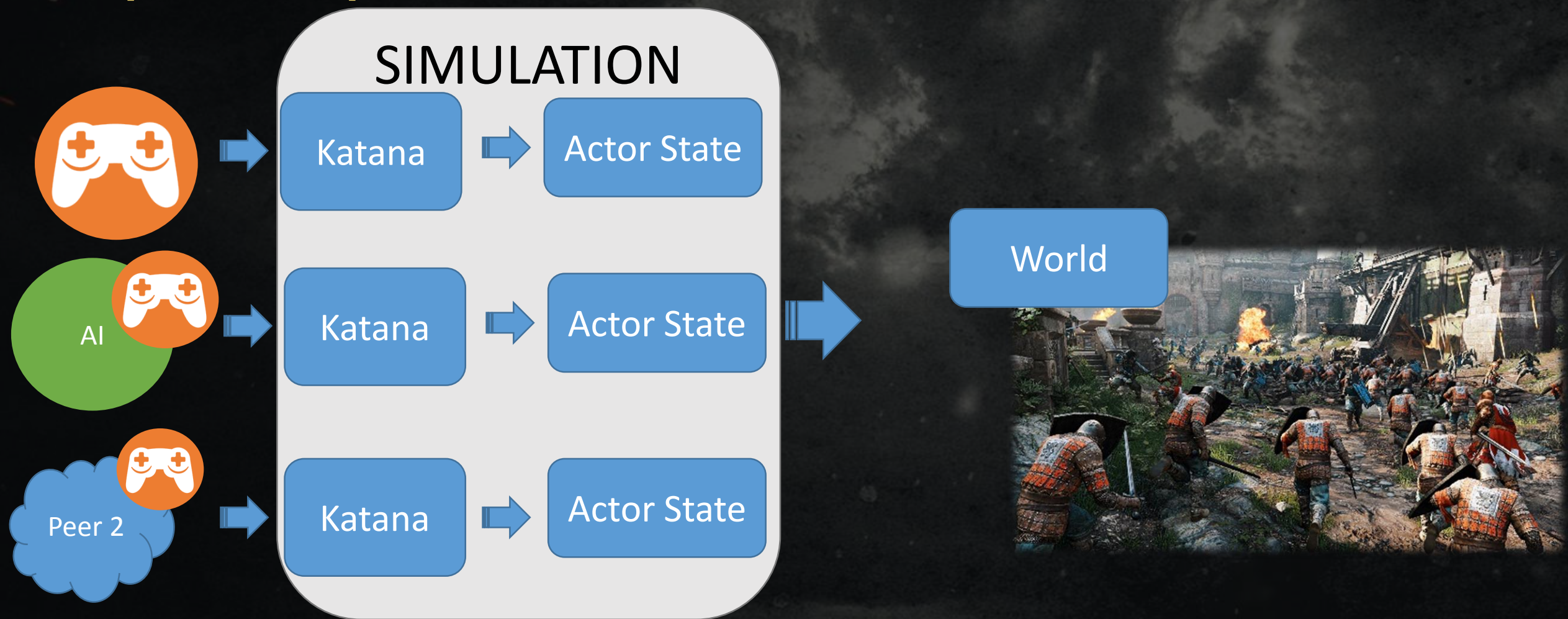
Timestamped Inputs

Deterministic Simulation on each peer



FUNDAMENTALS

Update Loop



FUNDAMENTALS

0



FUNDAMENTALS

1



T0 – P1
Attack



Frame

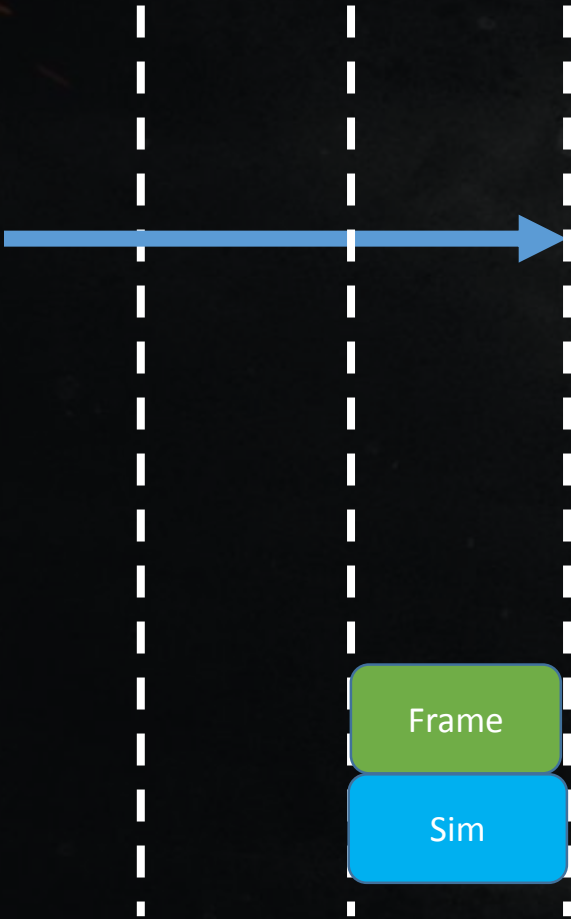
Sim



FUNDAMENTALS

1

2



FUNDAMENTALS

1 2 3



FUNDAMENTALS

1

2

3

4



T0 – P2
Change
stance



Frame



FUNDAMENTALS

1

2

3

4



T0 – P2
Change
stance



Frame

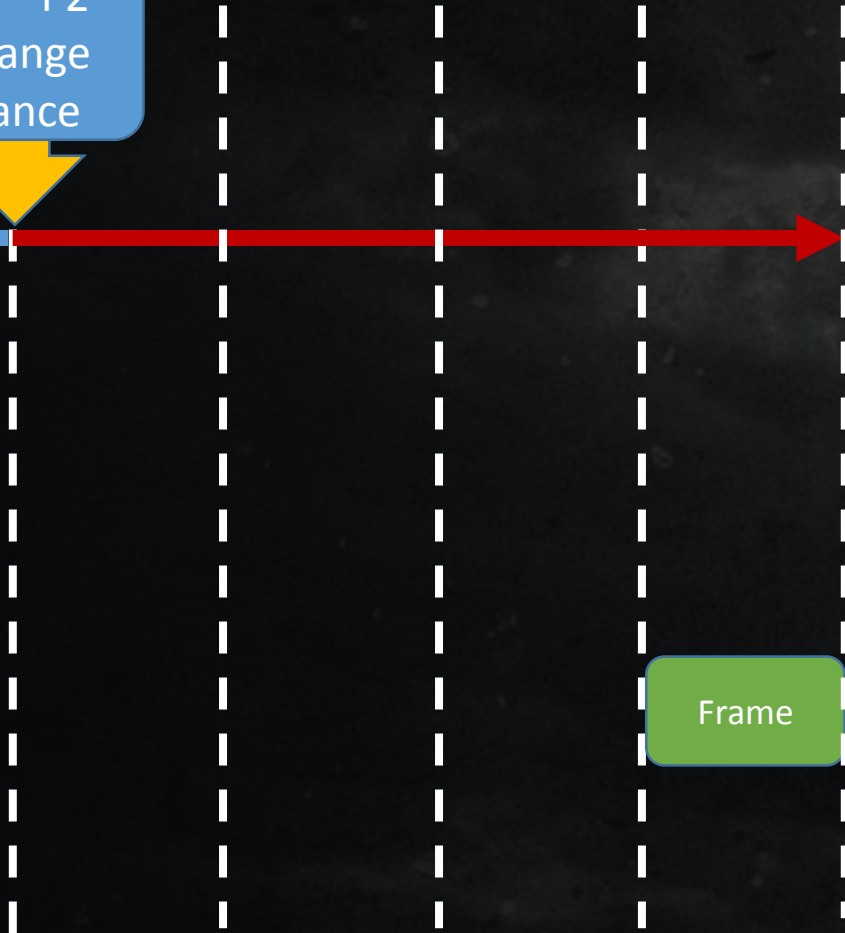
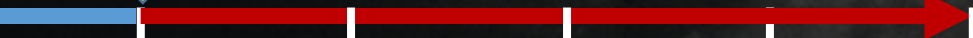


FUNDAMENTALS

1 2 3 4



T0 – P2
Change
stance



Frame

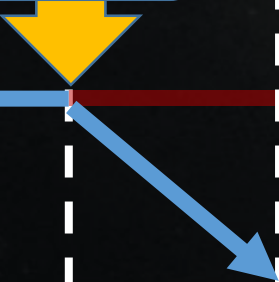


FUNDAMENTALS

1 2 3 4



T0 – P2
Change
stance



Frame

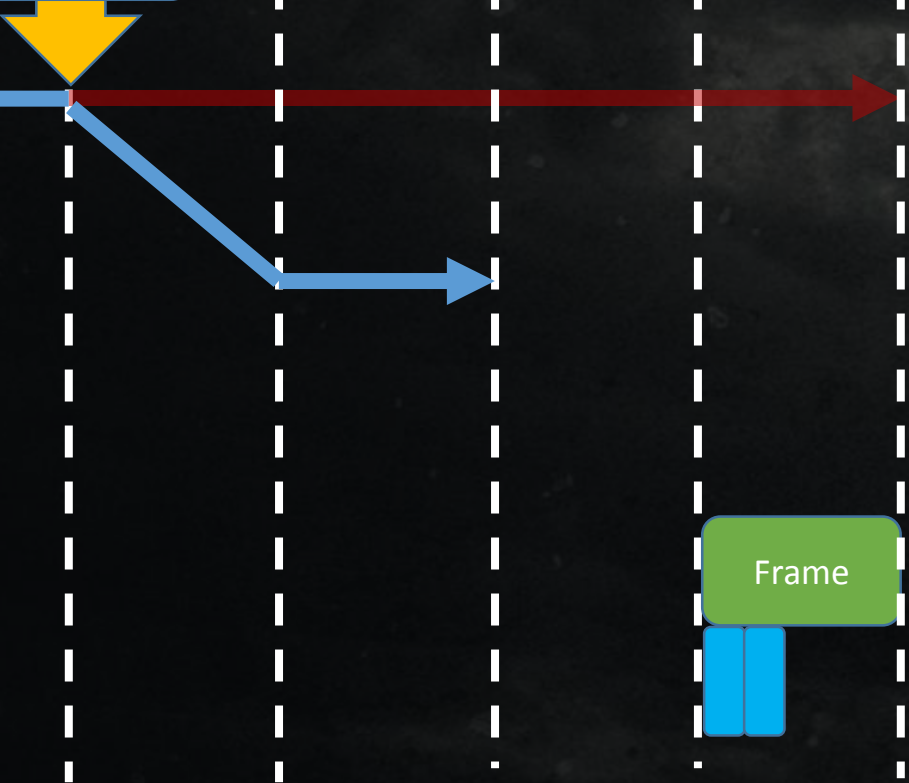


FUNDAMENTALS

1 2 3 4



T0 – P2
Change
stance

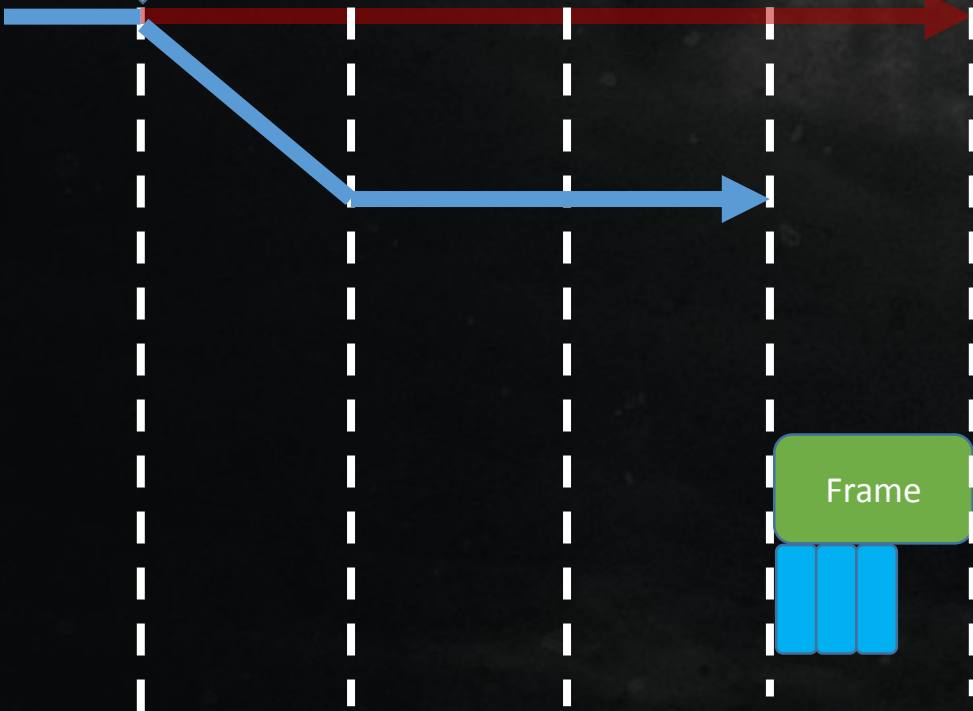


FUNDAMENTALS

1 2 3 4



T0 – P2
Change
stance

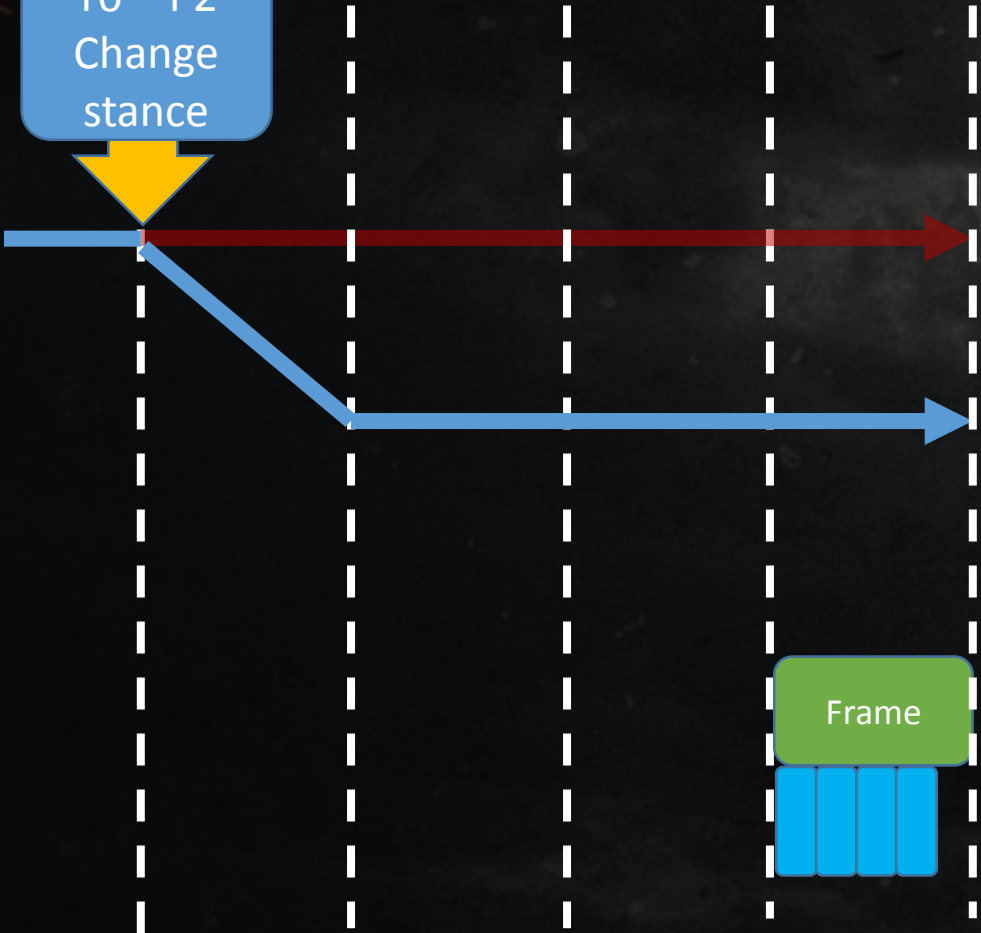


FUNDAMENTALS

1 2 3 4

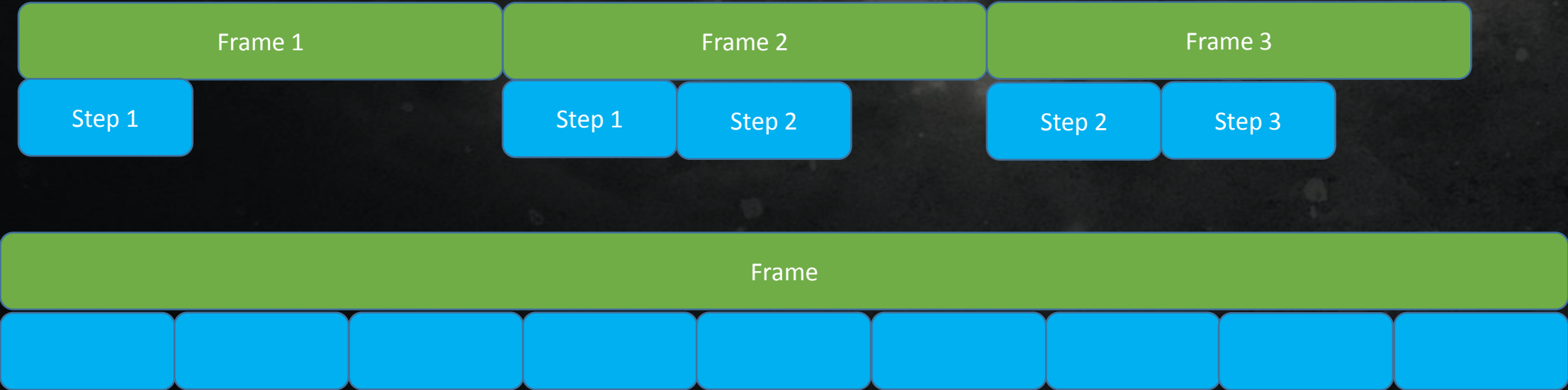


T0 – P2
Change
stance



FUNDAMENTALS |

Frame vs Simulation Step



FUNDAMENTALS |

Rewind Frequency

they happen **all the time**

Normal operation 100 ms delay
3 steps

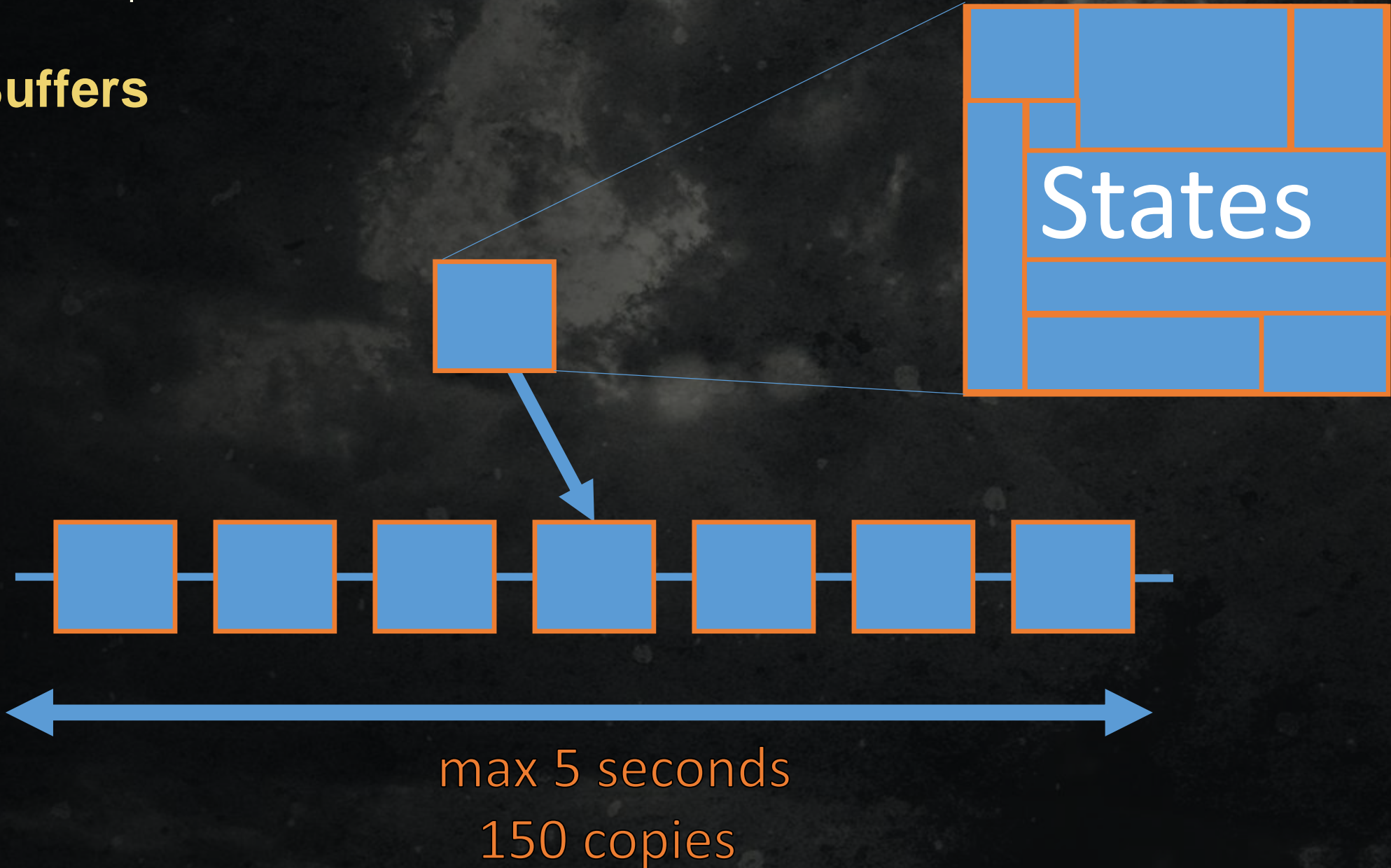


Peeks up to 300 ms delay
9 steps

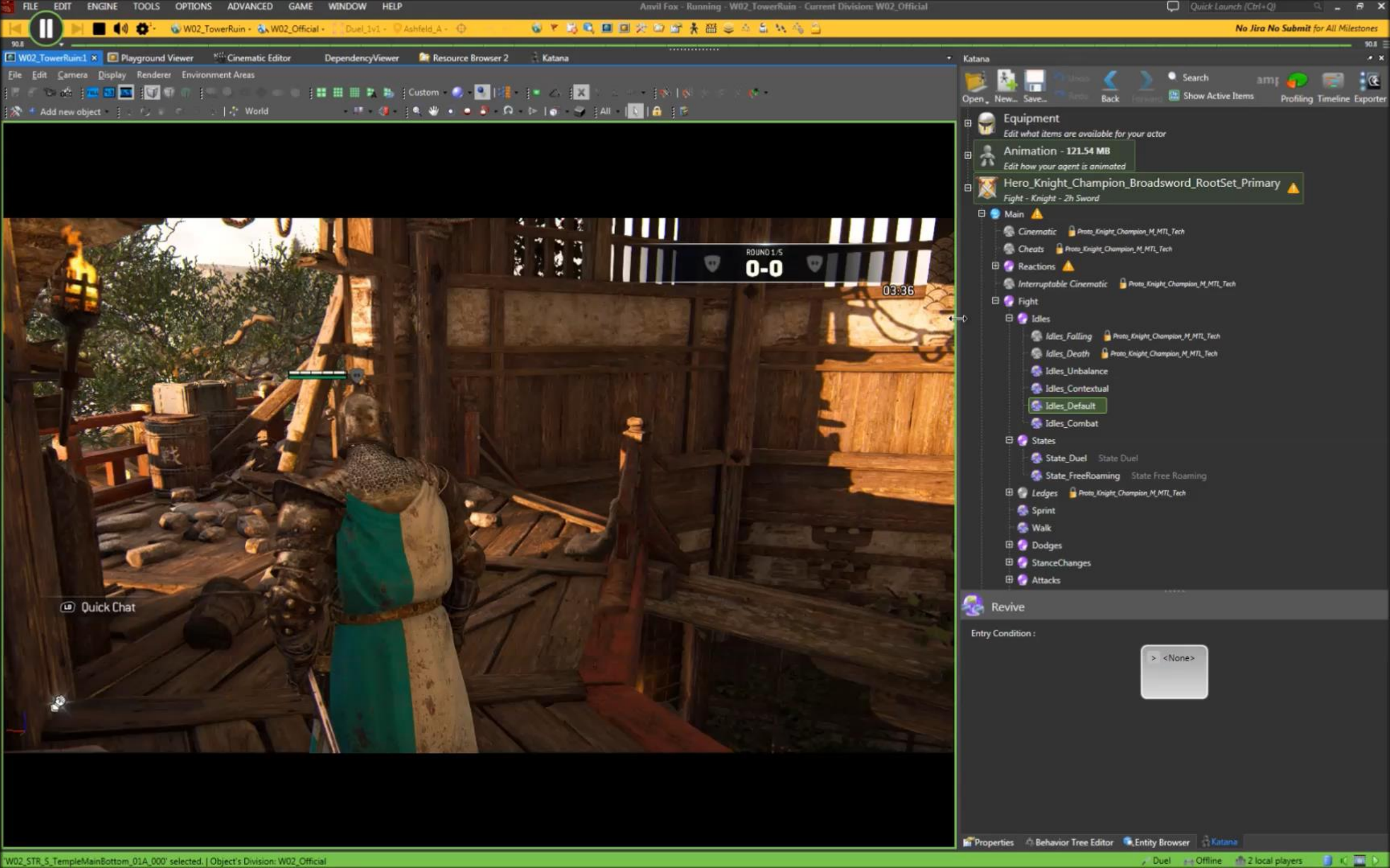


FUNDAMENTALS

History Buffers









DETERMINISTIC AI

DETERMINISTIC AI |

The Believable Medieval Battlefield



DETERMINISTIC AI

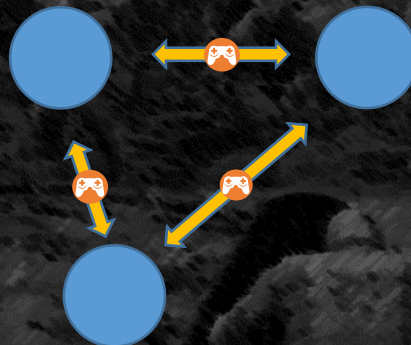
The Believable Medieval Battlefield



40 Bytes



~200
actors



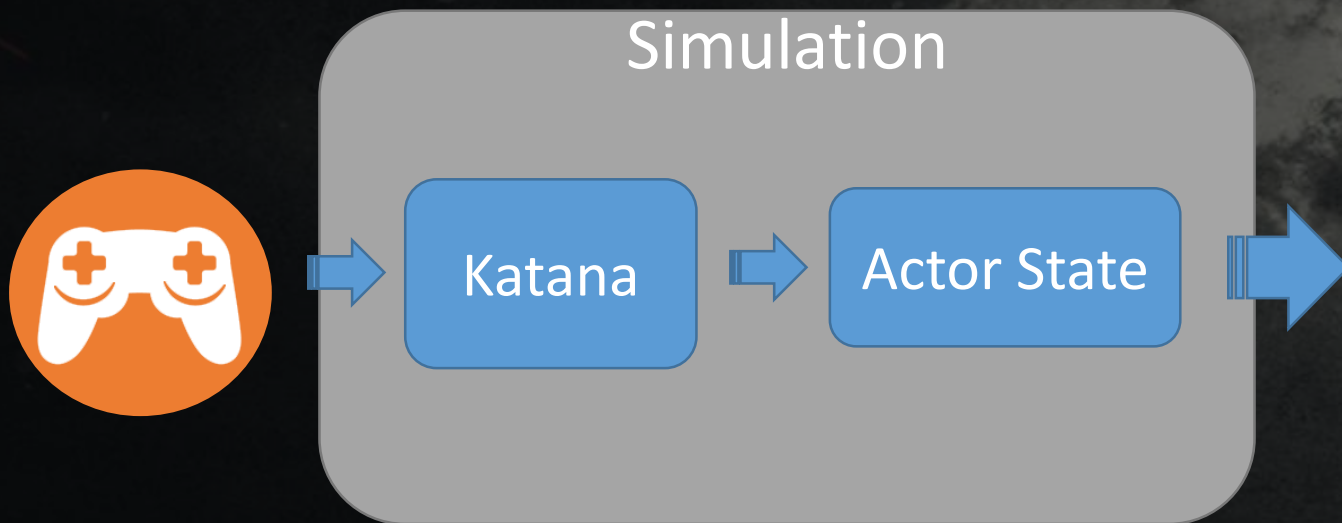
7 peers



1.6 MB/s of upload

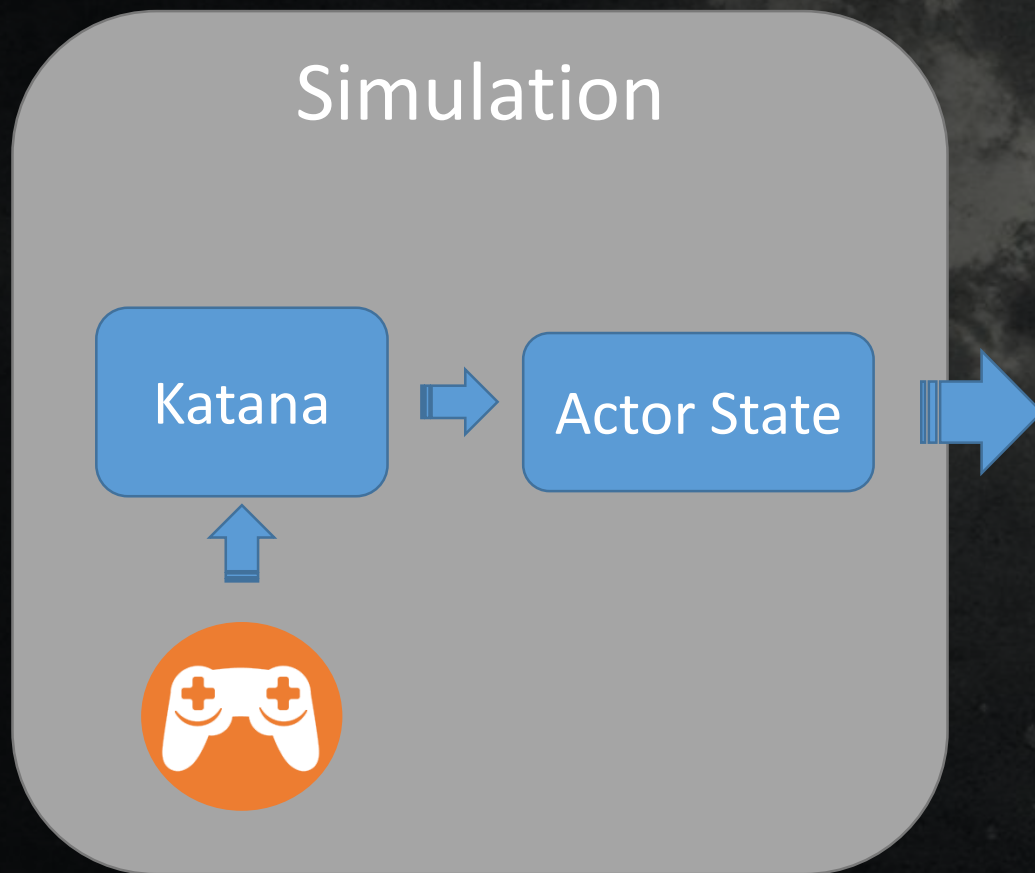
DETERMINISTIC AI

Update Loop



DETERMINISTIC AI

Update Loop



The Deterministic AI!

DETERMINISTIC AI

Implications

No network traffic

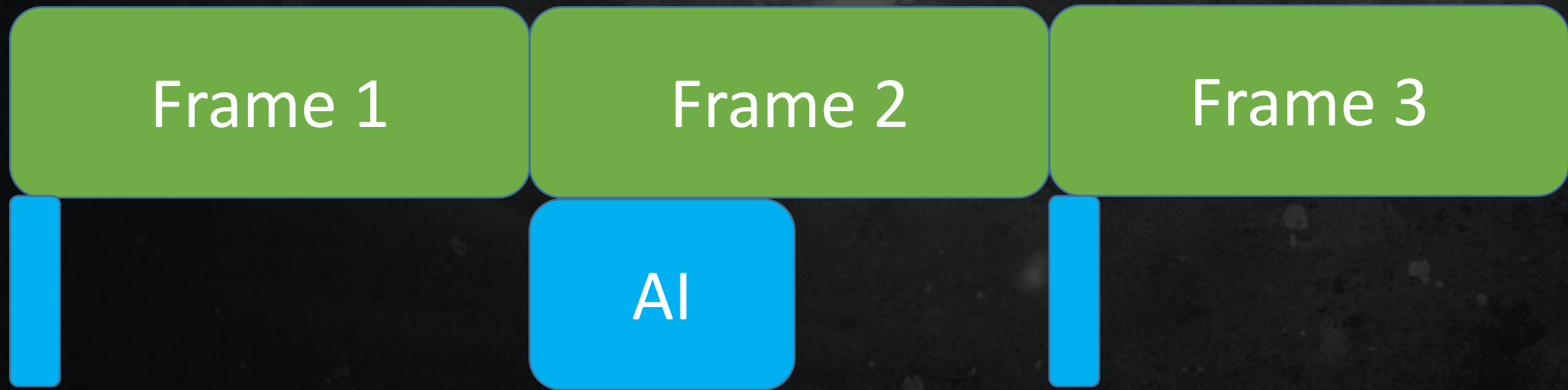


Must use as little CPU as possible



DETERMINISTIC AI

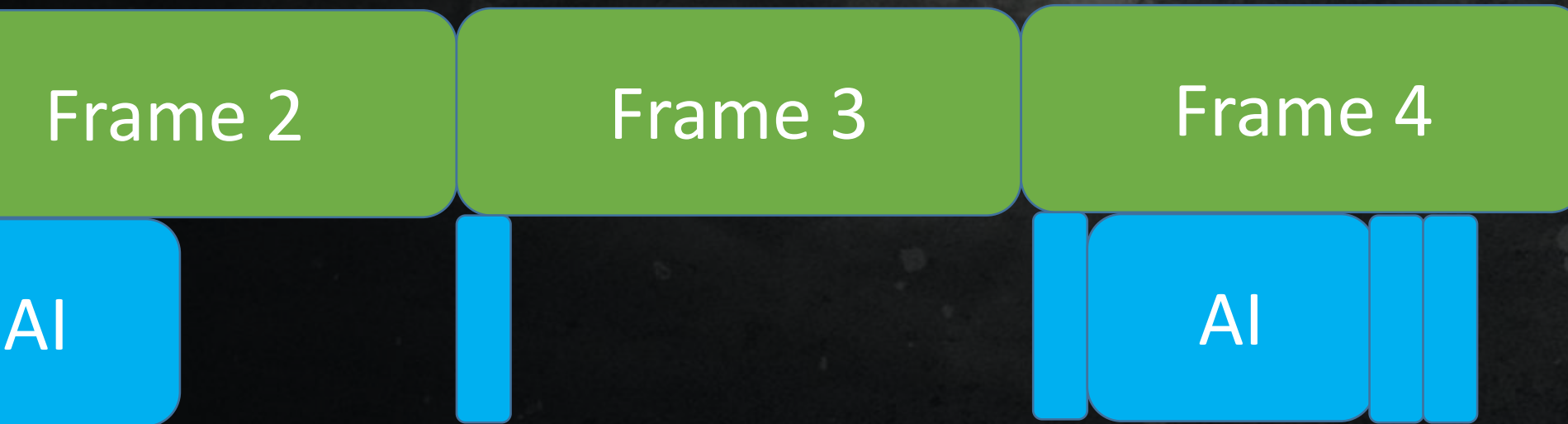
Step 1 : Time slicing



DETERMINISTIC AI

Step 1 : Time slicing

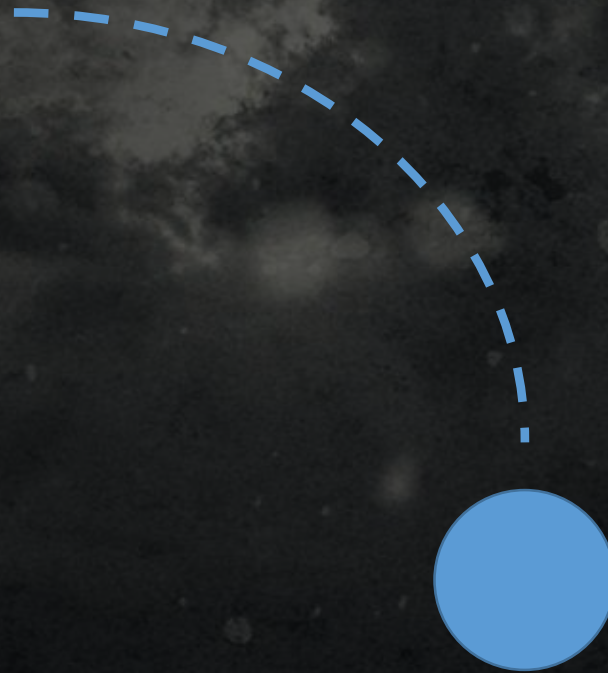
One update every **300 ms** (~3 Hz)



Allows us to be resilient to rewinds

DETERMINISTIC AI |

Step 2 : Simplified physics





Blue Shield Icon	0	Blue Bar
Orange Shield Icon	0	Orange Bar

19:55

B
100
pts

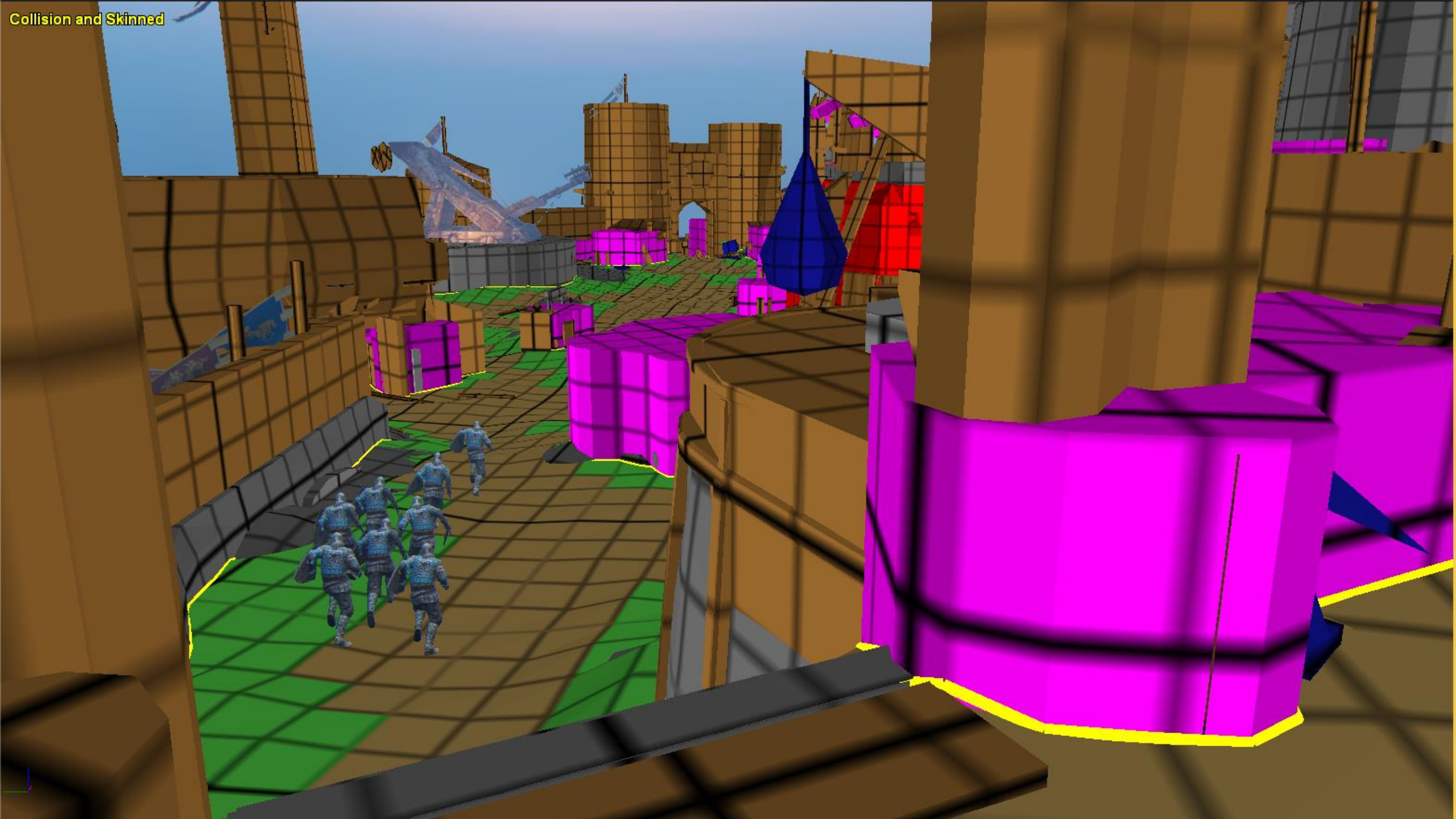
C

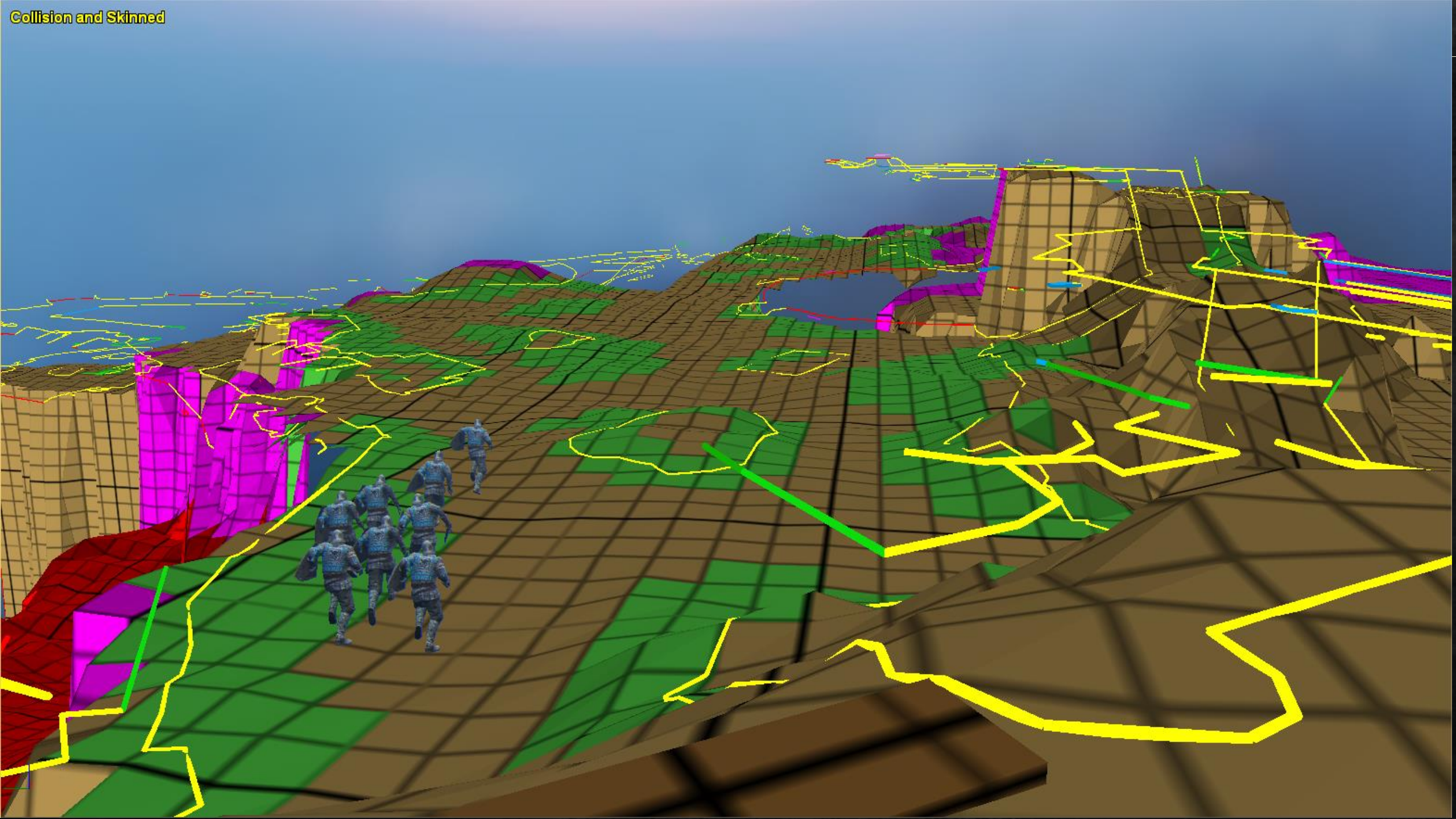
A

LB Quick Chat

🔒 🔒 🔒 🔒







DETERMINISTIC AI |

Step 3 : Navigation

No NavMesh pathfinding

NavMesh history buffers would have been too expensive in memory

CPU concerns for all those requests



NavFlows

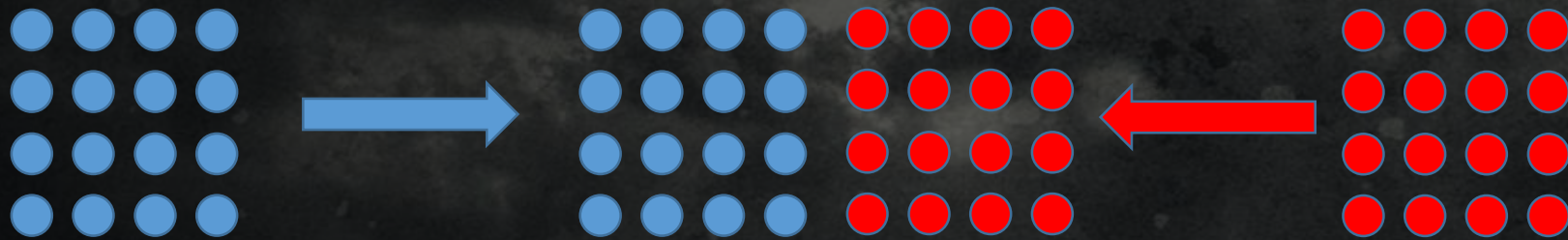




DETERMINISTIC AI |

Navigation – Group Behavior

Full synchronization, squads with defined position, etc.

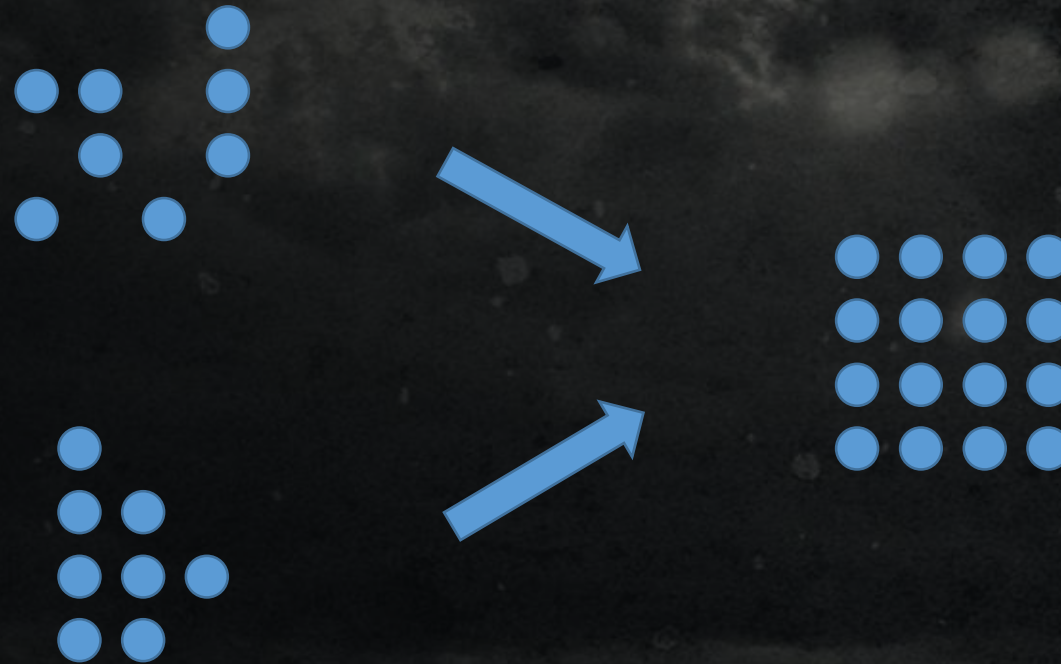


felt extremely fake / not very enjoyable for players

DETERMINISTIC AI |

Navigation – Group Behavior

the Merge Problem



DETERMINISTIC AI |

Navigation – Group Behavior

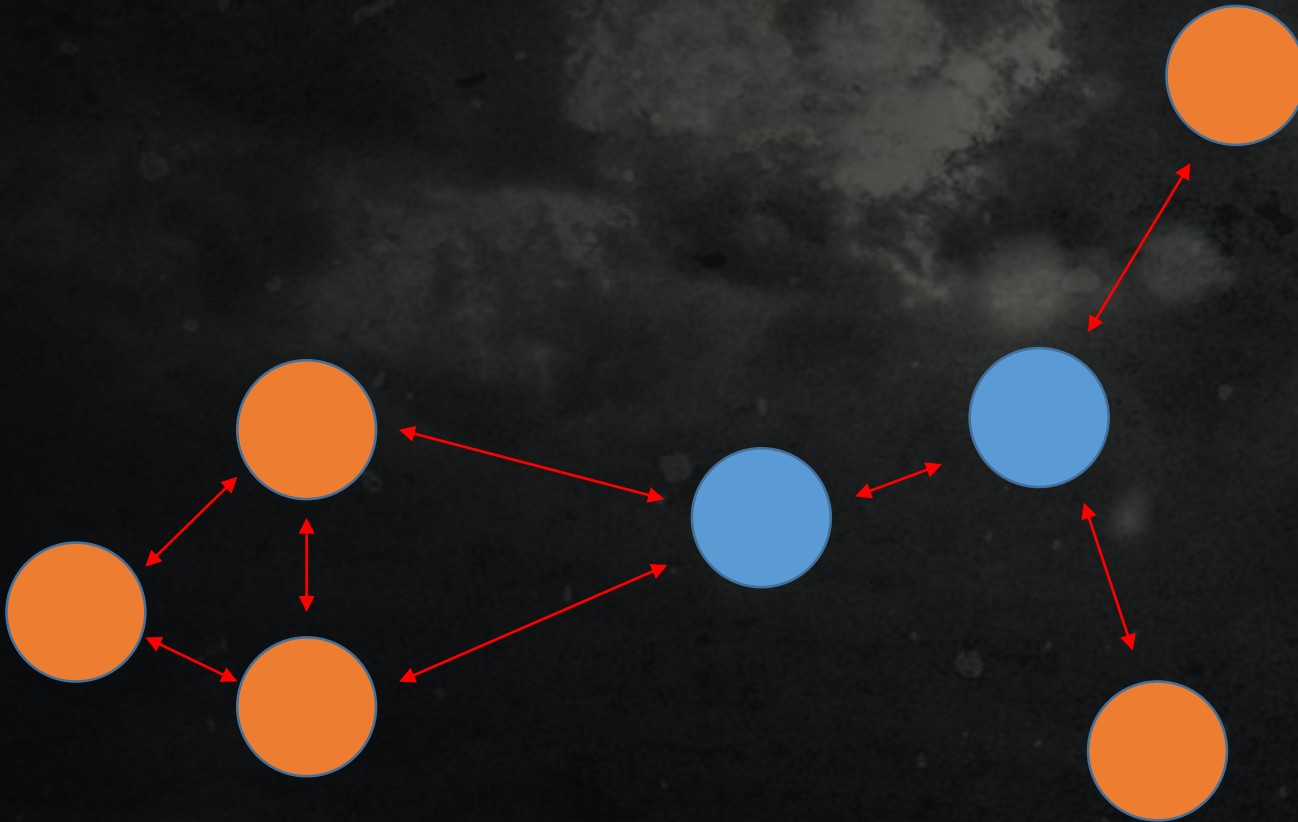
Our Solution : Flocking (++)



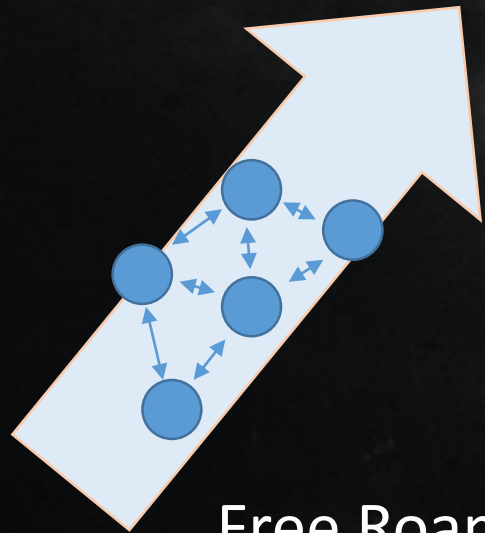
Easy to understand for players
Simple and elegant

DETERMINISTIC AI |

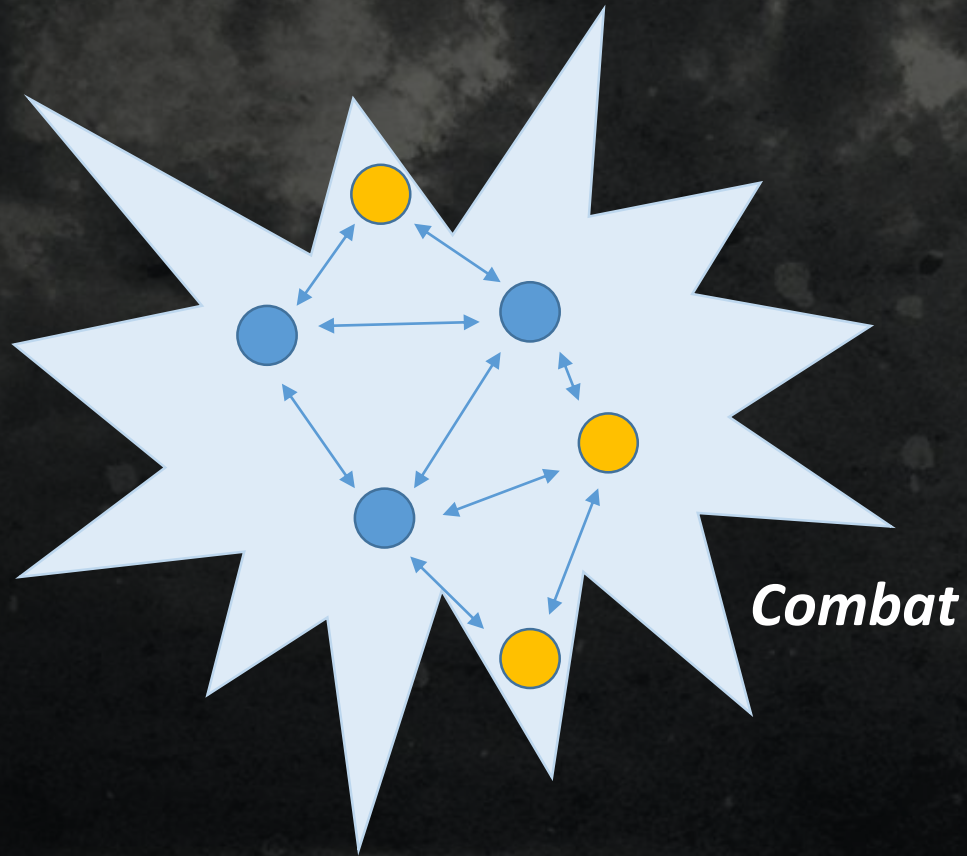
Navigation Rule 1 – Distance from Actor X



Navigation Rule 13 – Combat State

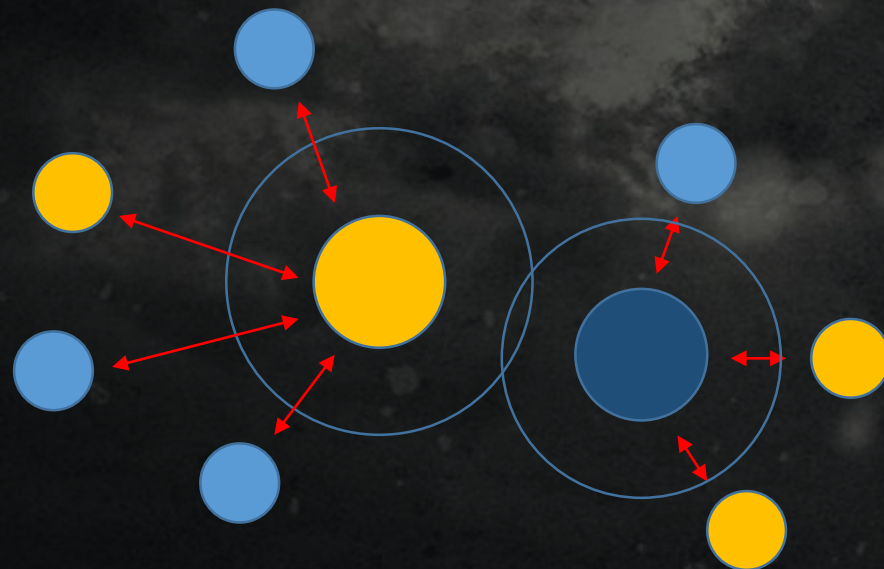


Free Roaming



Combat

Navigation Rule 42 – Player Actions



Navigation Rule 42 – Player Actions



DETERMINISTIC AI |

Navigation Rule 73 – Moses effect



Navigation Rule 73 – Moses effect



DETERMINISTIC AI |

Navigation tweaking

Let designers tweak all those values...!



DETERMINISTIC AI |

Navigation tweaking

**“One does not just mess with the lane...
It has a mind of it's own.”**

-Bio Jade Adam-Granger

DETERMINISTIC AI

Navigation tweaking Presets

Compact



Normal



Scattered





DETERMINISTIC AI |

Scattered



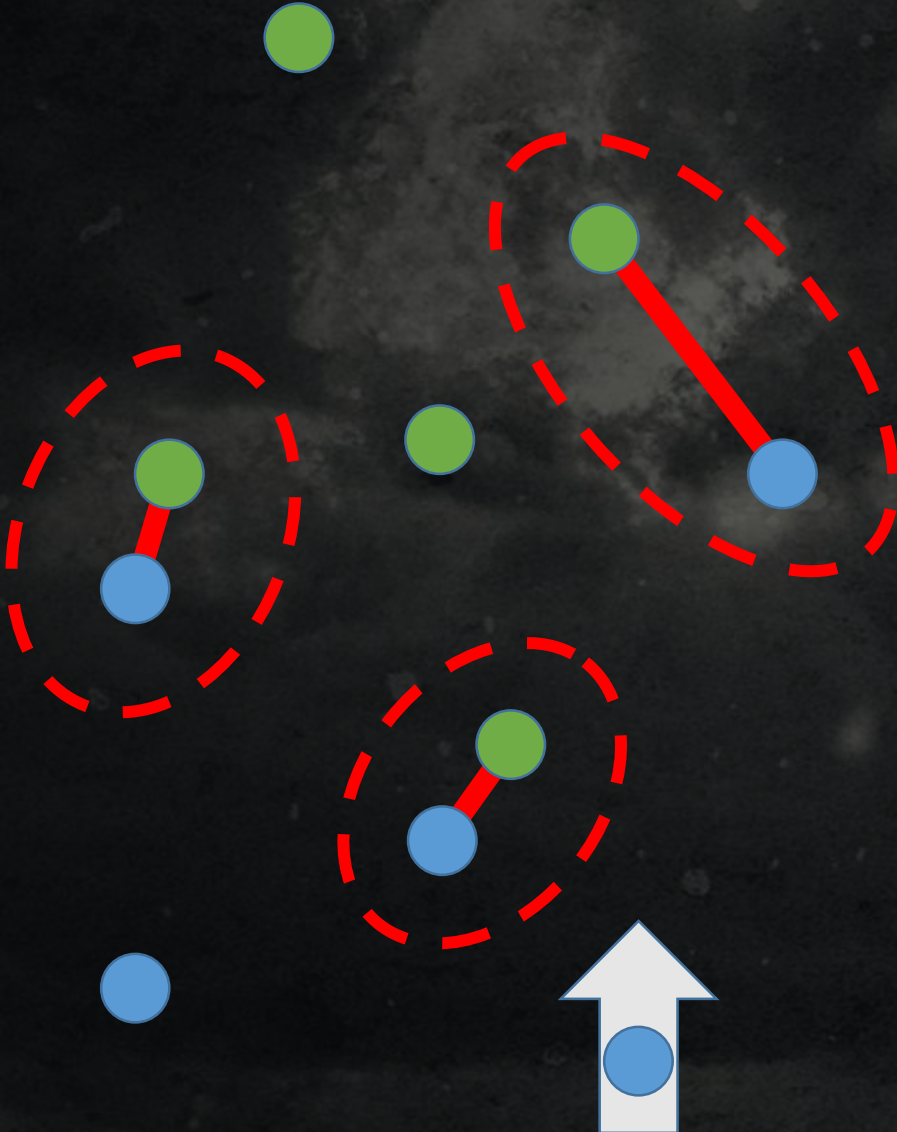
DETERMINISTIC AI |



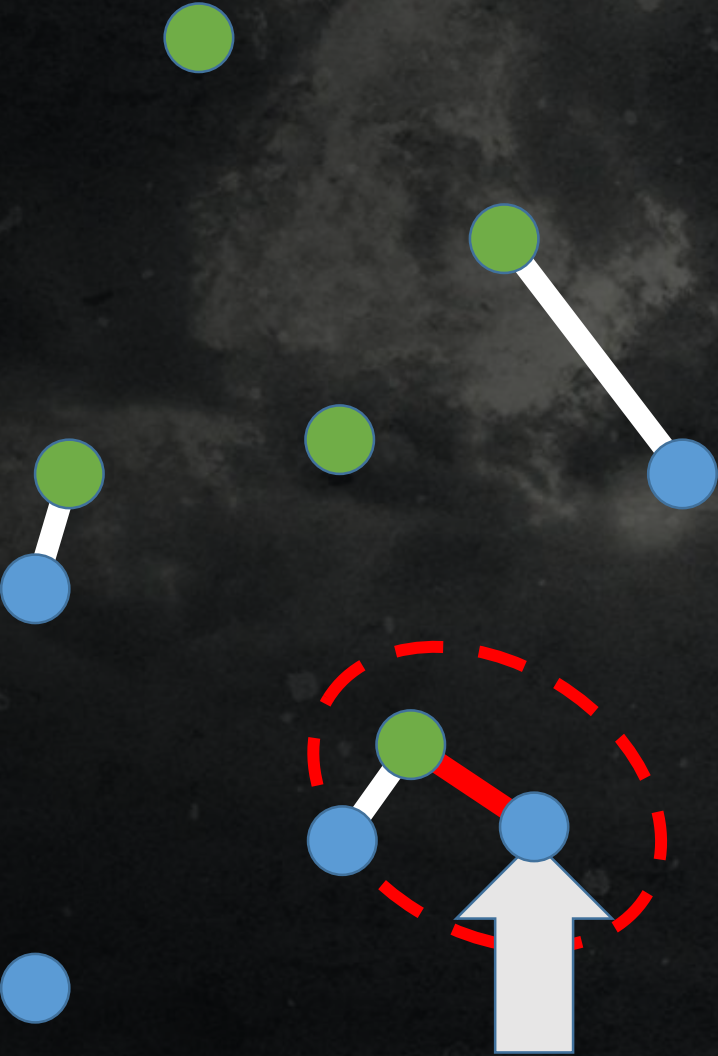
DETERMINISTIC AI



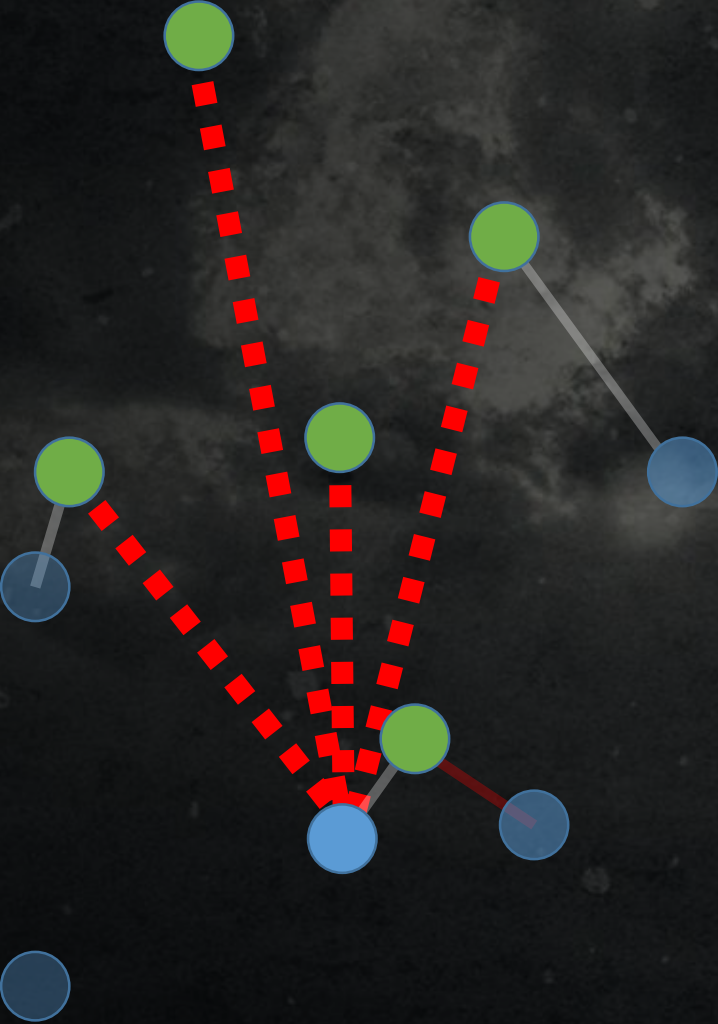
DETERMINISTIC AI



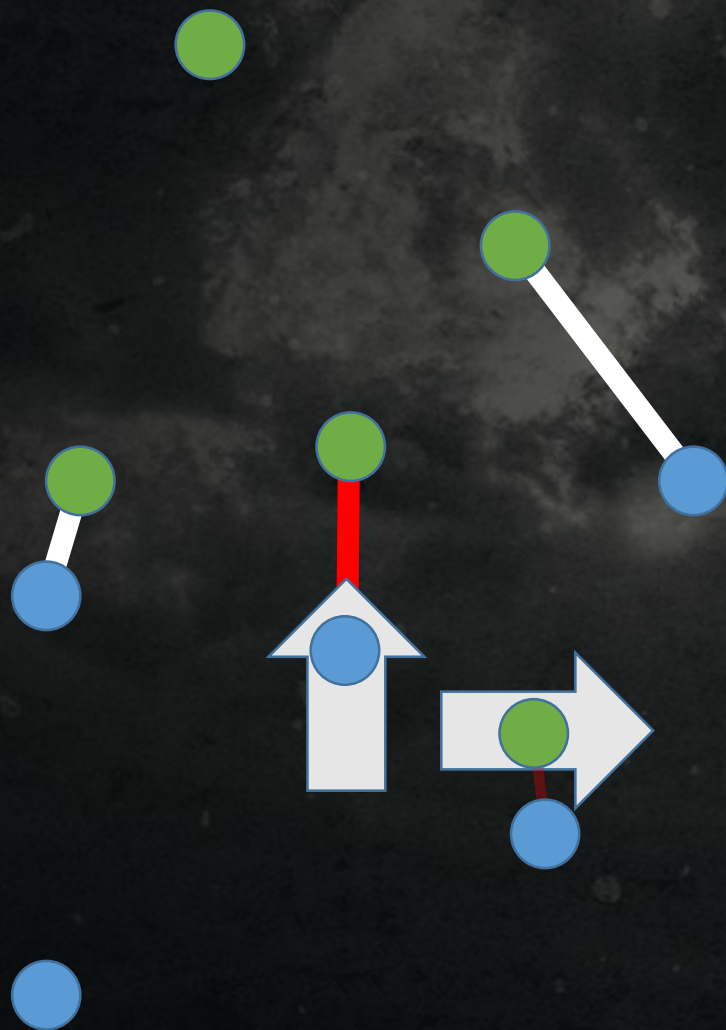
DETERMINISTIC AI



DETERMINISTIC AI



DETERMINISTIC AI





0
0

11:14

Quick Chat

Four locked icons (padlocks)



DETERMINISTIC AI |

Making them fight




ROUND 1/5

0-0

04:01

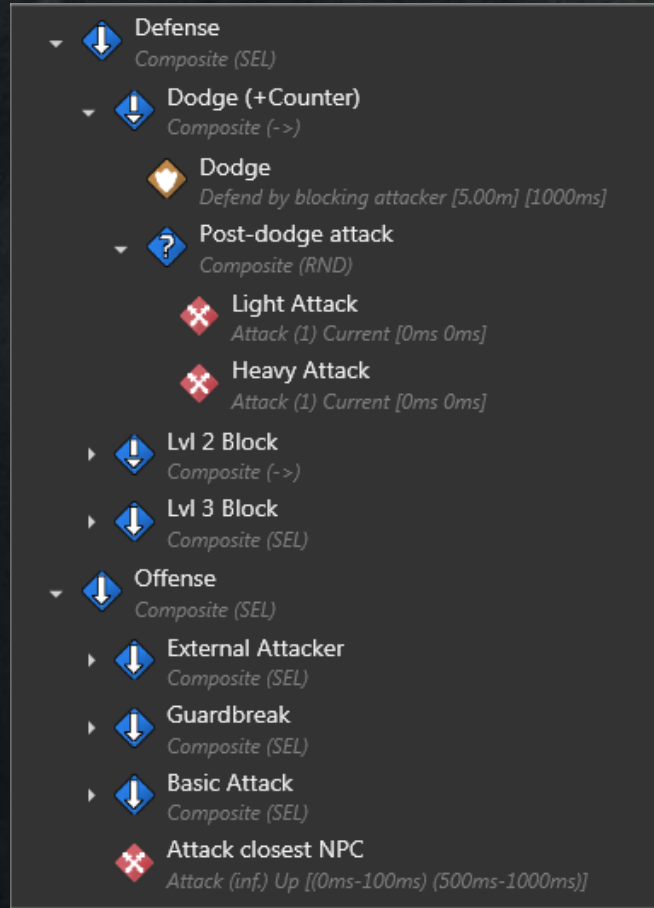
PRESS

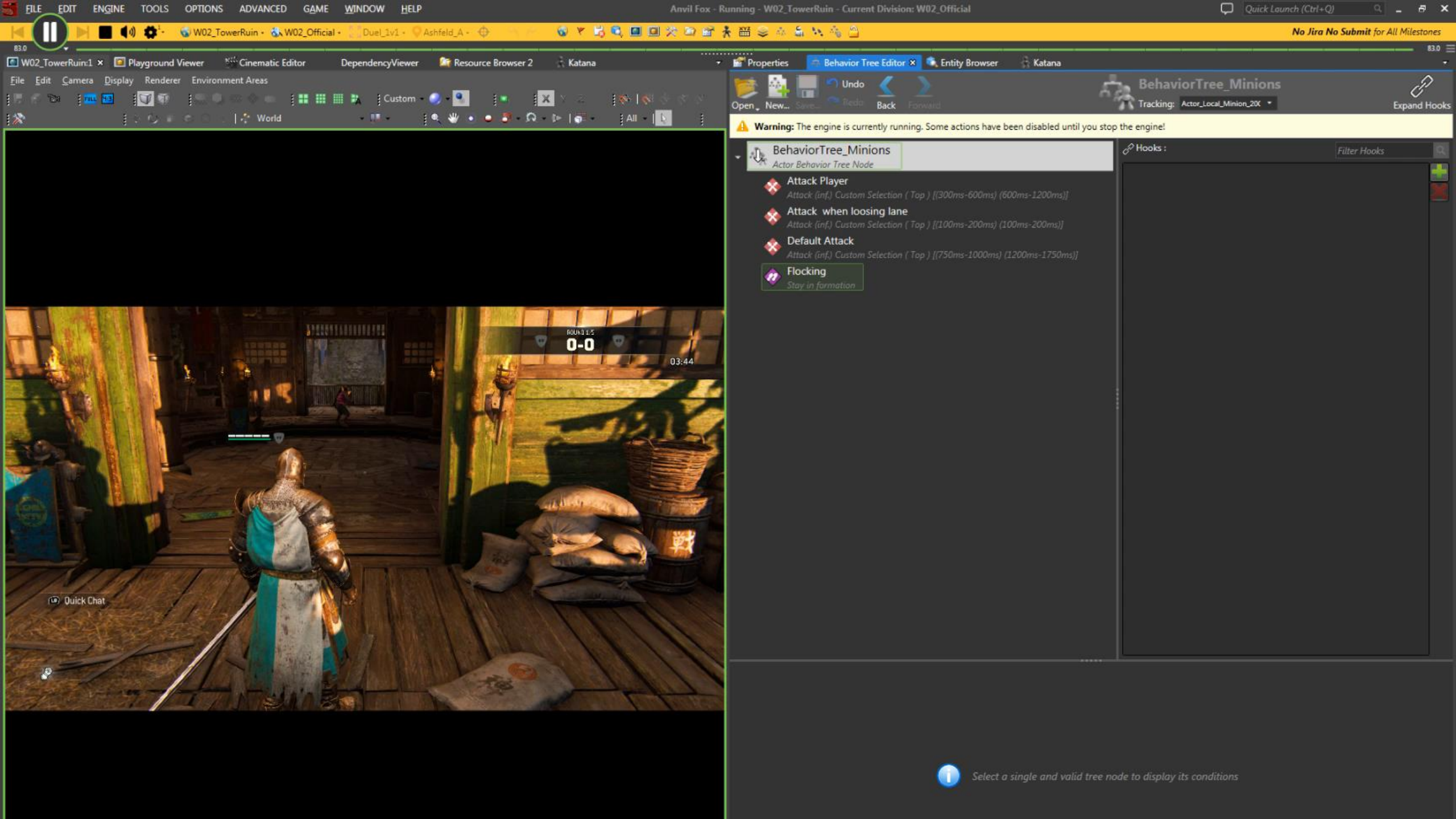


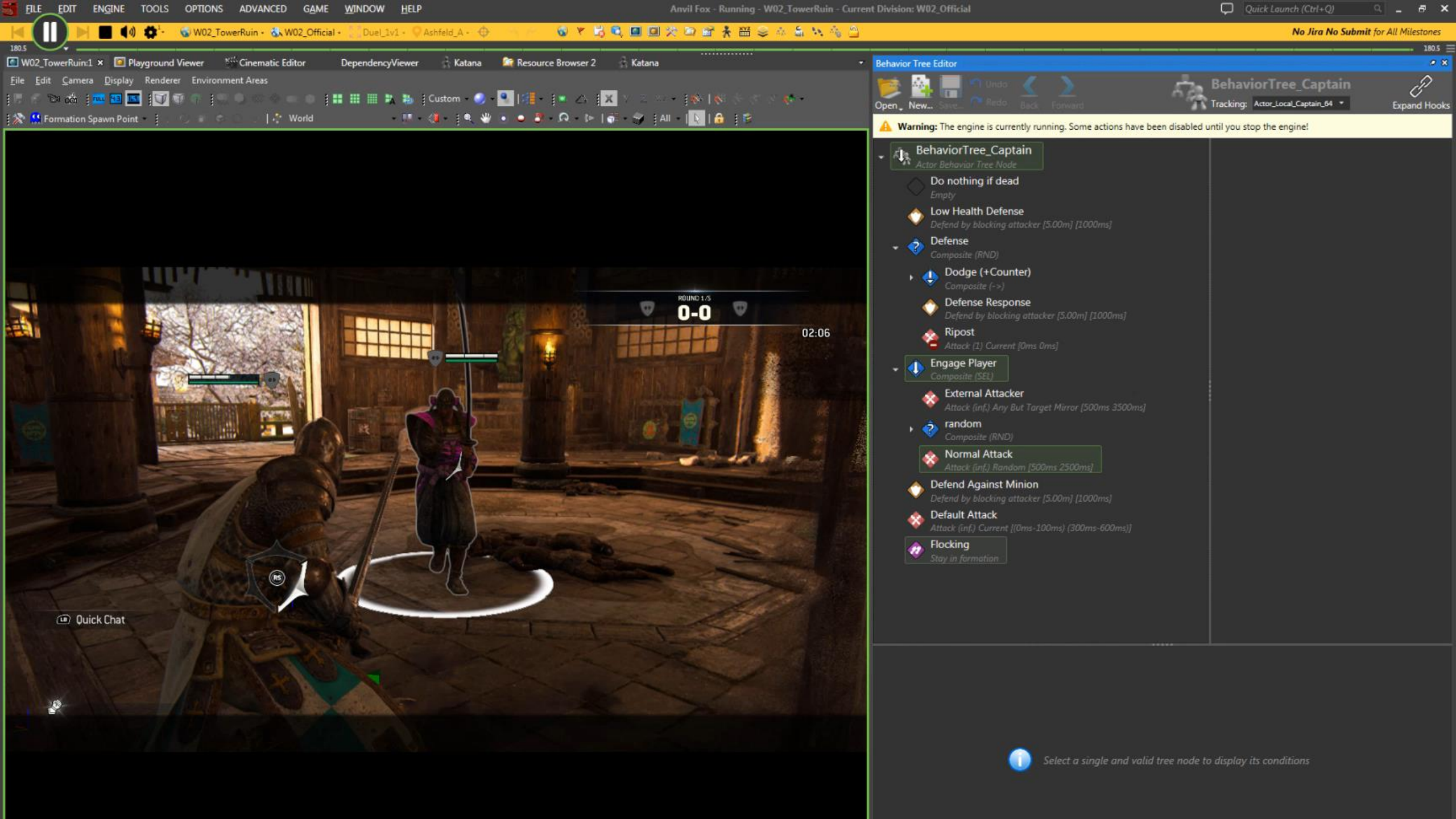
 Quick Chat

DETERMINISTIC AI

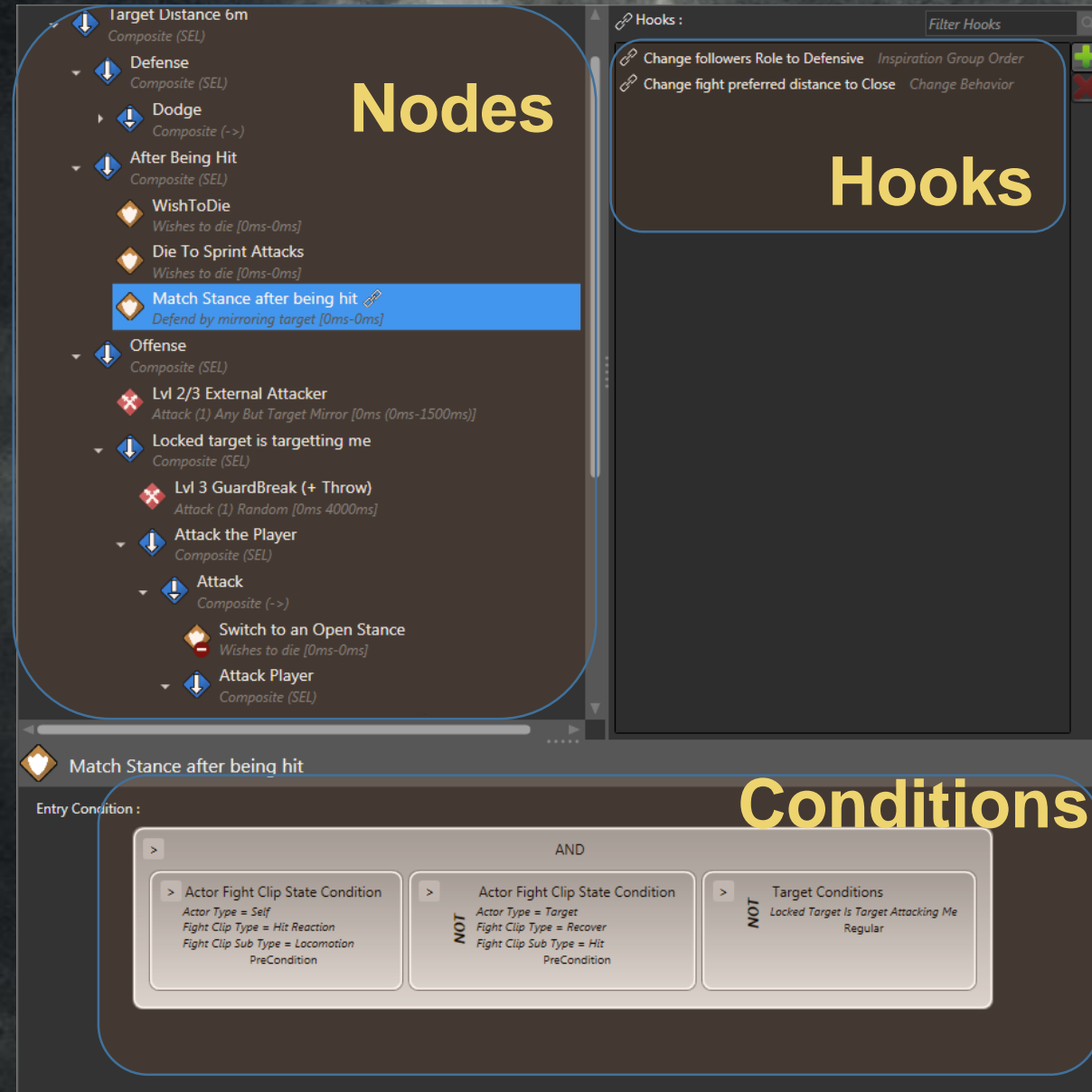
Behavior Trees







Behavior Trees



DETERMINISTIC AI |

And its failures...

Complexity problem



CPU cost



REPLICATED AI

REPLICATED AI |

Why another AI system?

Free movement in the map

Environment awareness

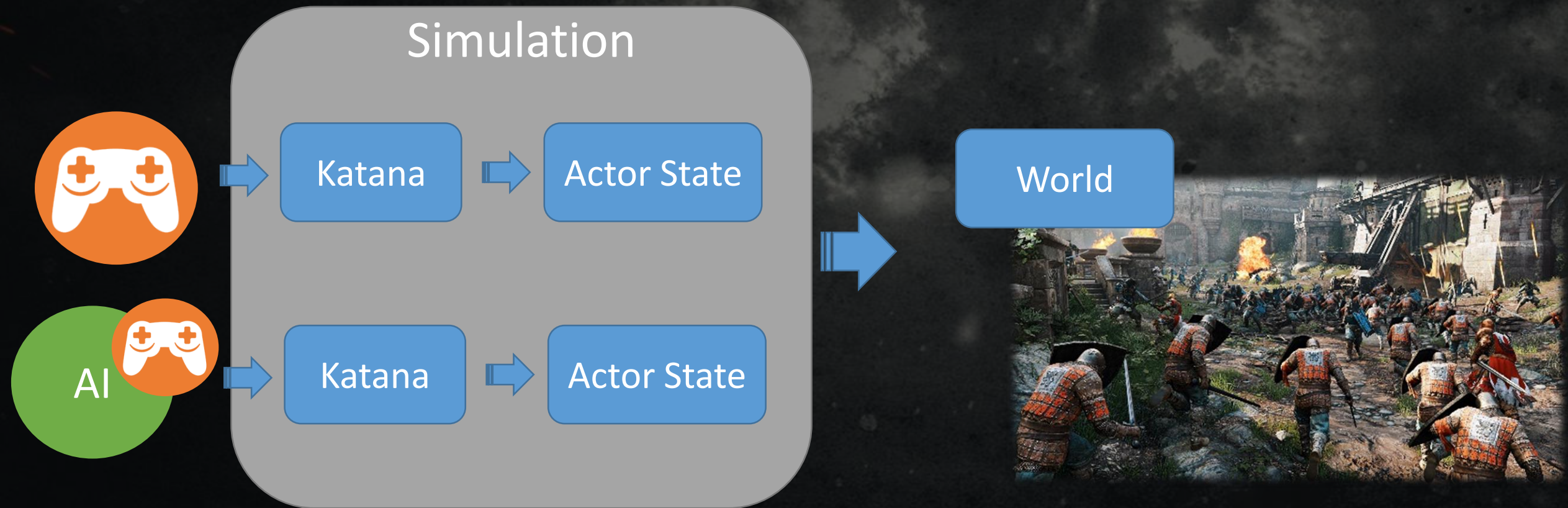
Reactivity

Difficulty: Skills > Stats



REPLICATED AI

Controlling a character



REPLICATED AI

Working out of the Simulation

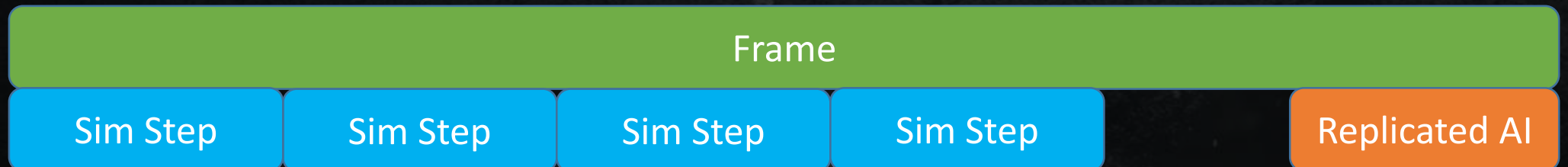
No need to predict replicated characters state

- Simulation does it

Do not consider rewinds

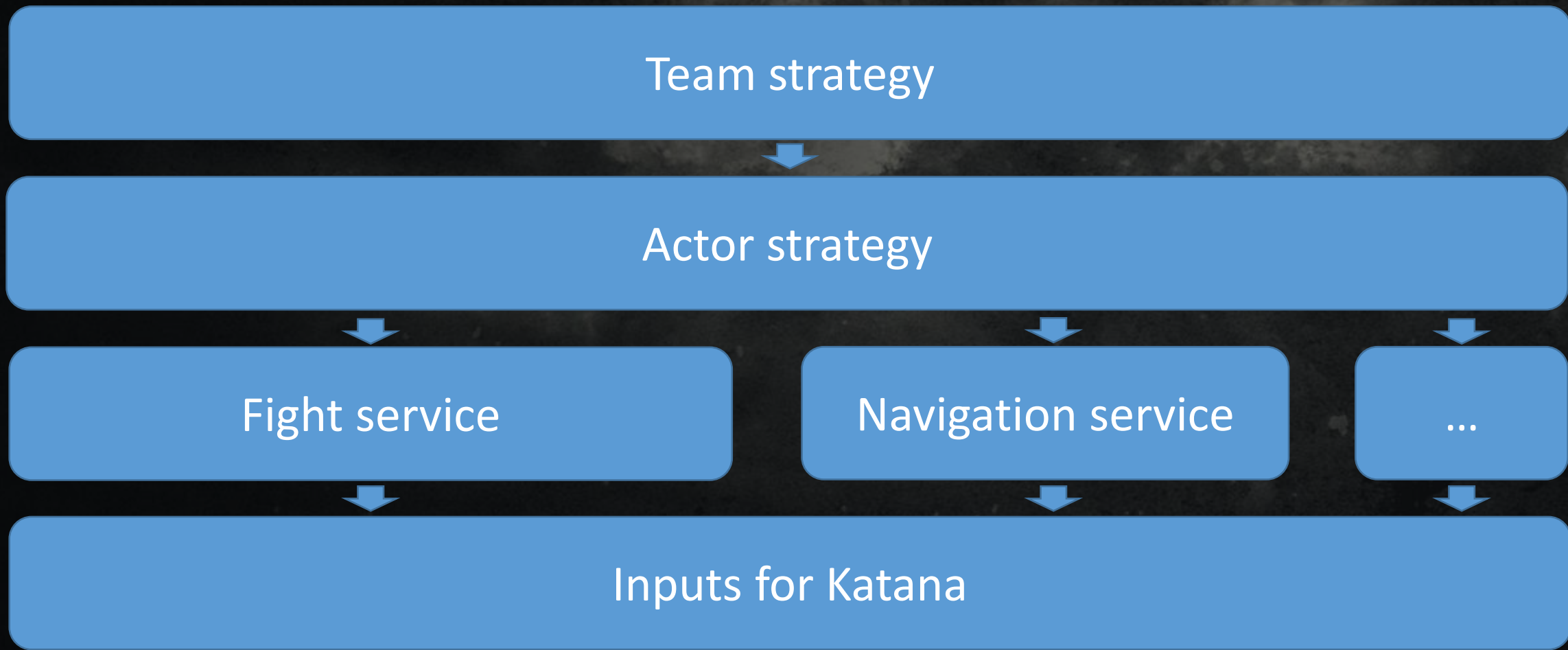
- Decisions based on current local world state only – Can take wrong decisions

Updated only once per frame!



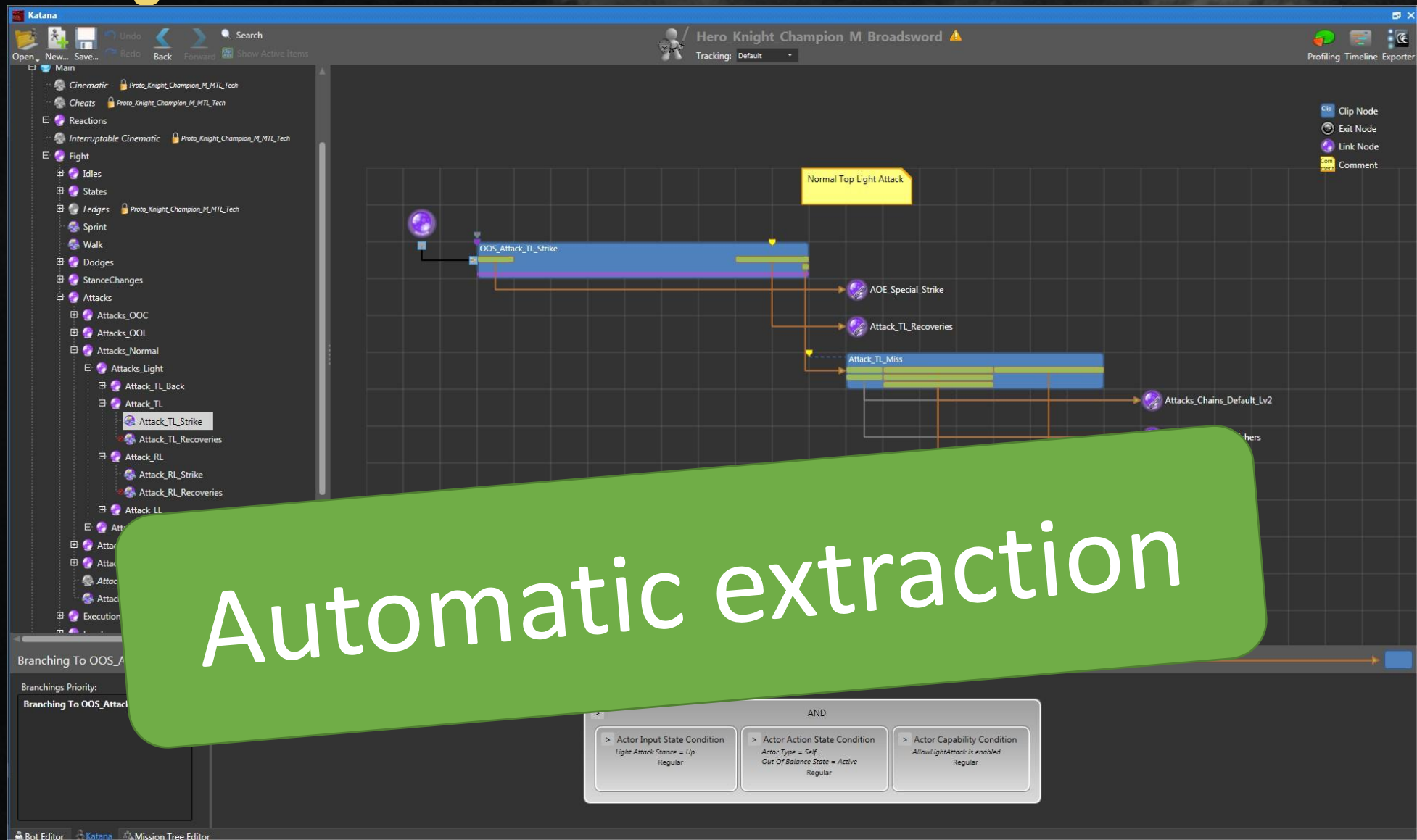
REPLICATED AI |

AI Layer Architecture



REPLICATED AI

Controlling Katana



REPLICATED AI

Know your character – Standard information

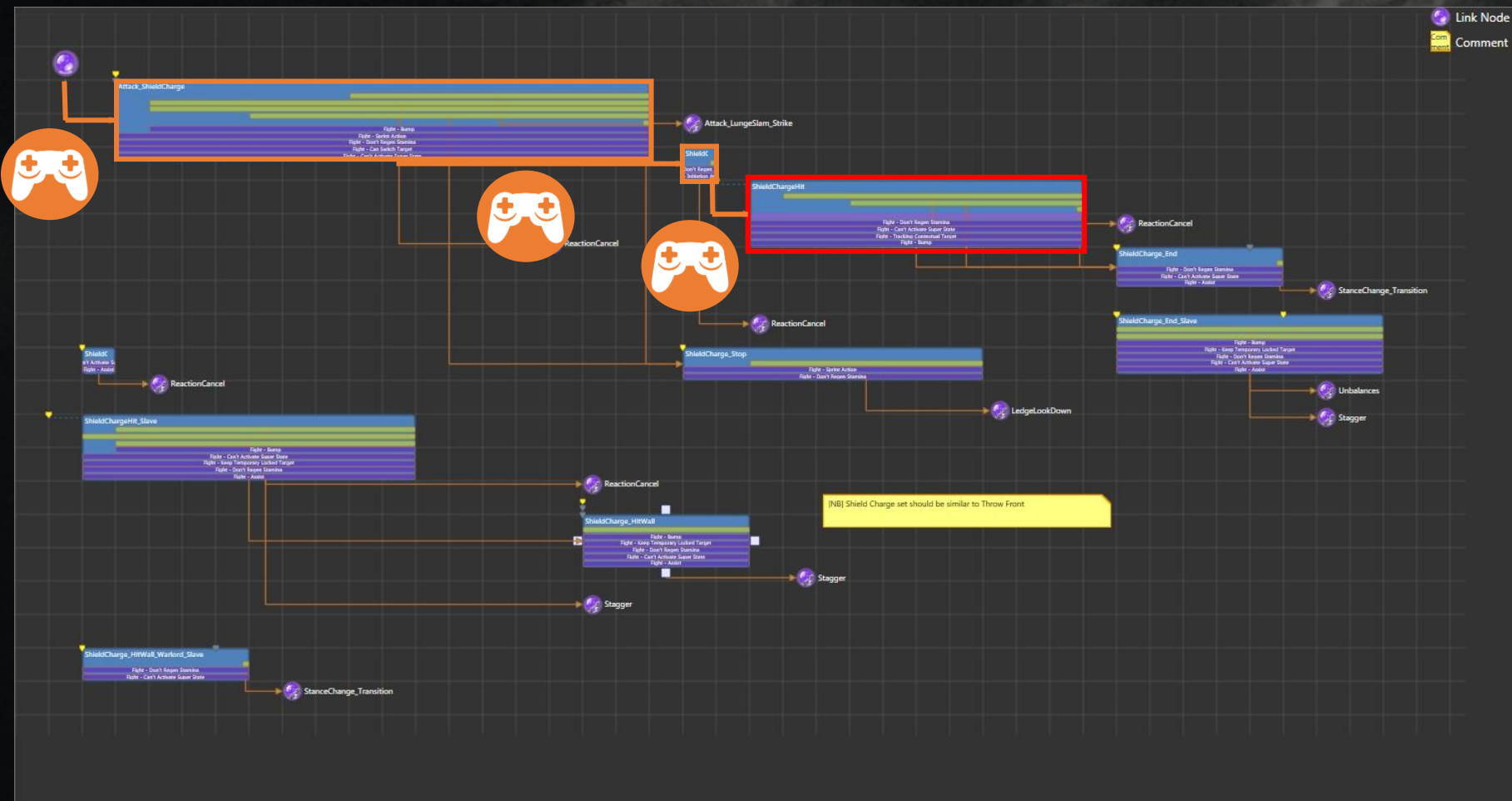
- Move availability
- Ranges
- Timings
- Special Properties



Need to define standards for characters with designers

REPLICATED AI

Know your character – Combo and Unique actions



Need AI specific data in Katana to orientate the search

REPLICATED AI |

Fight Actions

Simple logical blocks:

- Standard actions : Block, Attack, Dodge, ...
- Specific action : Play input path

Character agnostic: Use auto extracted data only

REPLICATED AI

Fight Actions – Example



REPLICATED AI

Fight Actions – Example



REPLICATED AI |

Let AI designers create fighters

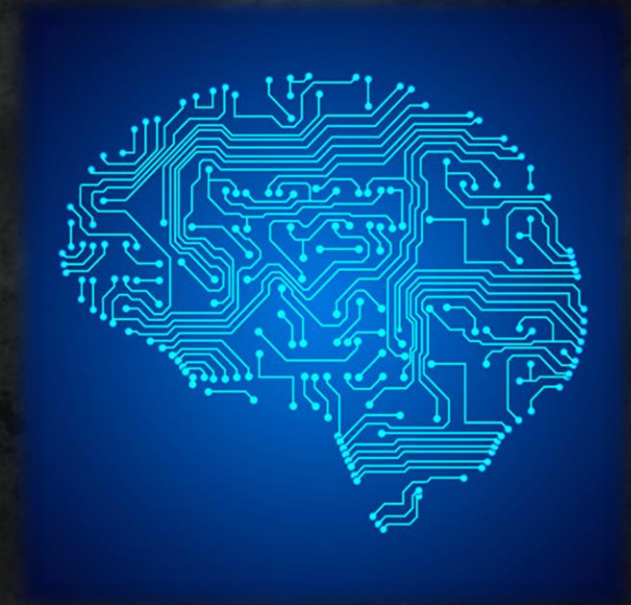
PvP:

- Player replacement
- Unpredictable fighter

PvE:

- Teach the game
- Pattern based
- Bosses with multiple stages

Solution: « Fight databases »



Bot Editor

Open New... Save... Undo Redo Back Forward

DT_TDM_Knight_Assassin

Tracking: [dropdown]

DT_TDM_Knight_Assassin

Fight AI

- Link to DT_PvP_Root_Attack
- Link to DT_Root_Defense(Dodge)
- Link to DT_Root_Guardbreak(Peacekeeper)
- Link to DT_PvP_Root_Finish
- Link to DT_Root_Attack_Minions
- CN_Chains
- CN_Special
- CN_Feints
 - HeavyFeint P 3000 | W 100
 - Parry P 3000 | W 100
 - FollowUpAttack P 2000 | W 100
 - Wait P 2000 | W 50
 - Guardbreak P 2000 | W 100
 - Stab P 2000 | W 200
- CN_States
- CN_Feats
- Attraction_Repulsion
- CN_Minions_OOL
- Link to DT_PvP_Root_Attraction

Decision Tree

Action Graph

Void

Heavy 1

Light 1

Heavy 2

LightCancel

GuardBreak

Heavy

LightCombo

FollowUpAttack

Entry Condition :

AND

Bot Fight Predicate - Fight Info

Is last Feint done during last 2.000s

Regular

Bot Fight Predicate - Bot Info

BotLevel >= Bot Lvl: 3

Regular

NOT

Bot Fight Predicate - Actor state

Locked Target

StatePredicate = Is Attacking

Regular

Exit Condition :

<None>

Conditions and Filters

Bot Editor

Katana

REPLICATED AI |

Fight Layer – Runtime

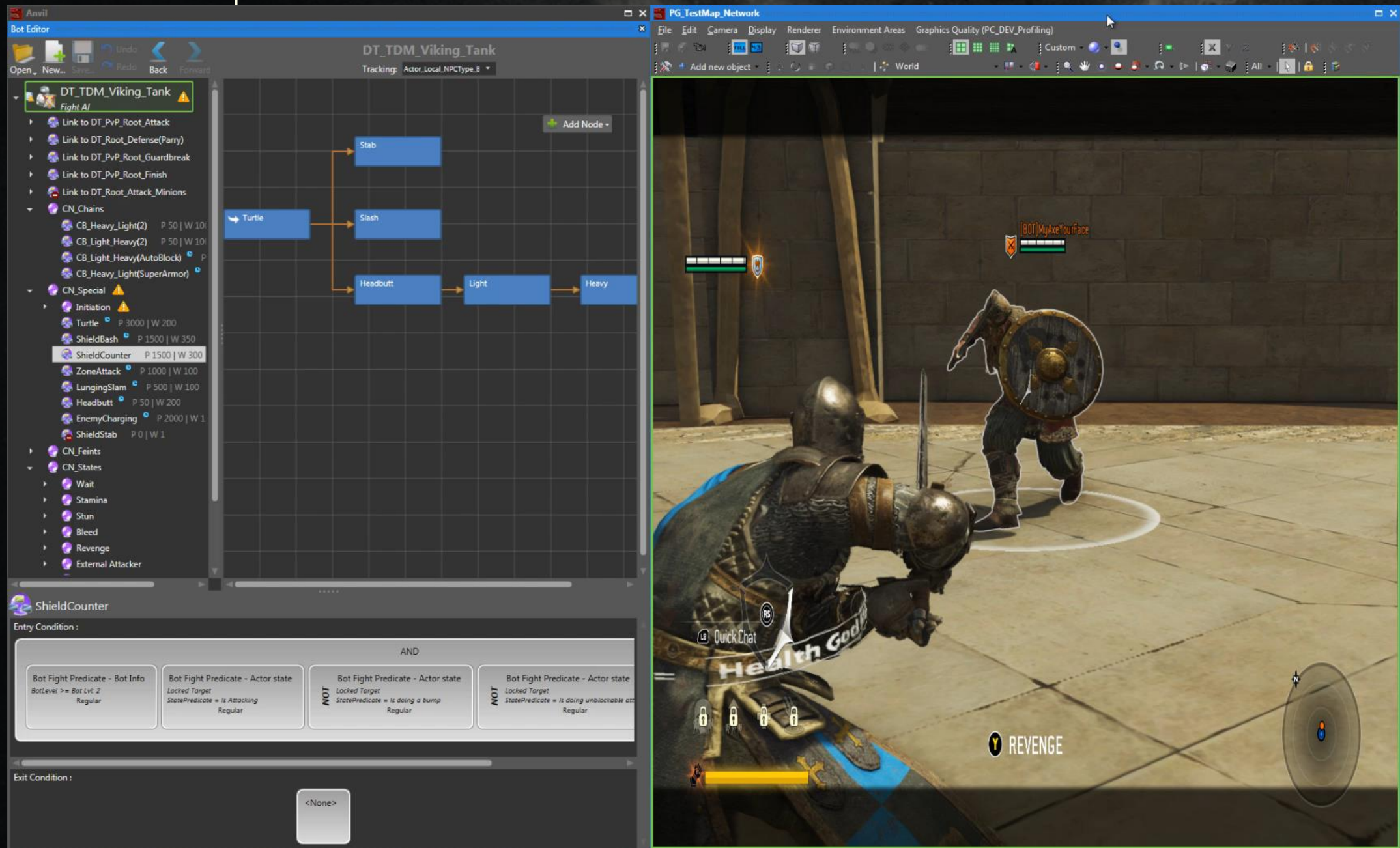
Queries almost every frame for each fighting AI



Optimizations:

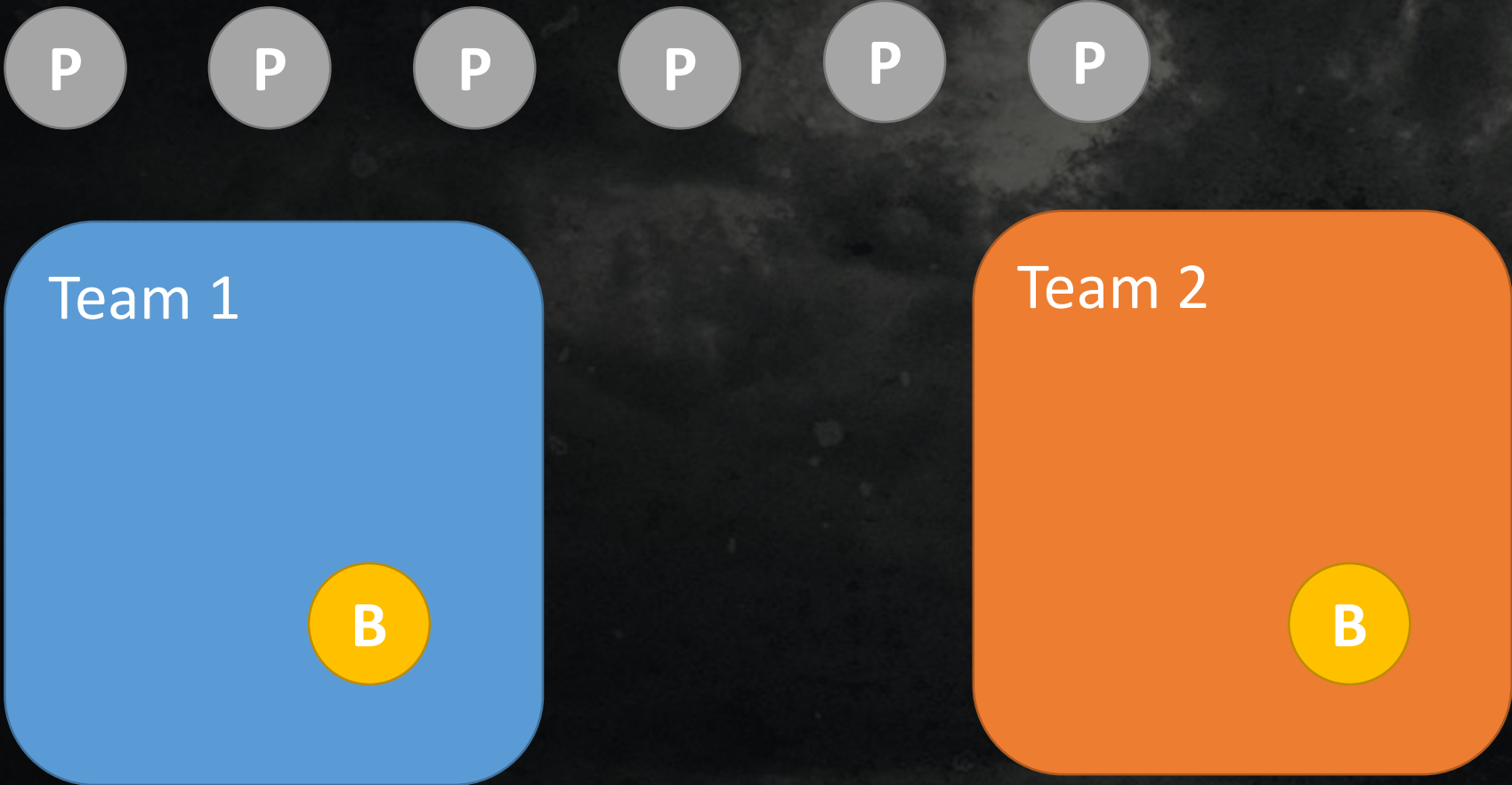
- Pre-compute as much as you can
- Early out thank to tree structure
- Partial queries

REPLICATED AI



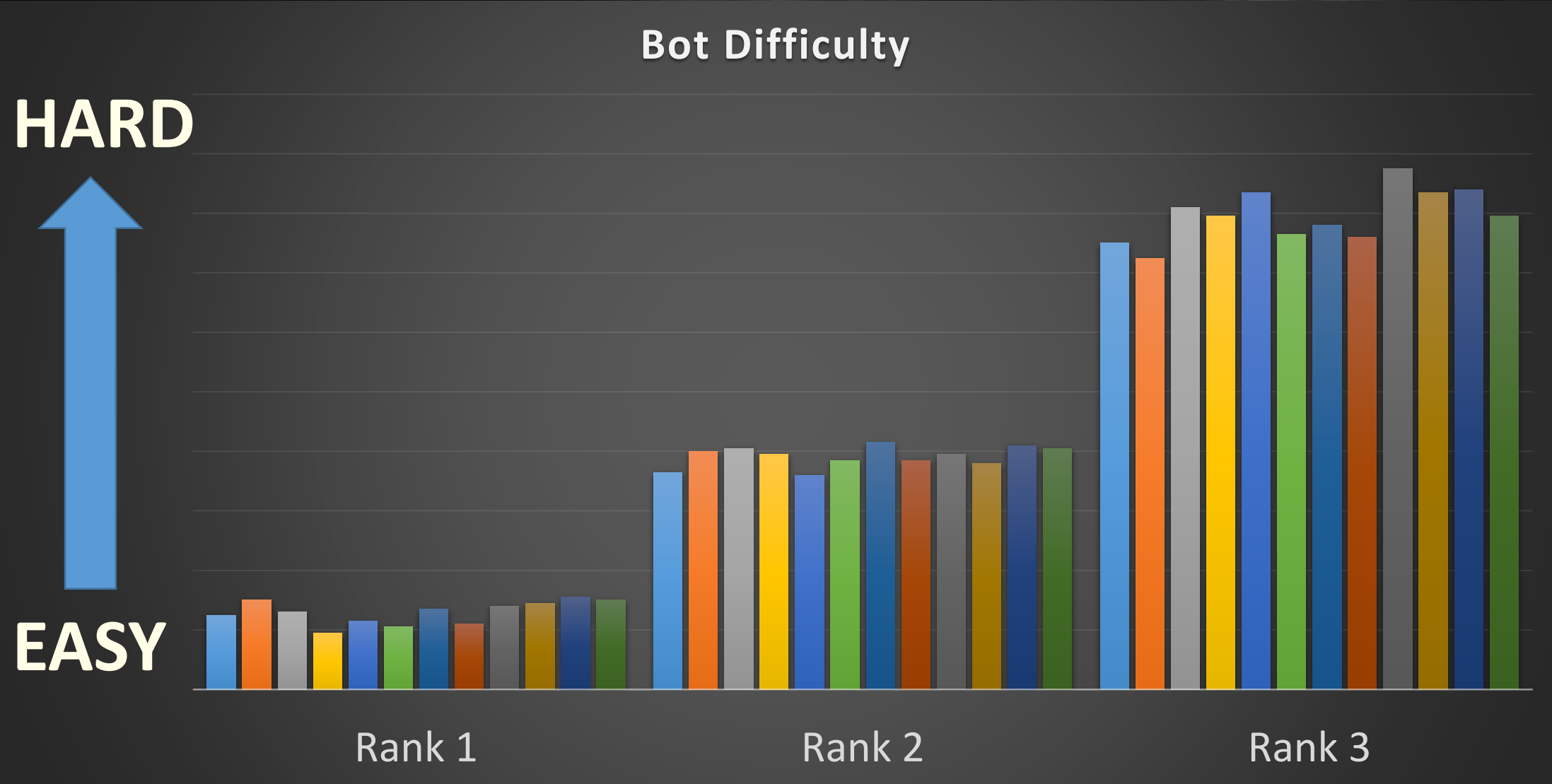
REPLICATED AI |

PvP Bot Selection



REPLICATED AI |

PvP Bot Selection



REPLICATED AI |

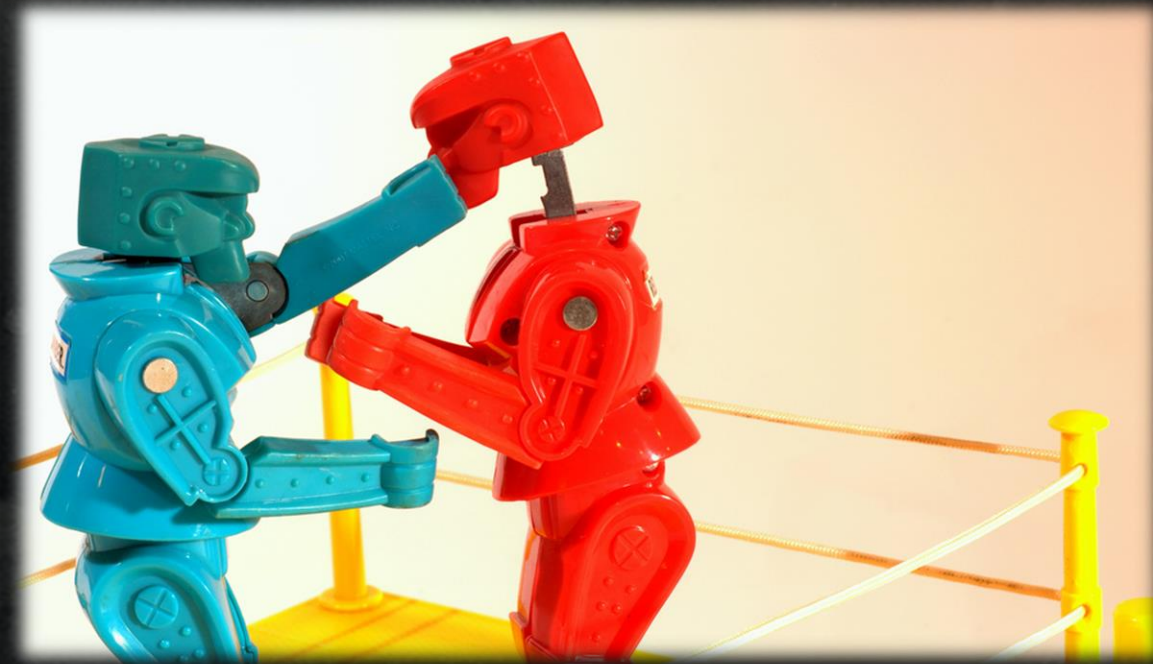
AI validation

$(12 \text{ Characters} * 3 \text{ Difficulties})^2 = \text{Too many to test!}$

Need to compare them using science not feelings

Solution:

Automatic bot duels with tracking



REPLICATED AI |

AI validation – Usage

1 PC = 250+ duels / night

Aim to reach predefined win ratio

Can only detect high level anomalies – Not a silver bullet





TAKEAWAYS

TAKEAWAYS

Input Driven ?



Yes!

TAKEAWAYS

Data Driven ?

The screenshot shows the Katana AI system editor. On the left, a tree view lists various behaviors under categories like Defense, After Being Hit, and Offense. The 'Match Stance after being hit' behavior is selected. On the right, the 'Hooks' panel shows two active hooks: 'Change followers Role to Defensive' and 'Change fight preferred distance to Close'. Below, the 'Entry Condition' for the selected behavior is shown, consisting of three conditions connected by AND logic:

- Actor Fight Clip State Condition: Actor Type = Self, Fight Clip Type = Hit Reaction, Fight Clip Sub Type = Locomotion, PreCondition.
- NOT Actor Fight Clip State Condition: Actor Type = Target, Fight Clip Type = Recover, Fight Clip Sub Type = Hit, PreCondition.
- NOT Target Conditions: Locked Target is Target Attacking Me, Regular.

Yes!

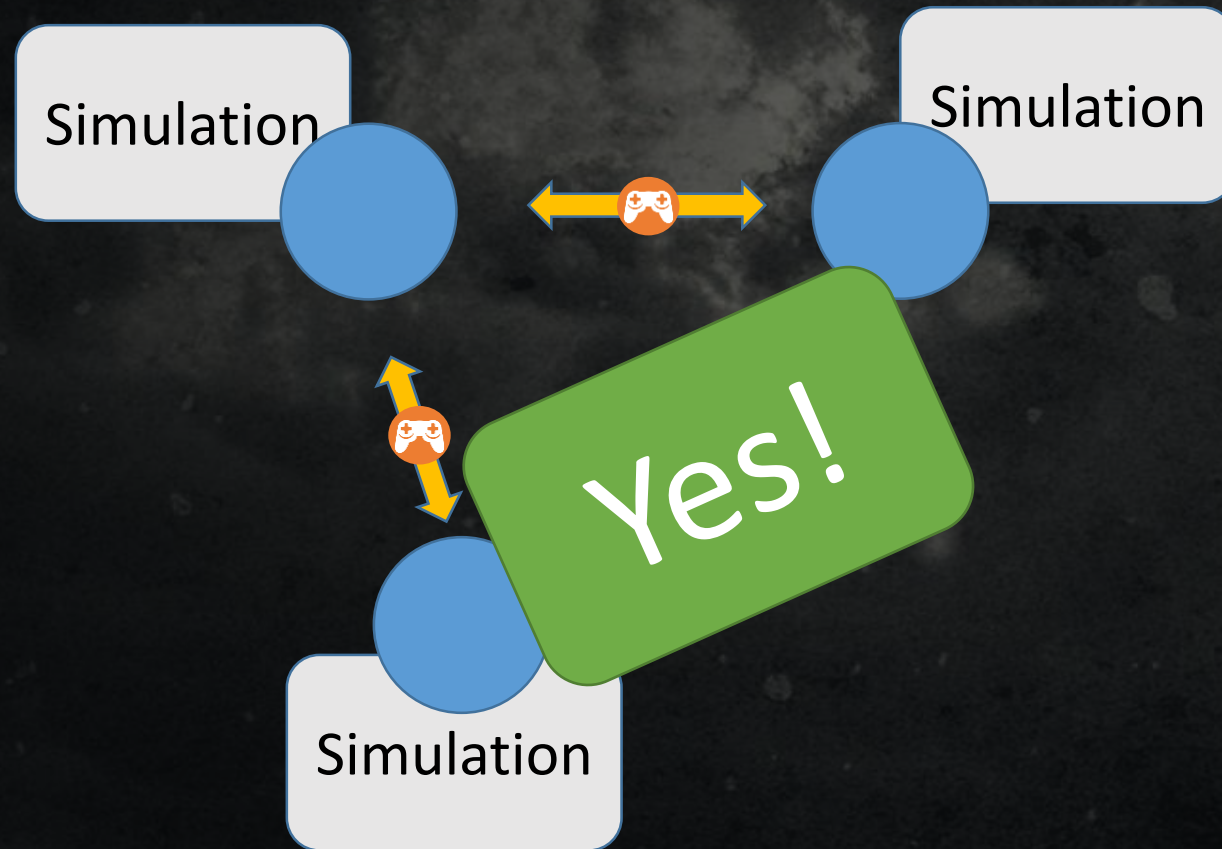
Because

The screenshot shows the Katana AI system editor. On the left, a tree view lists various behaviors under categories like Attacks, Attacks_OOC, Attacks_Normal, Attacks_Light, Attacks_Back, Attacks_TL, Attacks_RL, Attacks_LL, Attacks_Heavy, Attacks_Chains, Attacks_Specials, and Attacks_A. The 'FollowUpAttack' behavior is selected. On the right, the 'Entry Condition' for the selected behavior is shown, consisting of three conditions connected by AND logic:

- Bot Fight Predicate - Fight Info: is last frame done during last 2,000, Regular.
- Bot Fight Predicate - Bot Info: BotName != BotSelf, Regular.
- NOT Bot Fight Predicate - Actor state: Locked Target, StatusPredicate = Is Attacking, Regular.

TAKEAWAYS

The Simulation



TAKEAWAYS

2 distinct AI Systems ?



THANK YOU

Questions?

xavier.guilbeault@ubisoft.com

frederic.doll@ubisoft.com