PTS Domains and Locker-Room Agreements

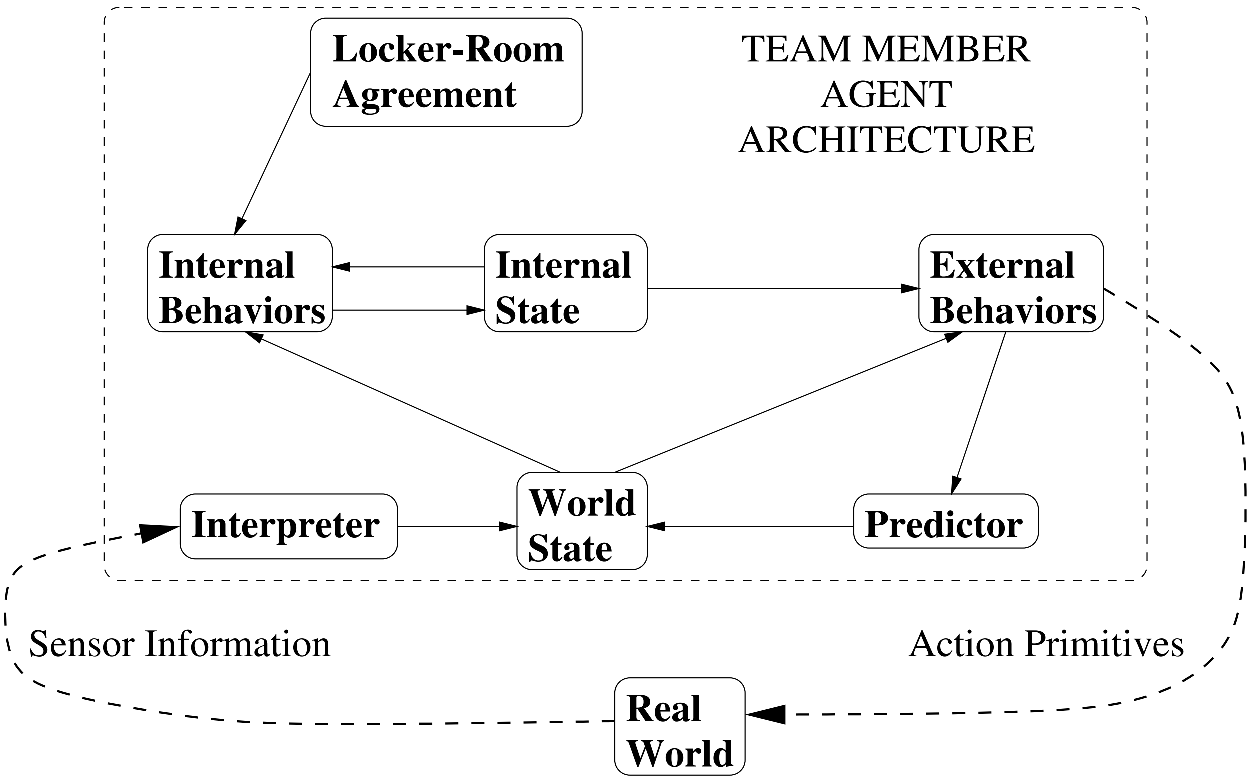
Periodic Team Synchronization Domains

- Persistent teams (common goal)
- Task execution: distributed, autonomous
  - Dynamic and real-time: time-critical
  - Unreliable/limited communication
- Periodically: deliberative
  - Safe, unrestricted communication
  - Share information

Locker-Room Agreements

- Shared by all agents
- Defines protocols, actions, contingencies, plans
- Hard-wired strategies or automatic planning
- Used to define **flexible team structure**

Architecture



Flexible Team Structure

Team of n agents: $A = \{a_1, a_2, \ldots, a_n\}$

Role: r

- Specifies internal and external behaviors
- Need not be rigid – can specify constraints

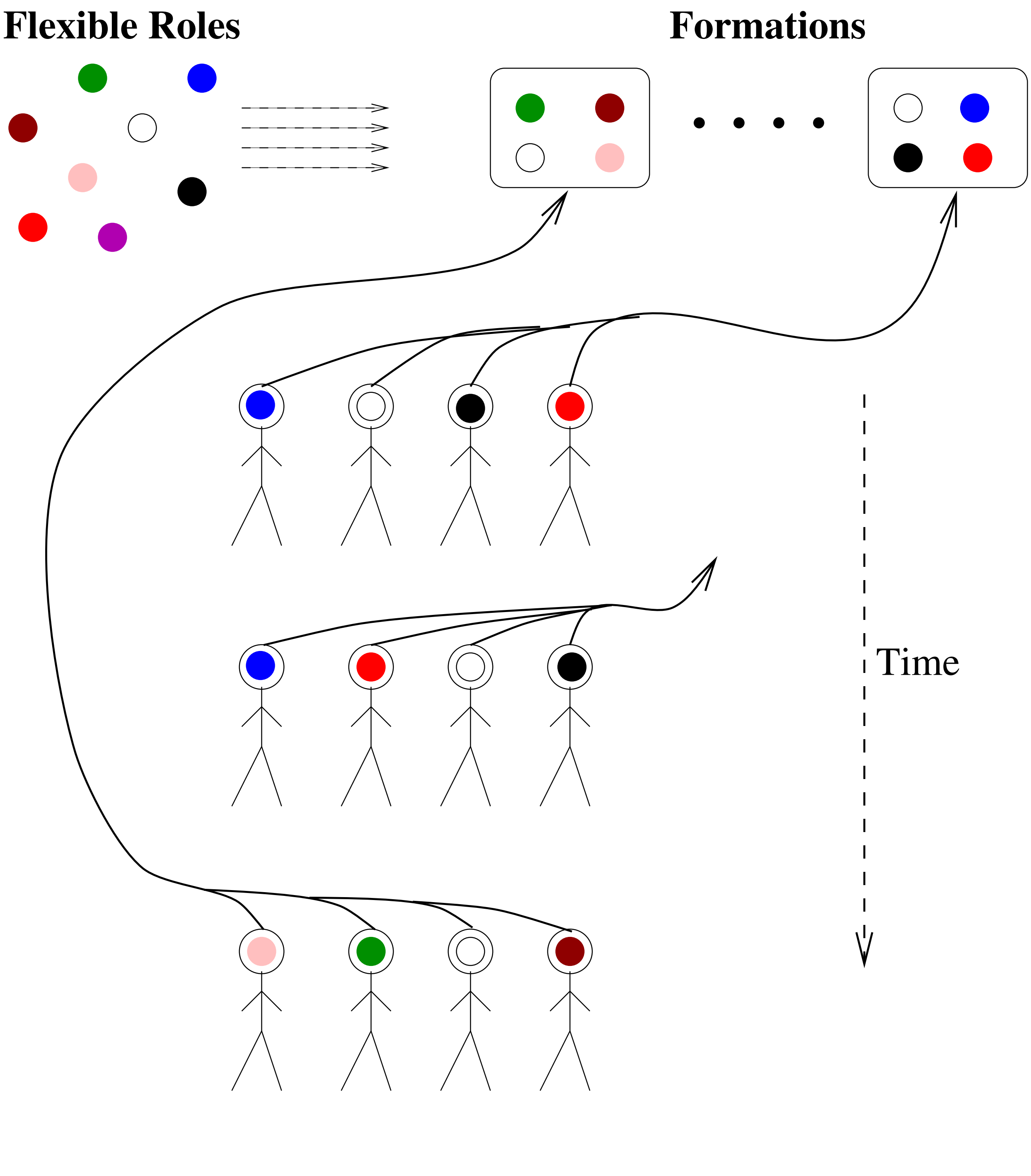
Formation: $F = \{R, \{U_1, U_2, \ldots, U_k\}\}$

- R is a set of roles $R = \{r_1, r_2, \ldots, r_n\}$
- Units $U_i \subset R$: issues of local importance
- F, $A \mapsto R$ can change dynamically
- Protocols ensure mapping stays 1-to-1

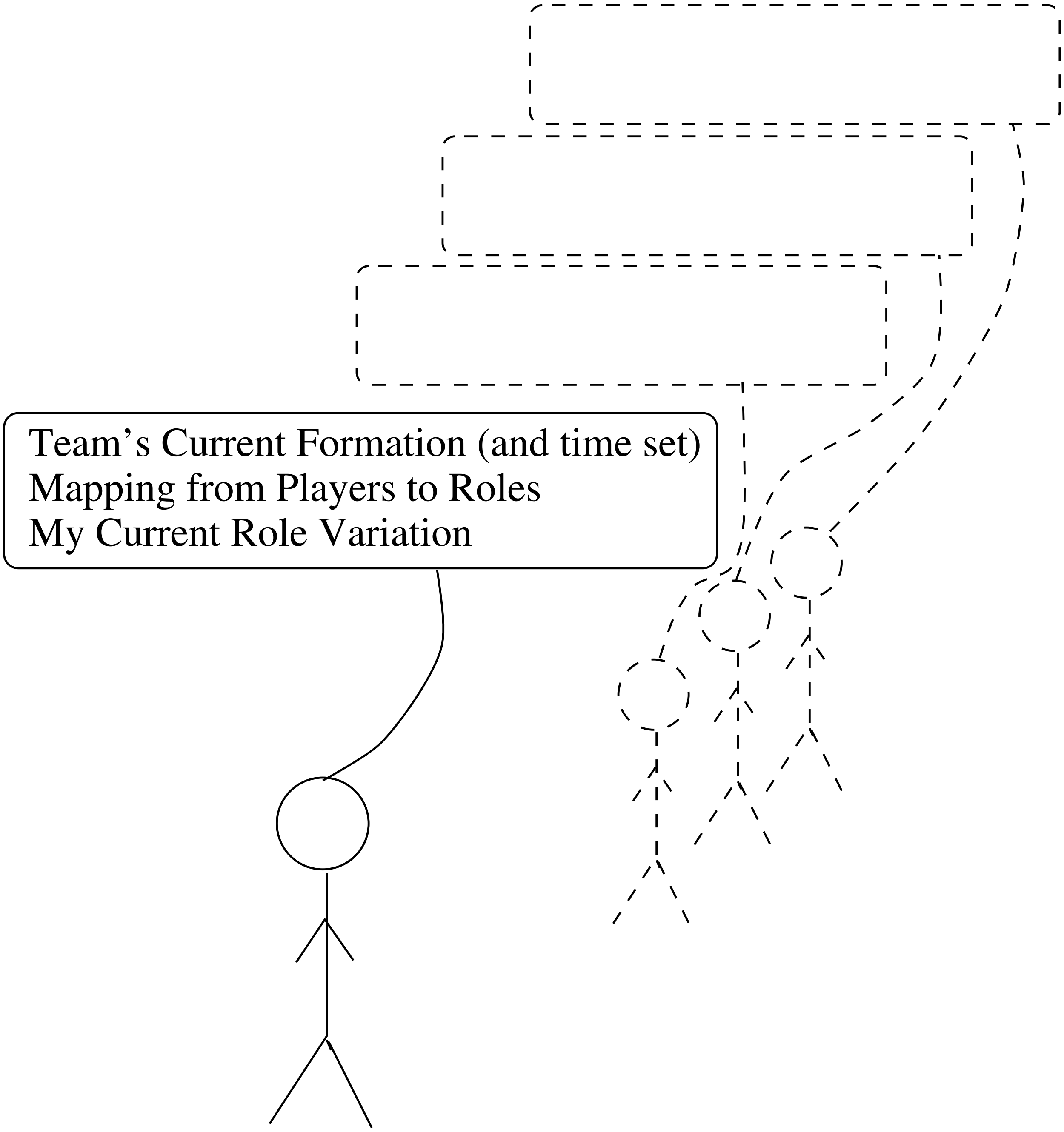
Set-play: $R_{sp} = \{spr_1, \ldots, spr_m\}, m \leq n$

- Pre-specified multi-agent plan
- Global trigger condition initiates set-play
- Roles mapped to set-play roles: $R \mapsto R_{sp}$
- spr_i defines behavior, termination condition

Roles and Formations



Autonomous Agents



Definitions

Position (Role) A flexible (partial) behavior specification

Formation A collection of Positions the same size as the team

Unit A (local) subset of the Positions in a Formation

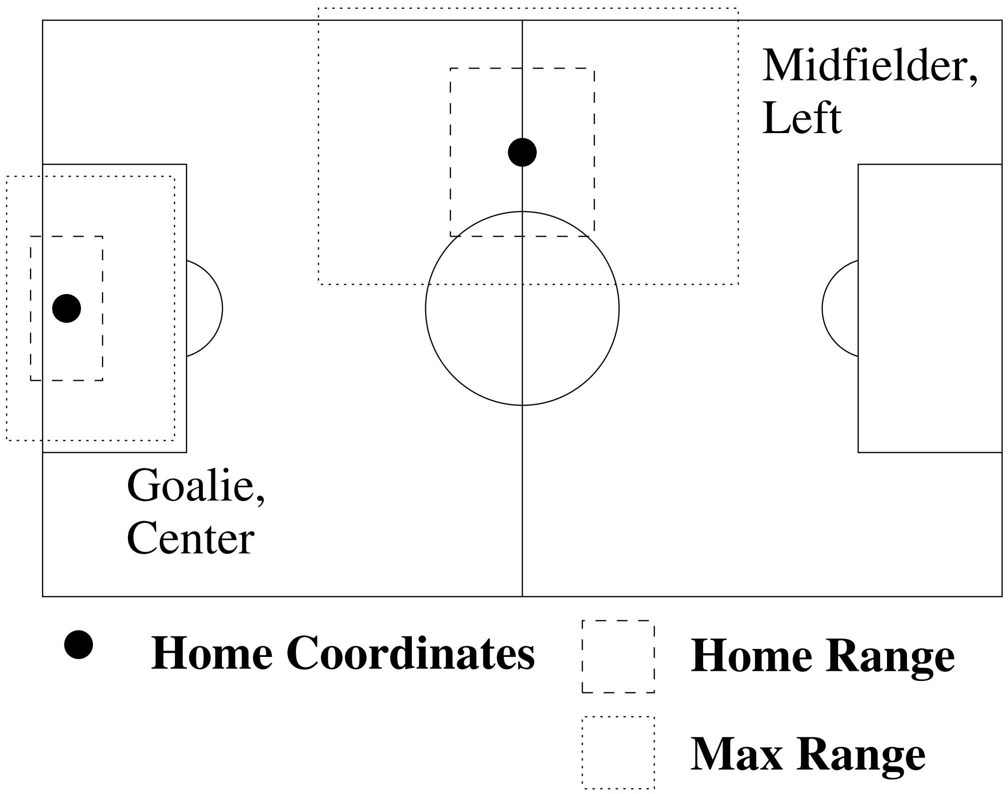
Captain The leader of a Unit

Player (Agent) Can fill any Role in Any Formation

Mode of Play A switch among behavior specifications

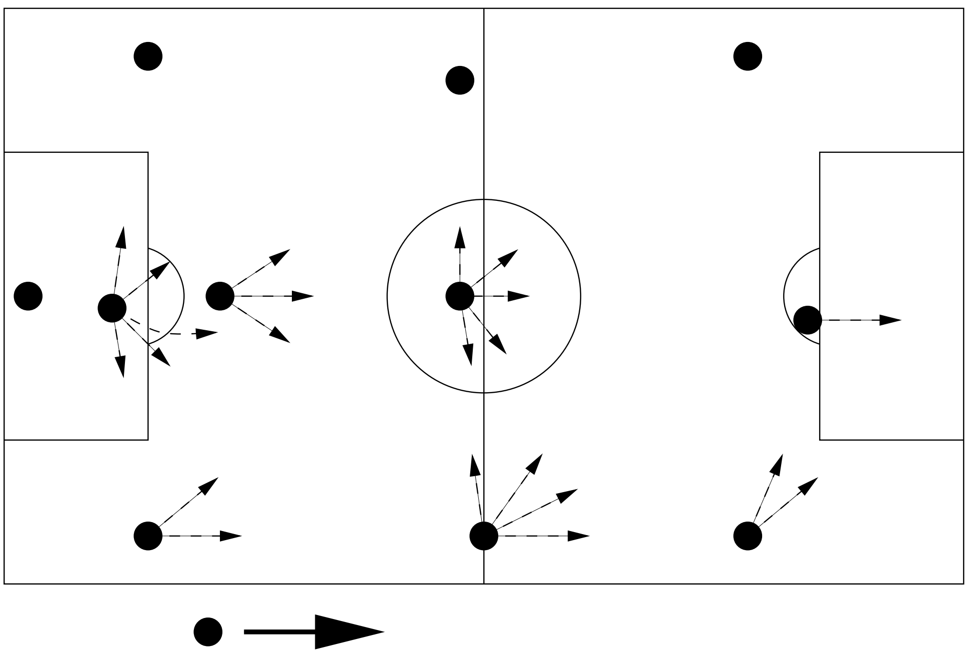
Position (Role)

- Home Coordinates
- Home Range ($\Rightarrow$ flexibility)
- Maximum Range
- Type (Goalie/Defender/Midfielder/Forward)
- Side (Left/Center/Right)



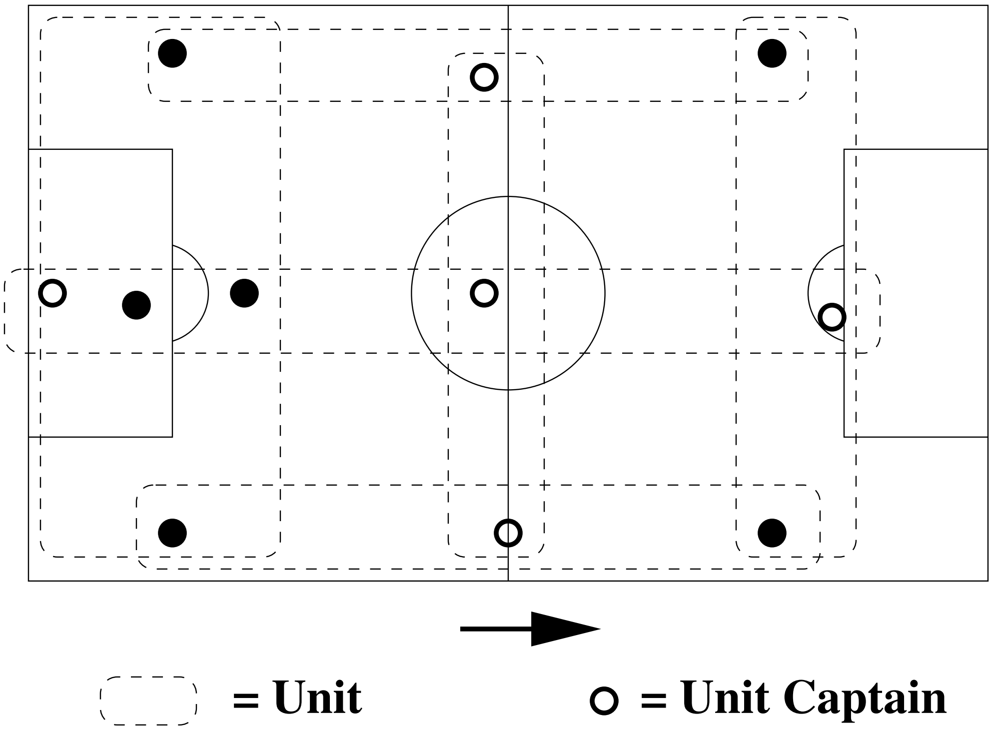
Formation

- List of positions
- List of candidate receivers by position
- List of Units



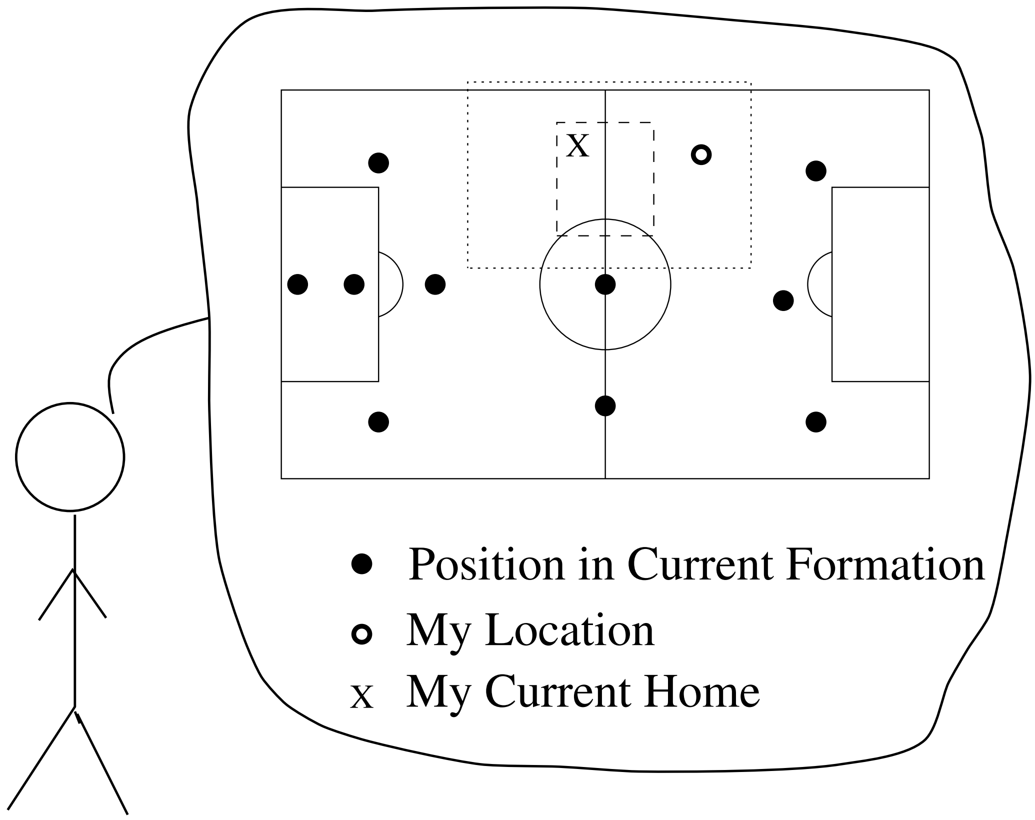
Unit

- List of positions in order of importance
- Captain
- Type (Defensive/Center/Left/etc.)
- Used to deal with problems of local importance



Player (Agent)

- Current Formation (with time)
- Map of Teammates $\longleftrightarrow$ Positions
- Current Home



Video

- Modes of play
- Multiple formations with units
- Flexible positions
- Changeable positions
- Special Purpose Plays (Set Plays)

Results

Tested a team using flexible teamwork **(flexible, changeable positions with set plays)** against one using fixed, rigid positions. Both used a 4-4-2 formation.

(Game = 10 min.)	Flexible	Rigid
Games won	31	3
Total goals	173	64
Avg. goals	4.55	1.68
Ball in own half	44%	56%
Avg. ball X	3.05	

Adversarial Behavior

Tested six different formations against each other

formation	total goals (for–against)	percentage
8-2-0	156–96	61.9%
3-3-4	308–267	53.6%
4-4-2	282–245	53.5%
4-3-3	289–271	51.6%
3-5-2	249–313	44.3%
2-4-4	293–385	43.2%

Team adjusts formation based on score and time

- Start in 3-3-4 formation
- Winning near end $\Longrightarrow$ 8-2-0
- All agents see score, time
- Locker-room agreement: triggers for switching