

# EMERGENT COALITIONS IN MULTI-AGENT REINFORCEMENT LEARNING IN KAZ

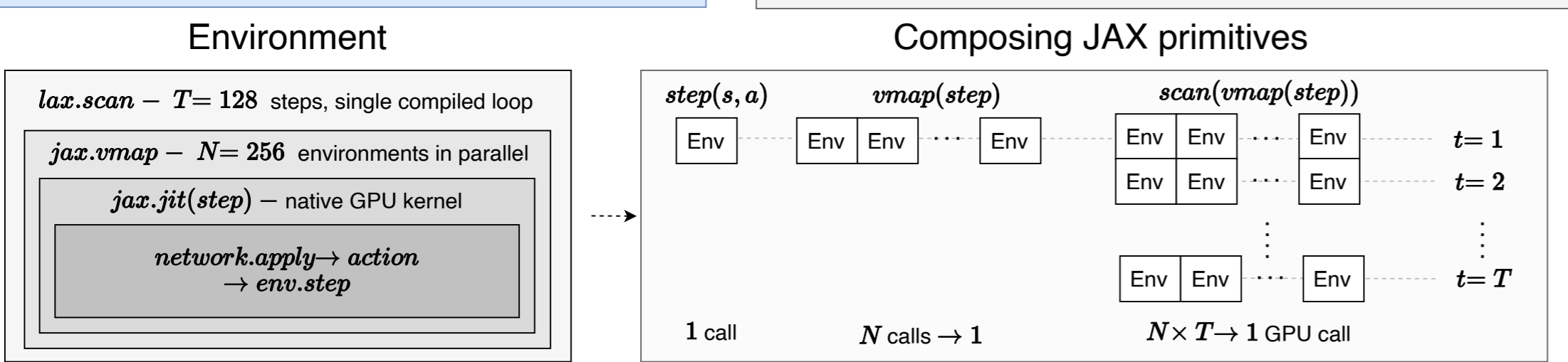


2 Knights, 2 Archers; Zombies descending down - upon reaching bottom / all agents killed = lose

Extended with: Bosses (more HP, ATK), Wave system (rising difficulty), XP / Leveling system (measures equality), Shielded Zombies (only knights can break)

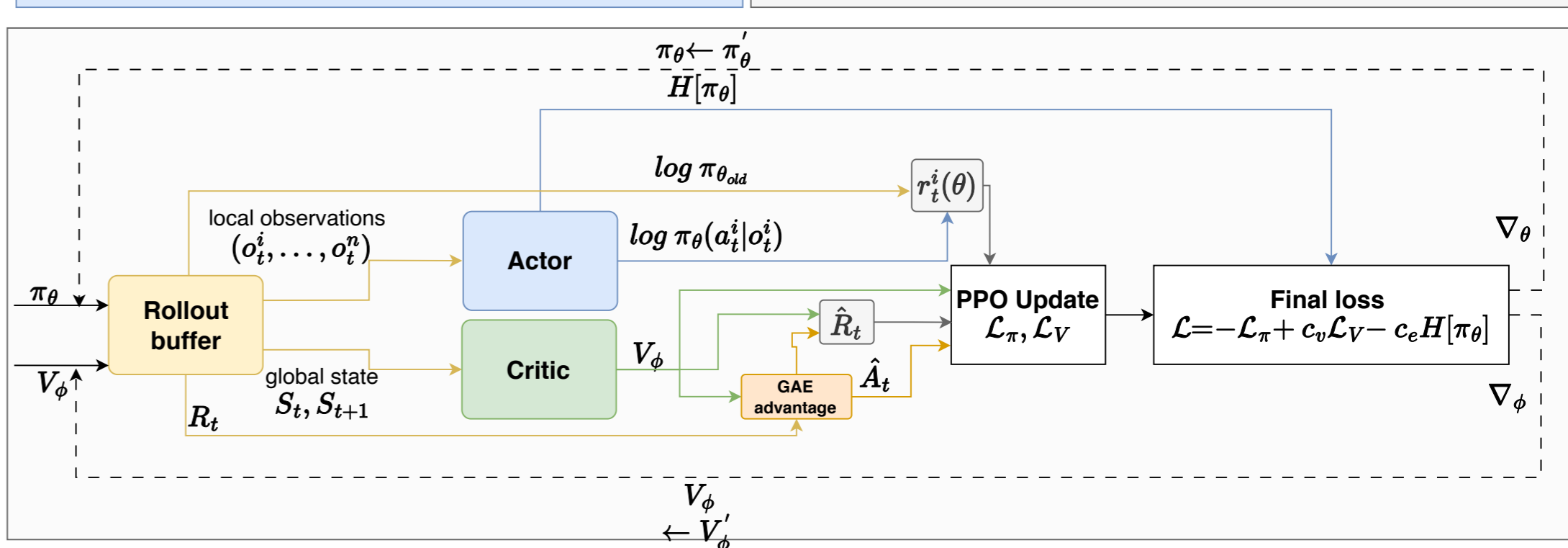
## Setup

### JAX Implementation:



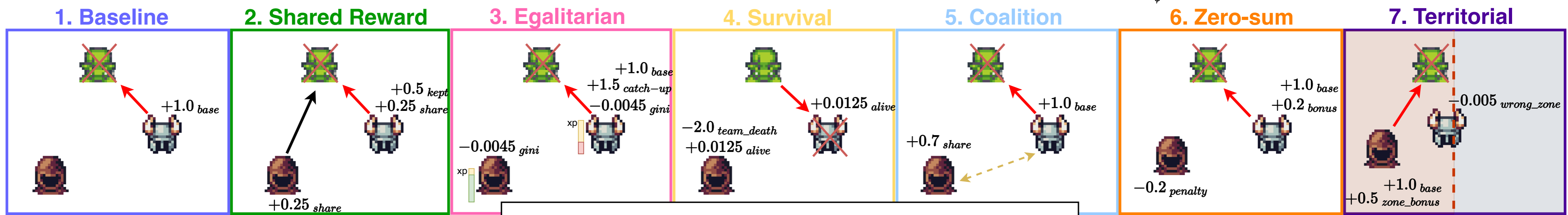
### Trained with MAPPO:

10,000 updates, fixed hyperparams, 256 parallel envs, 128 steps, 400px vision radius



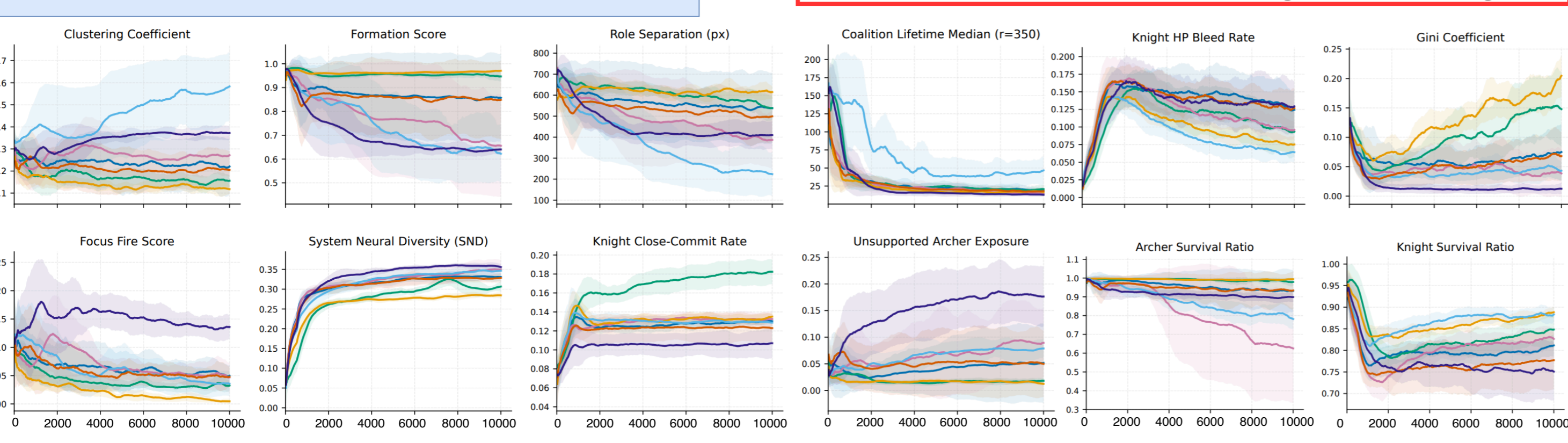
## Do rewards change coordination?

Seven reward schemes developed:

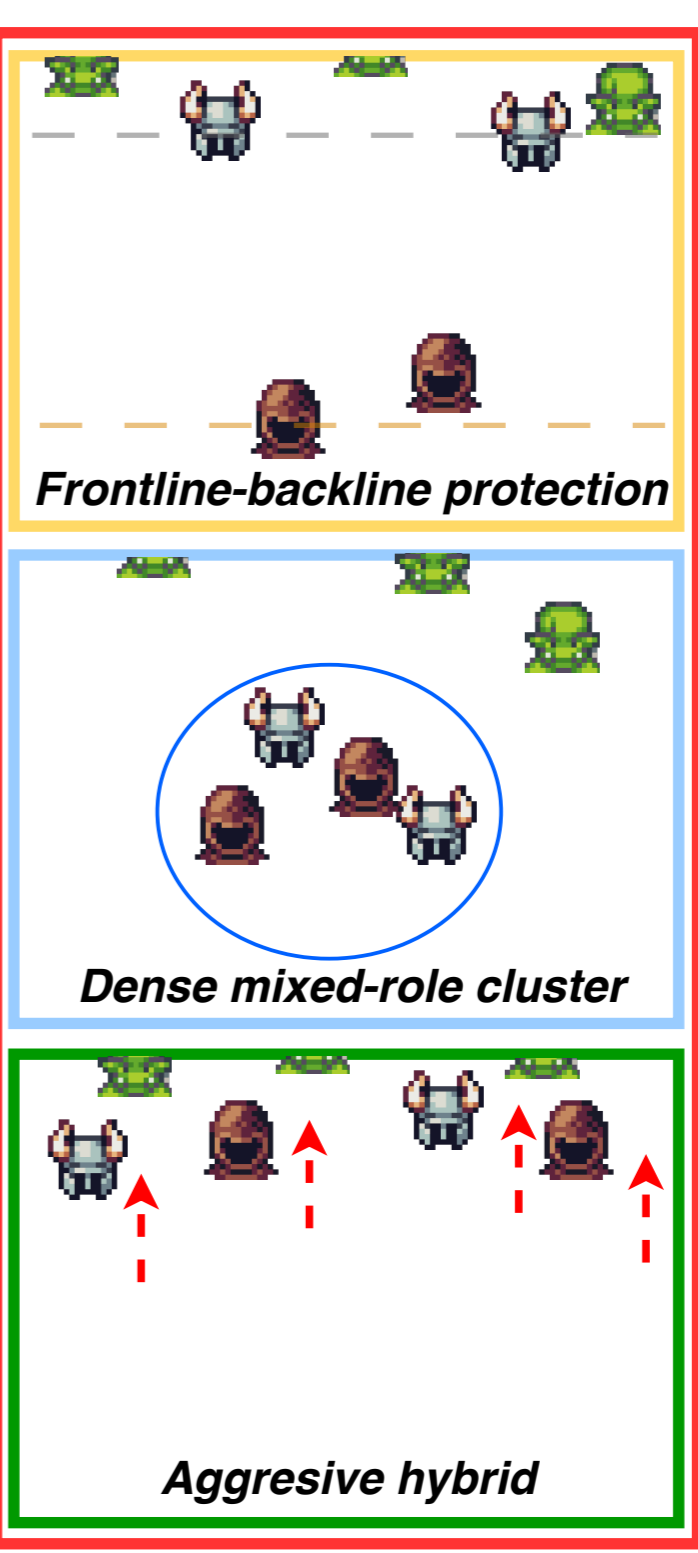


## Measuring emergent coalitions

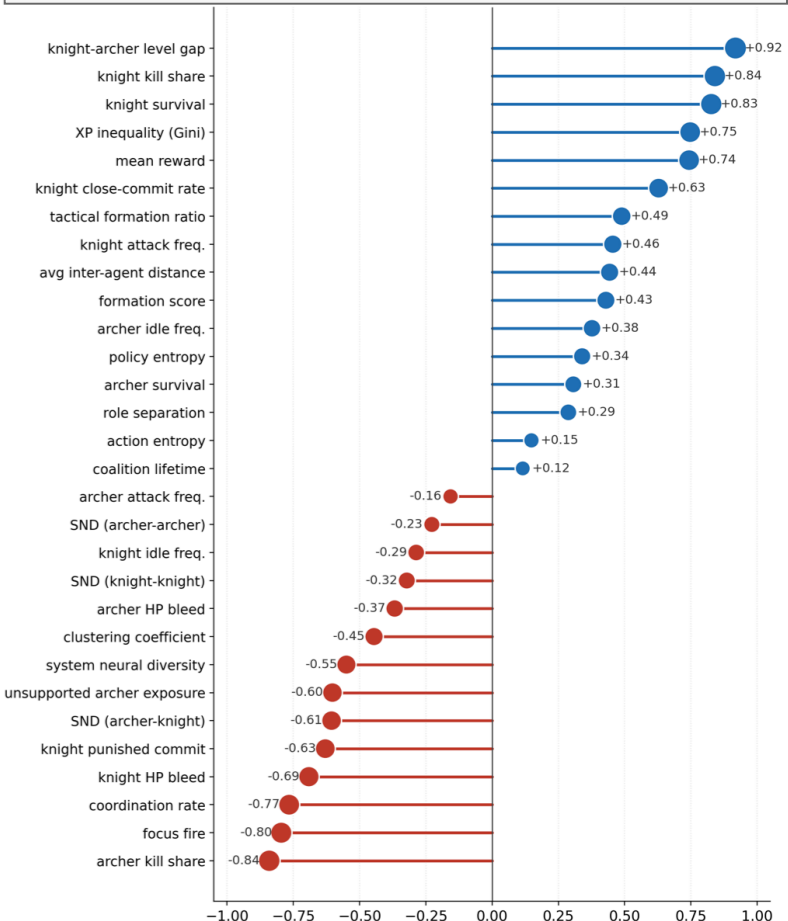
### Custom Metrics Implemented:



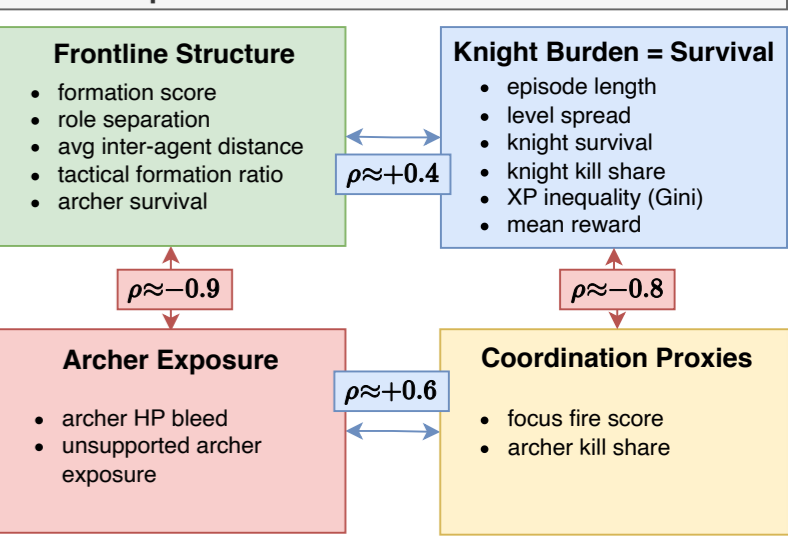
### Three main coordination regimes emerged:



### Metrics correlation against episode length



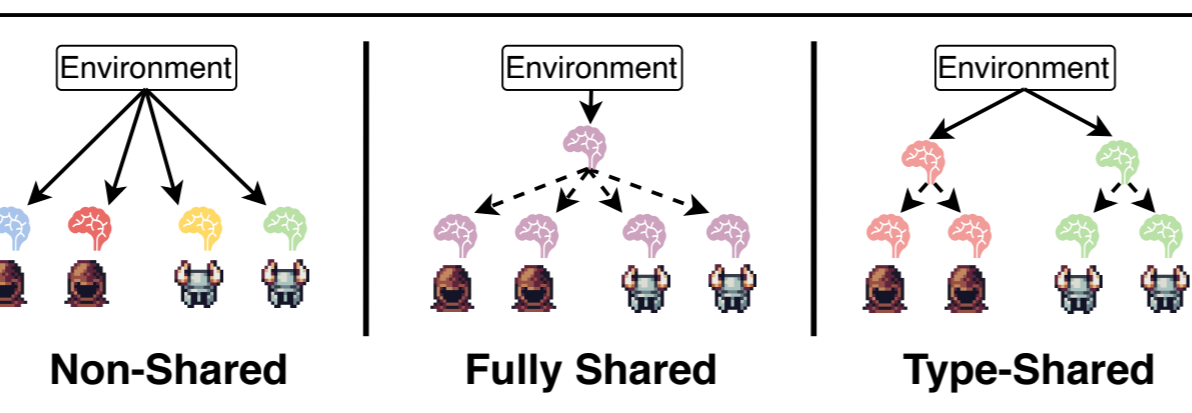
### The coordination metrics correlations collapse into 4 functional families



## Changing the mechanics reshuffles ranking

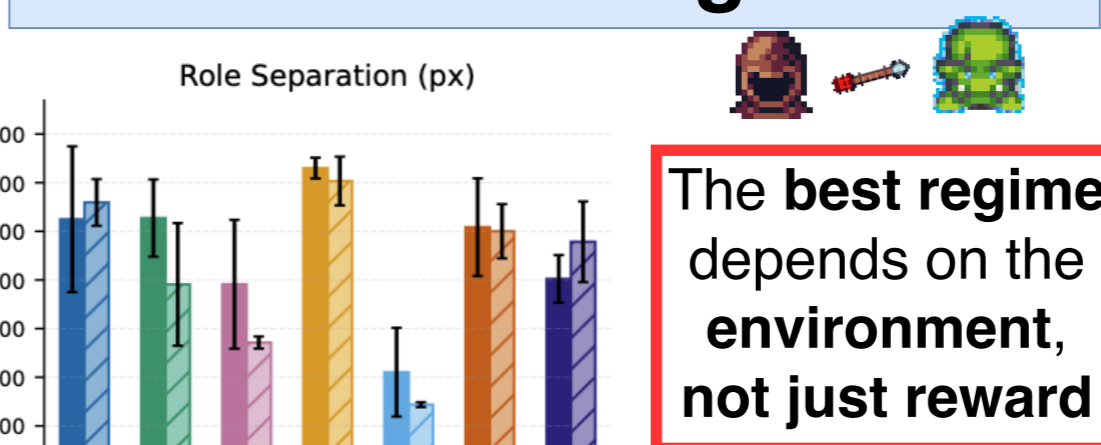
### Parameter Sharing

Three modes tested:



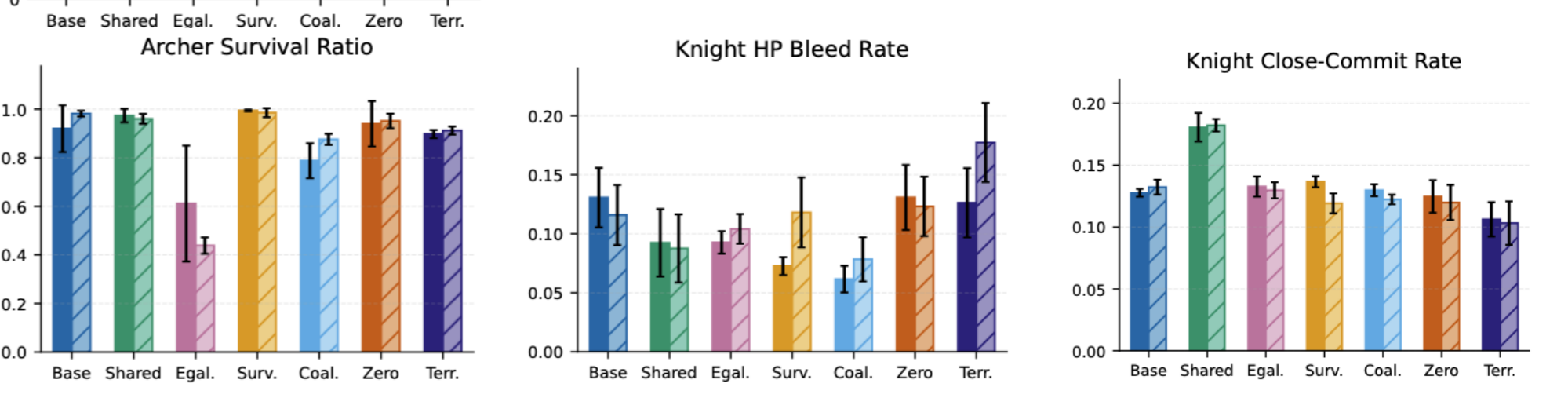
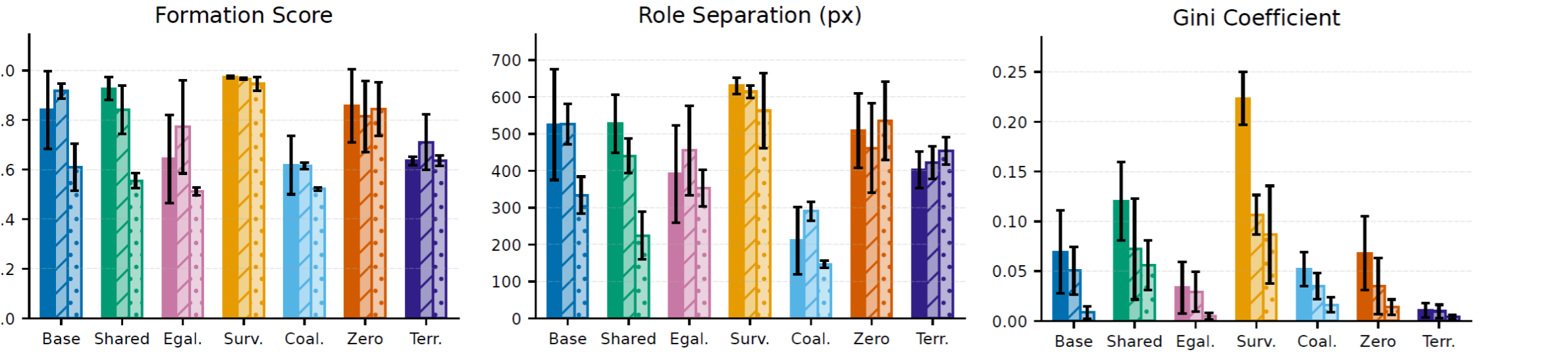
Type-shared works best. Non-shared keeps some visible structure, but underperforms. Fully-shared pushes XP inequality near zero, suggesting weaker role specialization

### Archers breaking shields



The best regime depends on the environment, not just reward

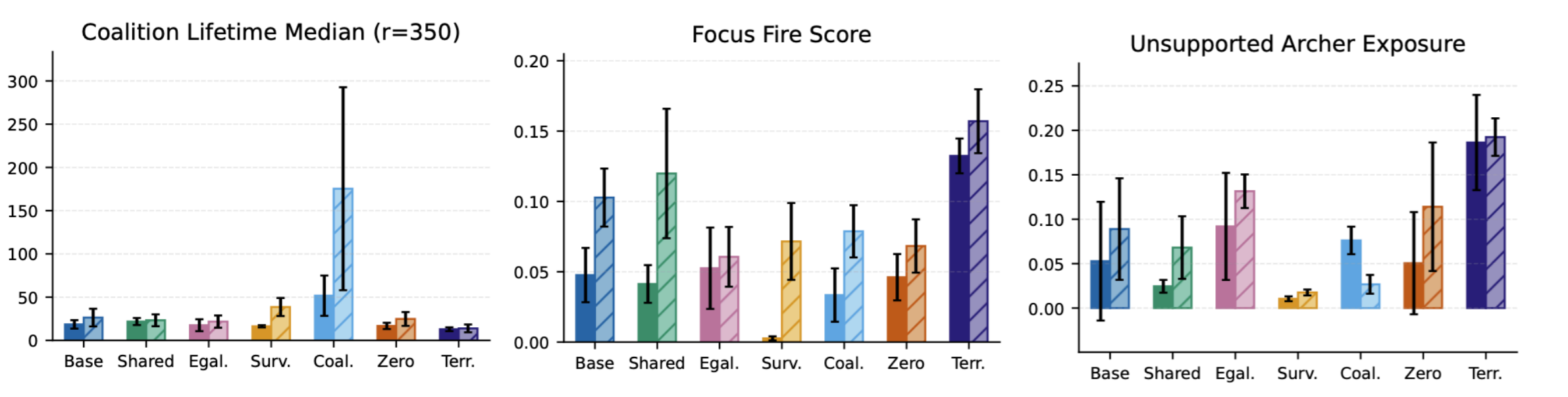
Policy	Control $\rightarrow$ ABS	$\Delta$
Baseline	556.3 $\rightarrow$ 571.6	+15.3
Shared Reward	608.8 $\rightarrow$ 668.3	+59.5
Egalitarian	552.8 $\rightarrow$ 551.8	-1.0
Survival	701.1 $\rightarrow$ 572.9	-128.2
Coalition	583.3 $\rightarrow$ 633.8	+50.5
Zero-Sum	534.4 $\rightarrow$ 539.7	+5.3
Territorial	431.7 $\rightarrow$ 525.2	+93.5



### Vision

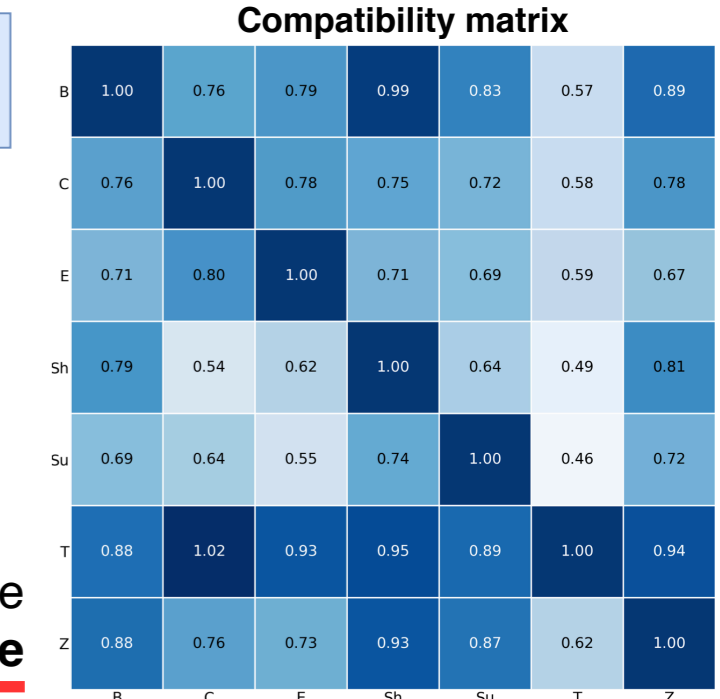
Agents have a vision radius: 400px vs infinite

More vision does not always help. It can destroy useful local coordination



### Cross-play & Leave-one-out

Policy	Archer $\Delta$ ep	Knight $\Delta$ ep
Baseline	-35.5	-299.5
Coalition	-79.5	-320.8
Egalitarian	-74.2	-293.1
Shared Reward	-2.0	-360.3
Survival	-37.1	-451.0
Territorial	-5.6	-121.6
Zero-Sum	-3.8	-274.1



Knight removal is catastrophic

Mixed teams are only partly compatible

