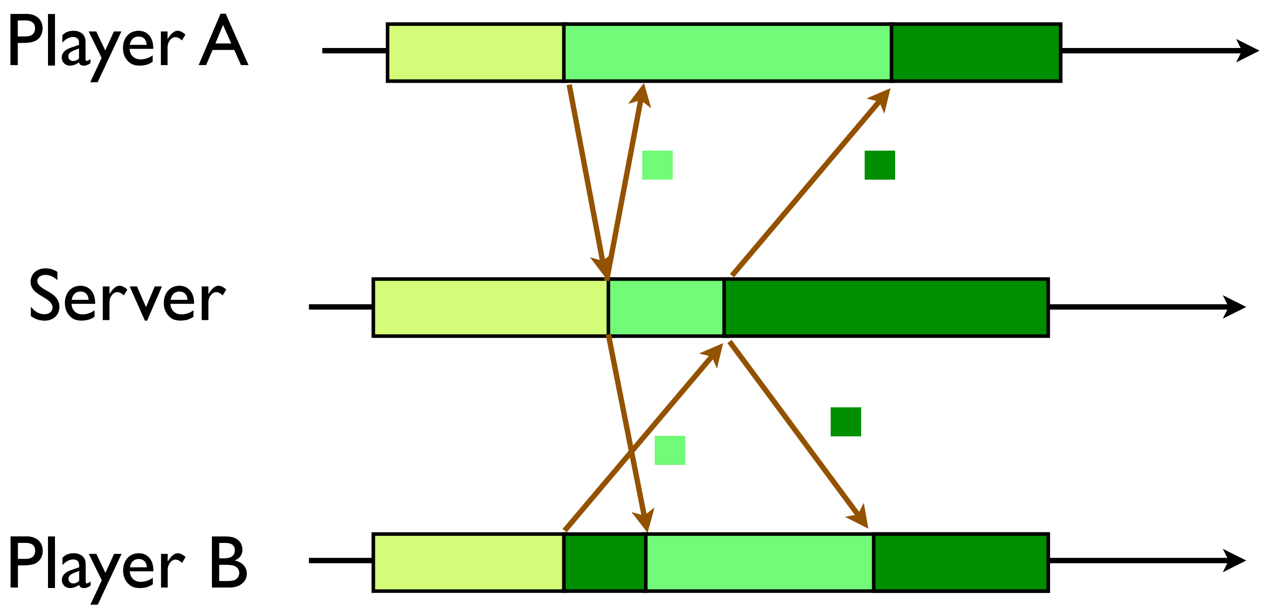
Centralized Server Architecture

Short circuiting: players perform "local prediction" to predict their own state without waiting for replies from the server.



Opponent Prediction

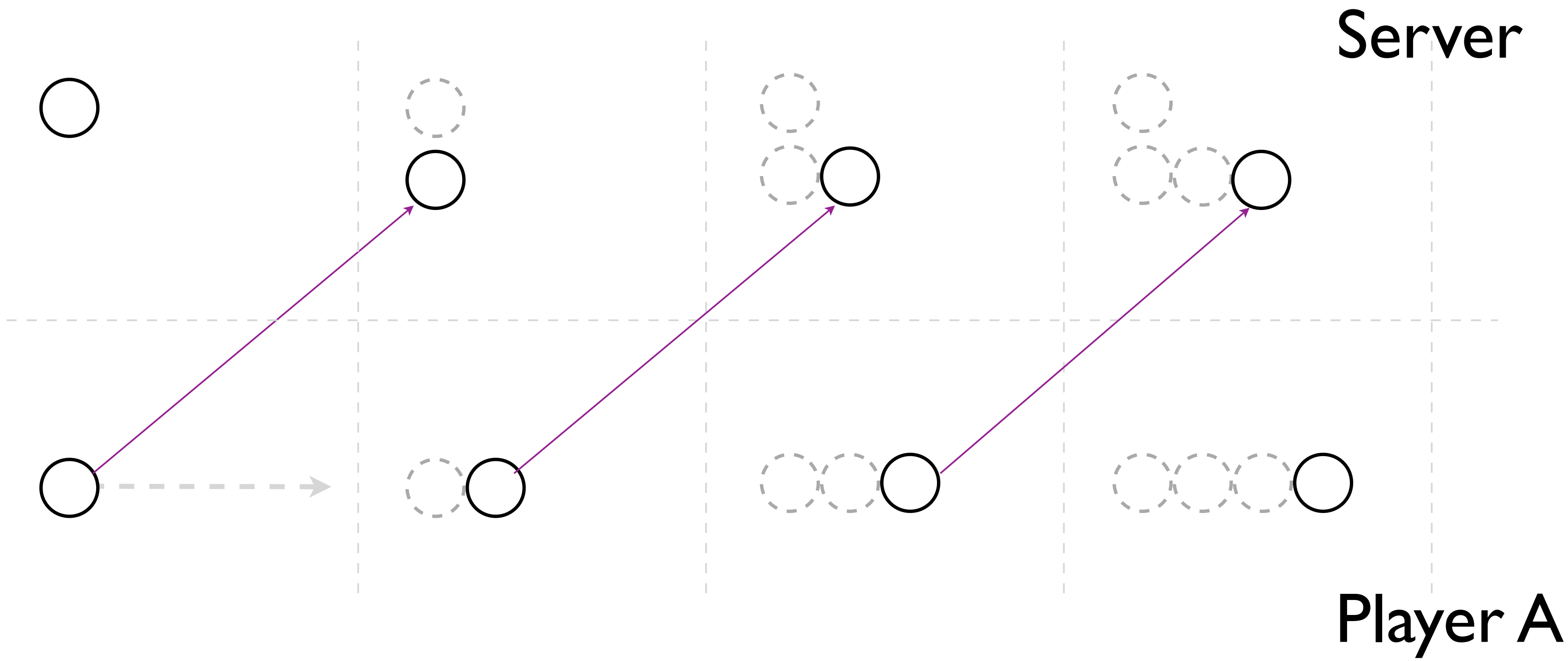
Dead Reckoning

Extrapolation

Also used in marine navigation, ariel navigation, GPS etc.

A general technique that works between any two parties (players/server). But we will see example for a server and a player.

Server keeps track of the position of entities through updates from the players.

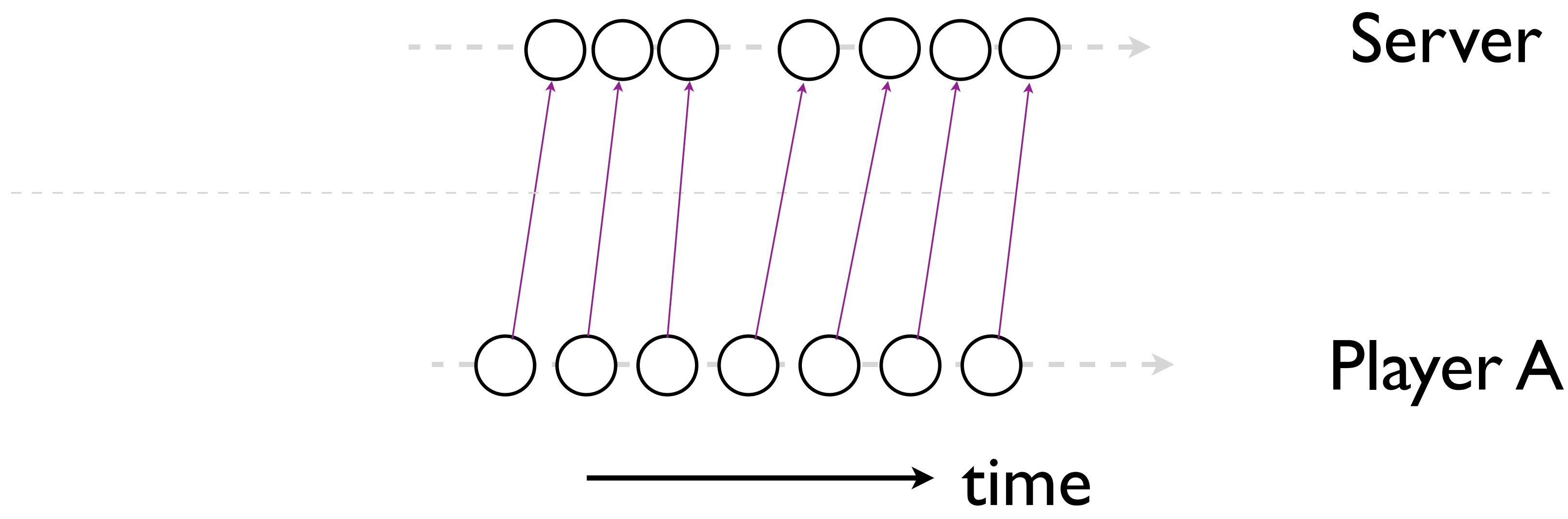


Naive method: update position only

Two issues:

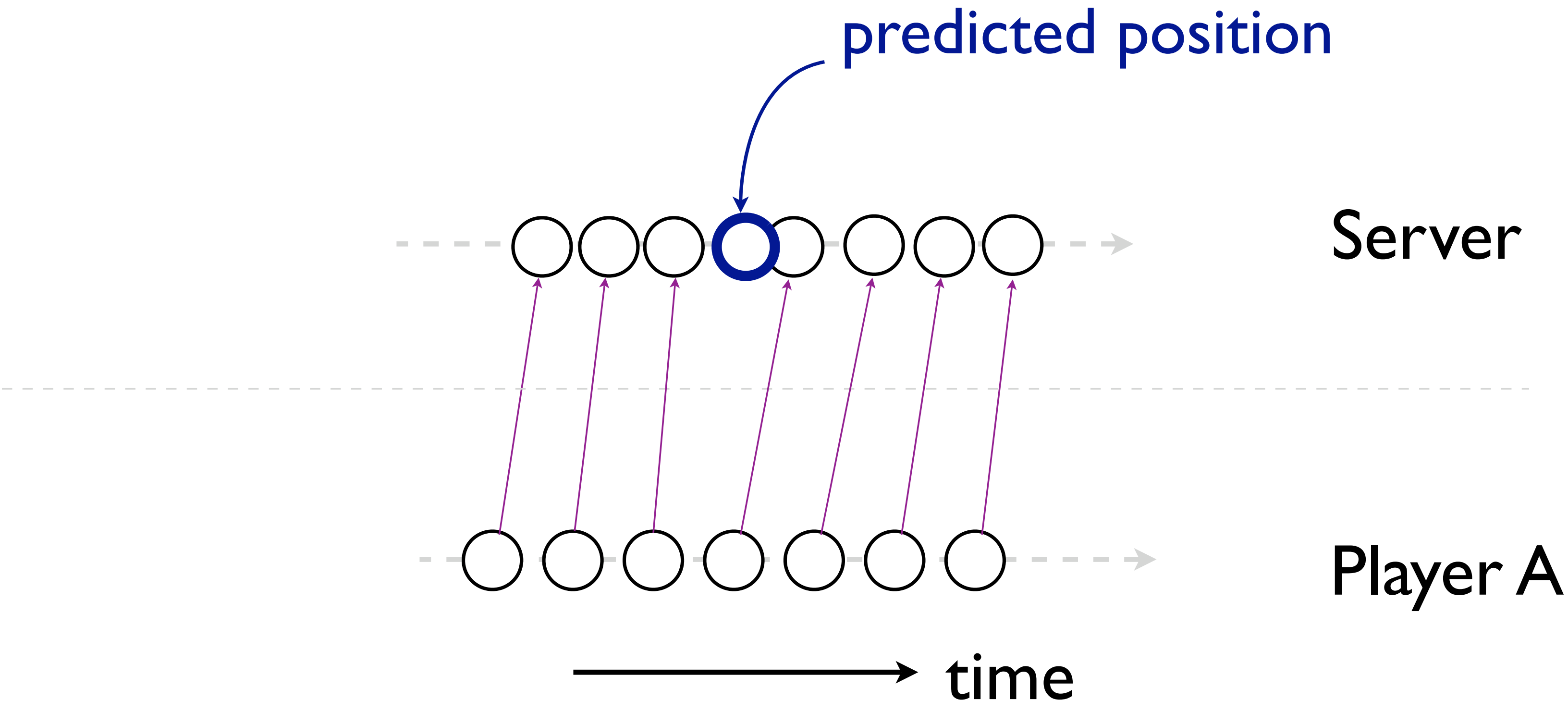
Message overhead
Delay jitter

Delay jitter causes player's movement to appear erratic.

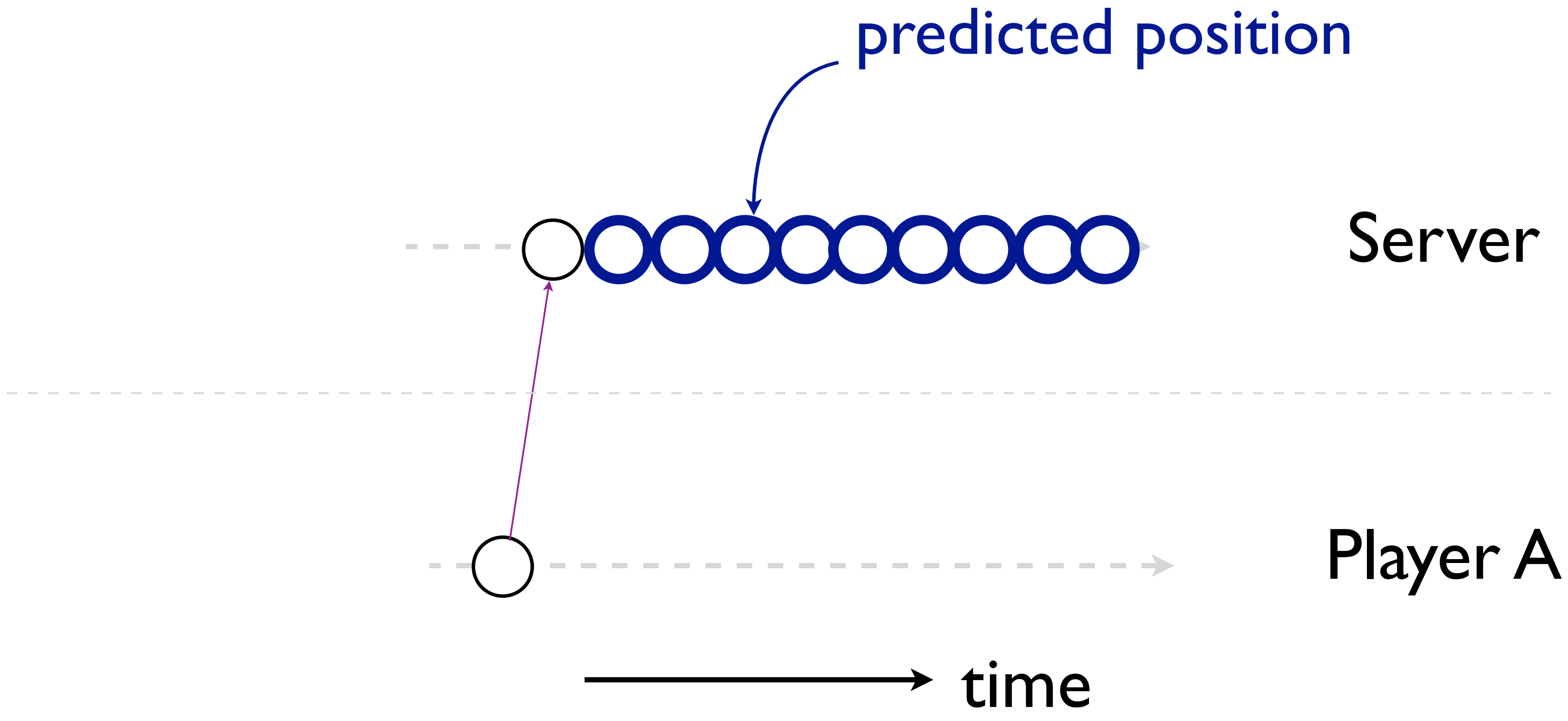


Naive method: update position only

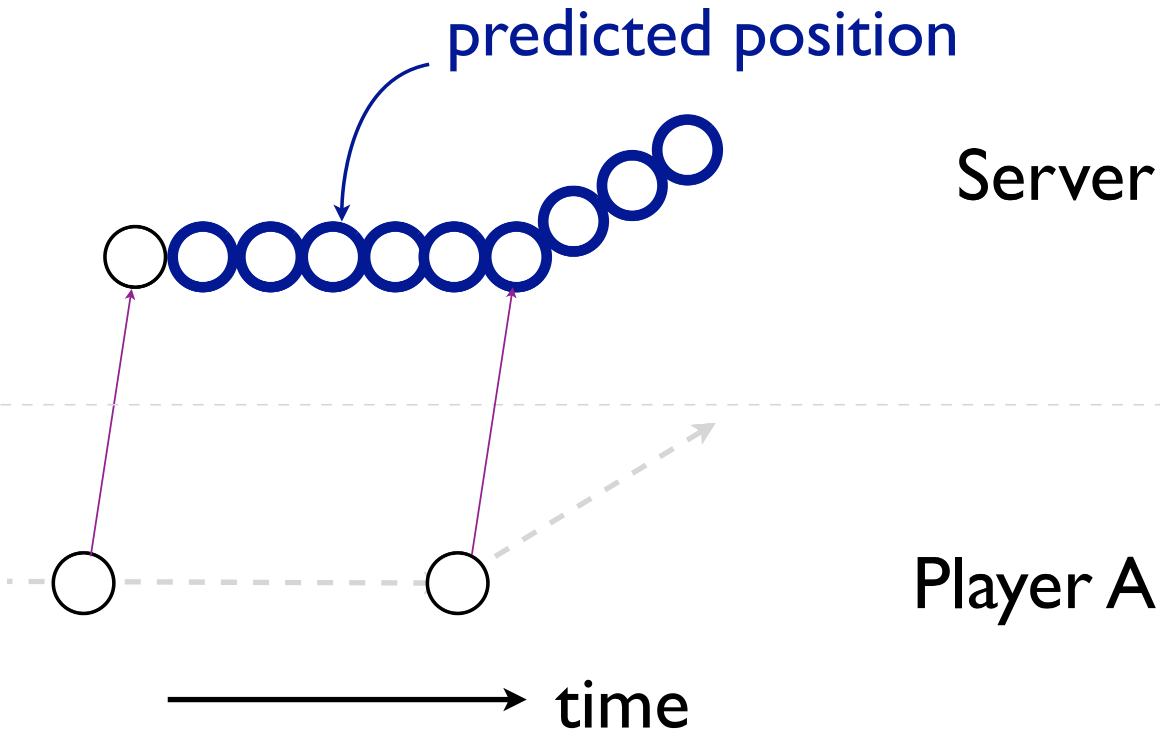
Improvement: update the position and velocity -- if an update arrives late, server can predict B's position.



Improvement: if the velocity remain constant, server can predict every position at all time.



Server, however, needs to update position and velocity when velocity has changed.

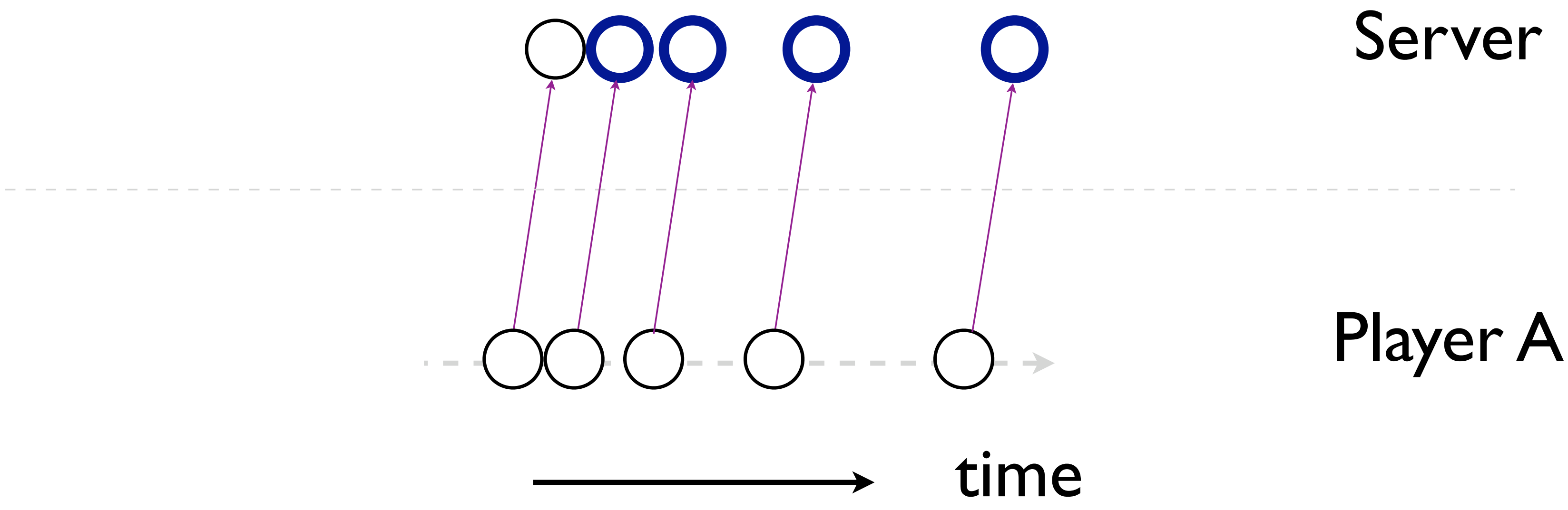


$x[t]$ position of entity at time t

v velocity of the entity

$$x[t_i] = x[t_{i-1}] + v \times (t_i - t_{i-1})$$

But velocity may change all the time (e.g. a car accelerating). To counter this, we send position, velocity, and acceleration as update.



$x[t]$	position of entity at time t
v	velocity of the entity
a	acceleration of the entity

$$x[t_i] = x[t_{i-1}] + v(t_i - t_{i-1}) + \frac{1}{2}a(t_i - t_{i-1})^2$$

caution: any delay in updating the acceleration would result in large error in position.

History-based Prediction

$x[t]$ position of entity at time t

v velocity of the entity

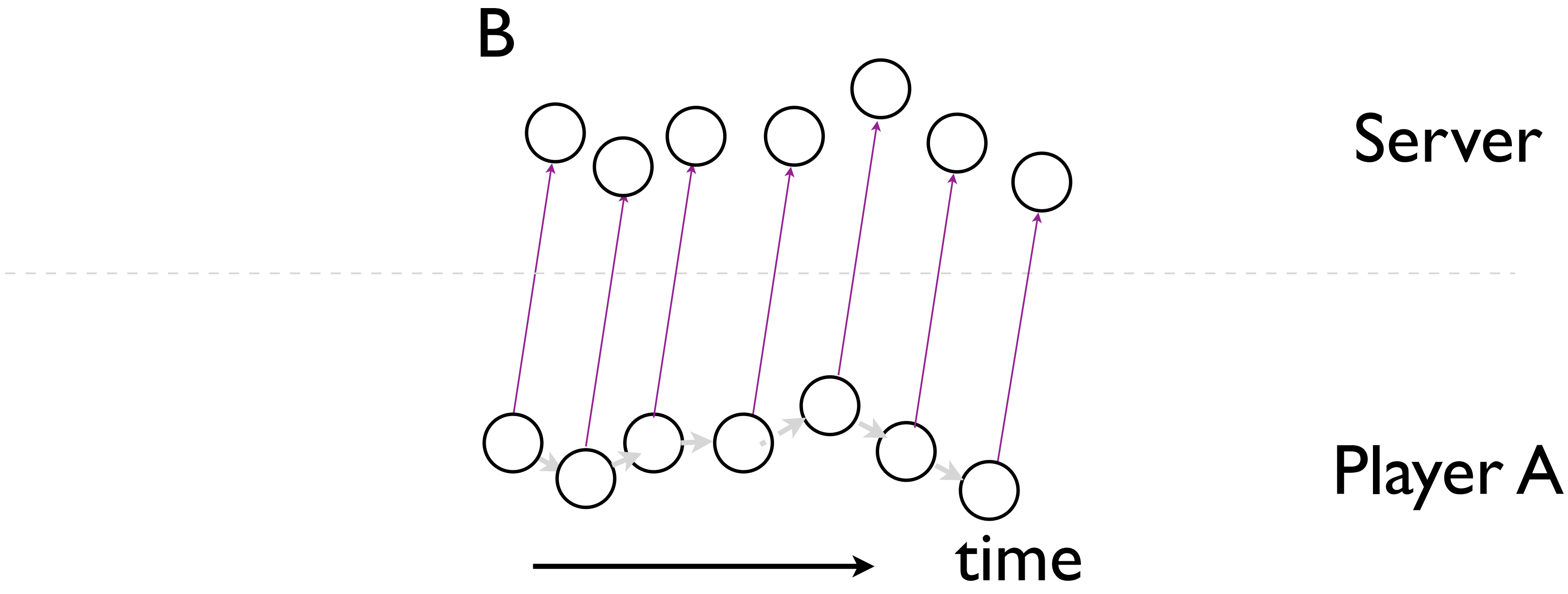
$$v = \frac{x[t_{i-1}] - x[t_{i-2}]}{t_{i-1} - t_{i-2}}$$

$$x[t_i] = x[t_{i-1}] + v \times (t_i - t_{i-1})$$

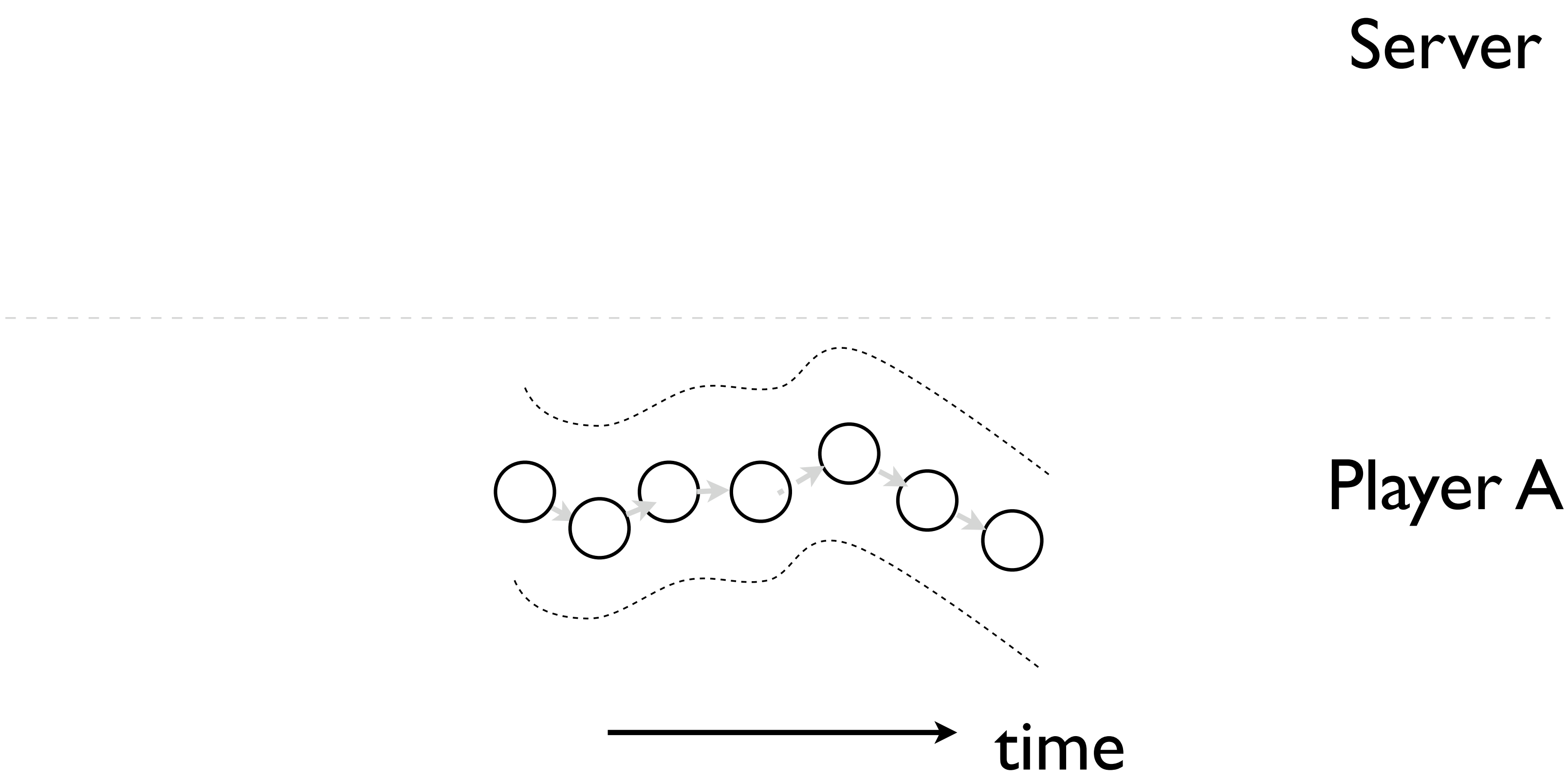
$x[t]$ position of entity at time t

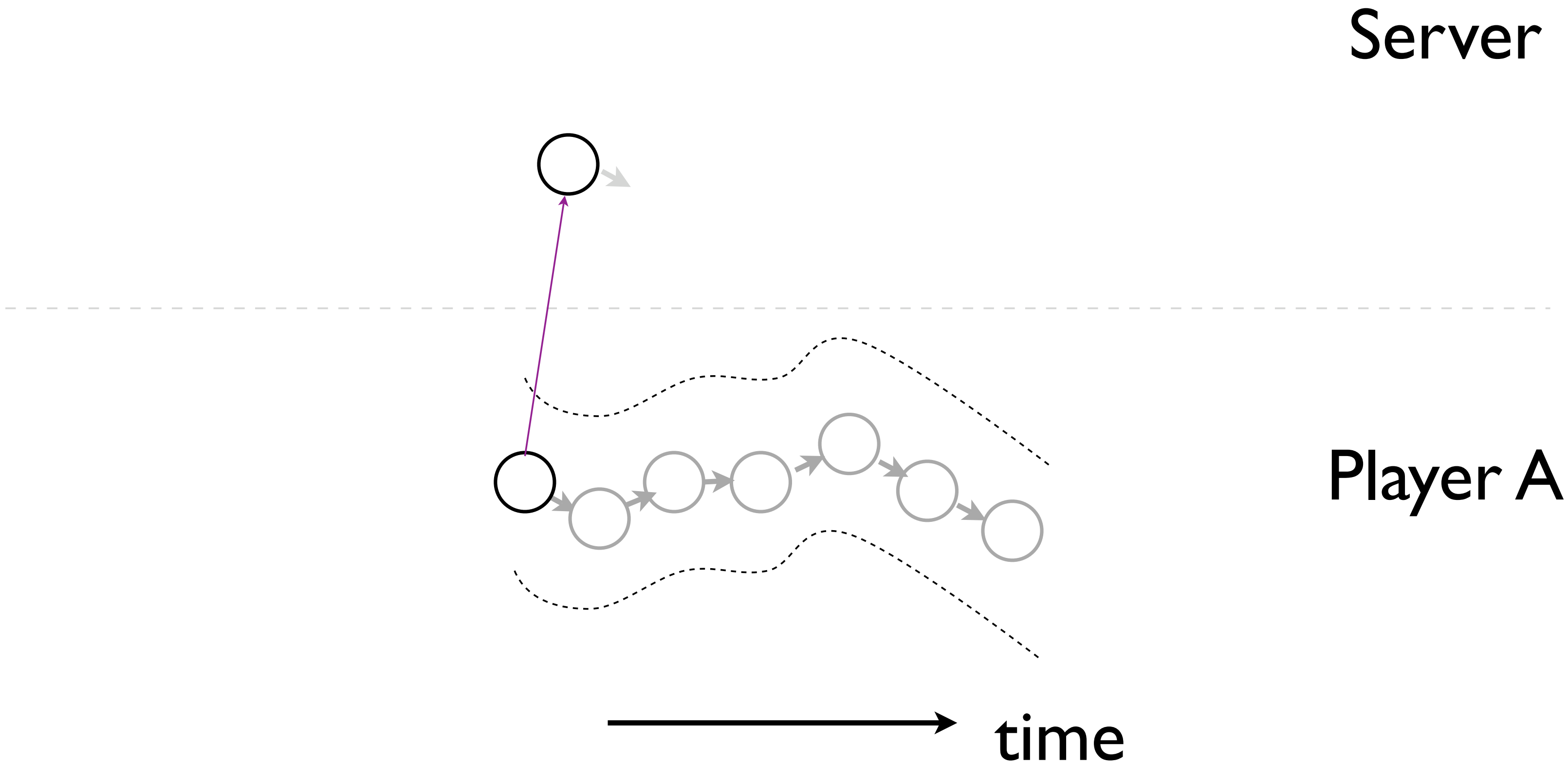
$$x[t_i] = x[t_{i-1}] + \frac{t_i - t_{i-1}}{t_{i-1} - t_{i-2}}(x[t_{i-1}] - x[t_{i-2}])$$

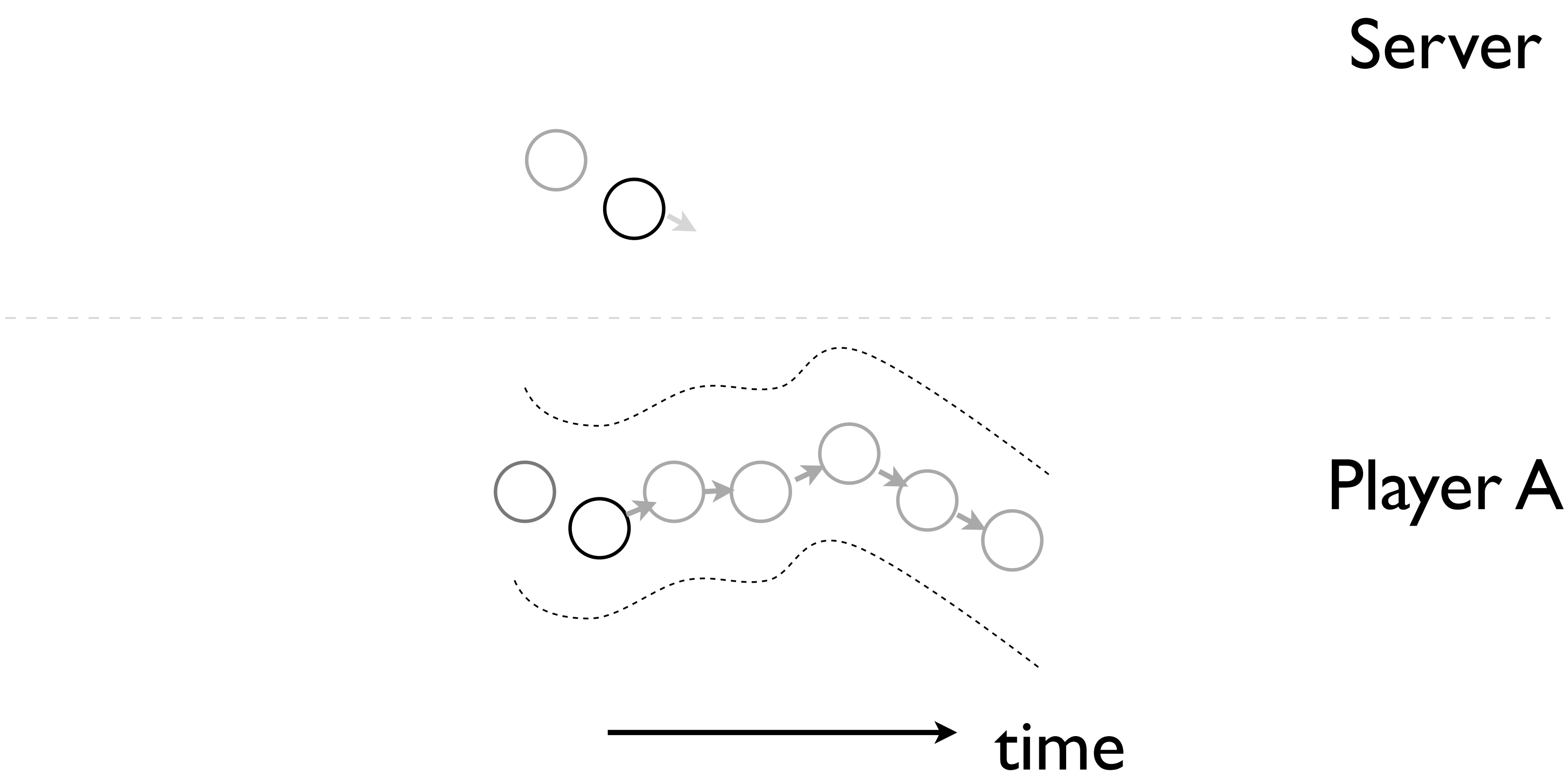
We will still need substantial number of updates if the direction changes frequently (e.g. in a FPS game).



idea: trade-off message overhead and accuracy. No need to update if error is small.

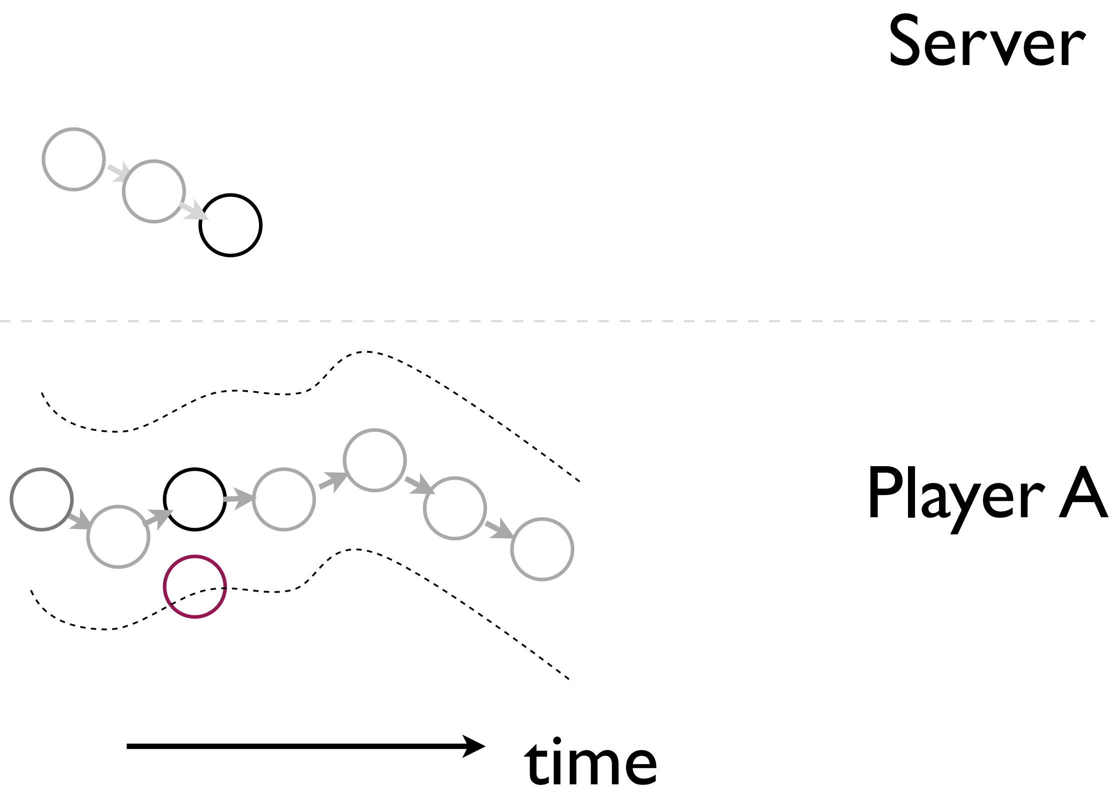

Server
Player A
time


Server
Player A
time

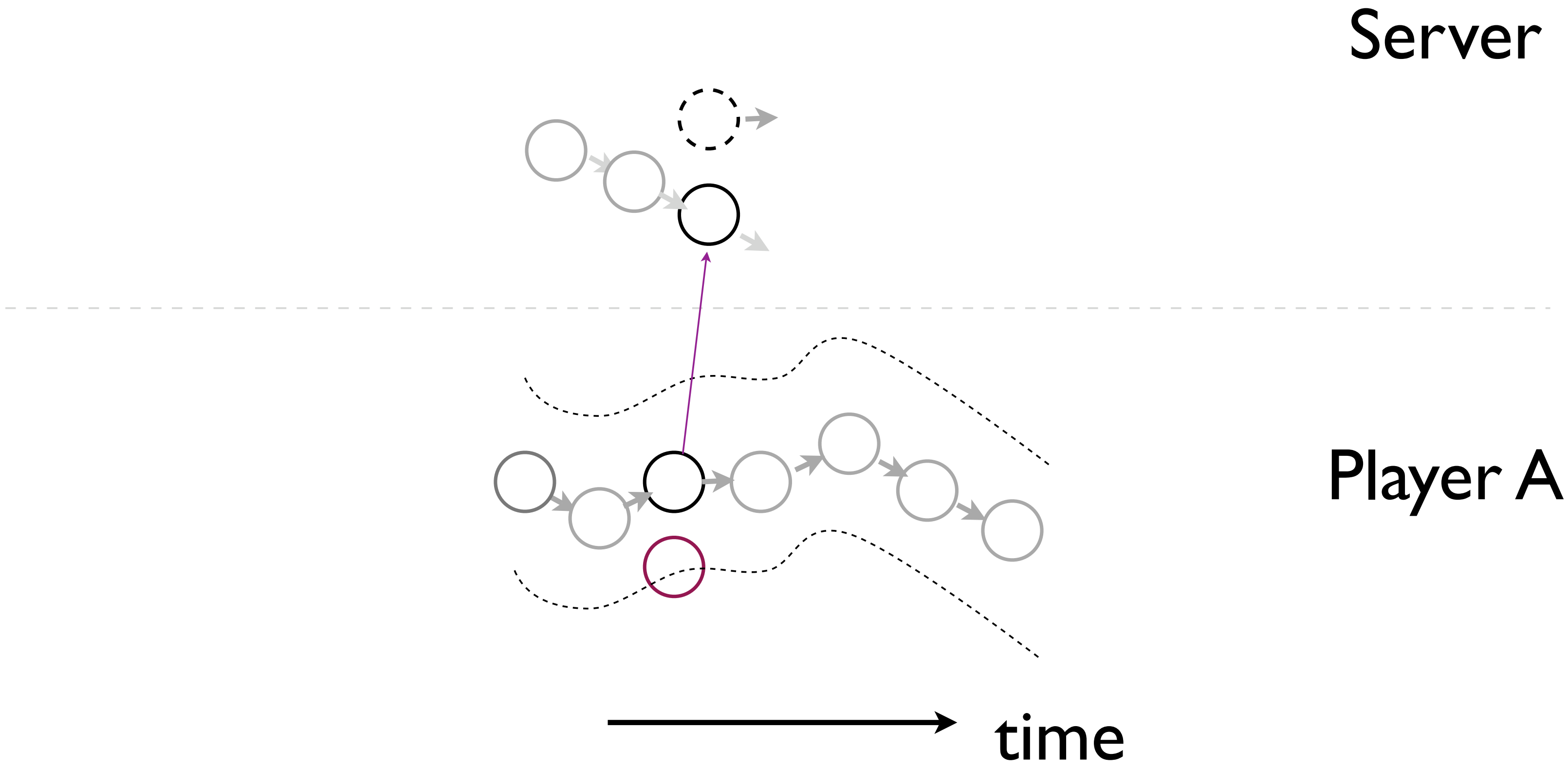

Server
Player A
time

○ where the entity is according to server

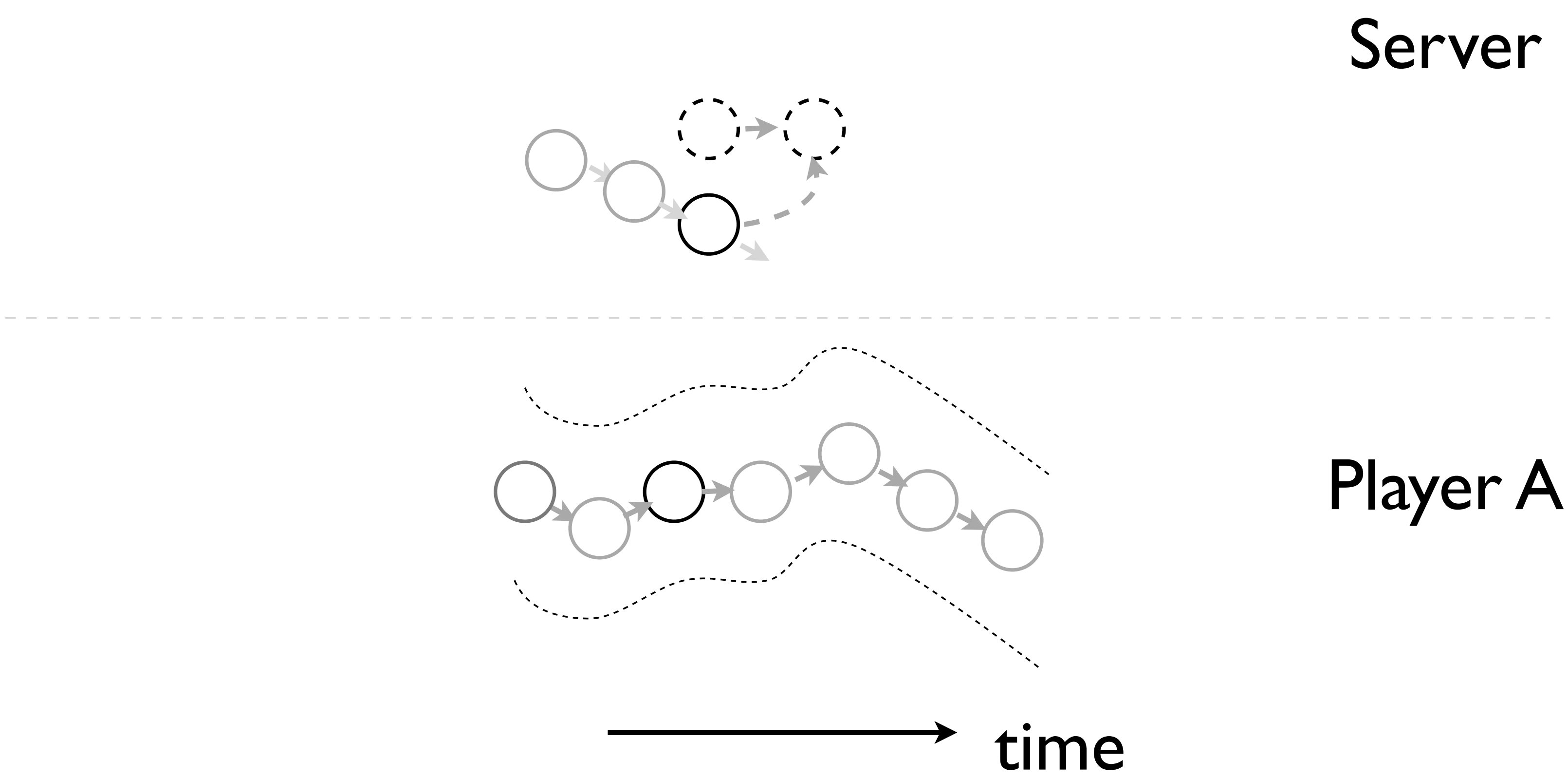
○ where the entity is according to A at the server



A’s version of the entity’s position is now too far away from the correct position. Server updates A with the new velocity and position.



A converges the entity to the correct position smoothly.



How to set threshold?

Depends on games. One can adapt the threshold according to requirement (e.g. distance to other players)

drawback: higher CPU cost -- since a player needs to simulate the opponent.

drawback: player with higher latency experience more error (but we can introduce server lag to equalize the error).

Generalized Dead Reckoning : Prediction Contract

e.g.: “return to base” : the path of the unit can be predicted if the same path finding algorithm is executed.

e.g.: "drive along this road"

Responsive

Consistent

Cheat-Free

Fair

Scalable

Efficient

Robust

Simple

- Predictions, both local and opponent prediction, is discussed in [Armi06] Section 6.2. Dead reckoning is discussed in Section 9.3 of [Smed06].

- **[Smed06]** J. Smed and H Hakonen, "*Algorithms and Networking for Computer Games*", Wiley, July 2006.

  [Armi06] G. Armitage, M. Claypool and P. Branch, "*Networking and Online Games: Understanding and Engineering Multiplayer Internet Games,*" Wiley, June 2006.

Putting it all together..

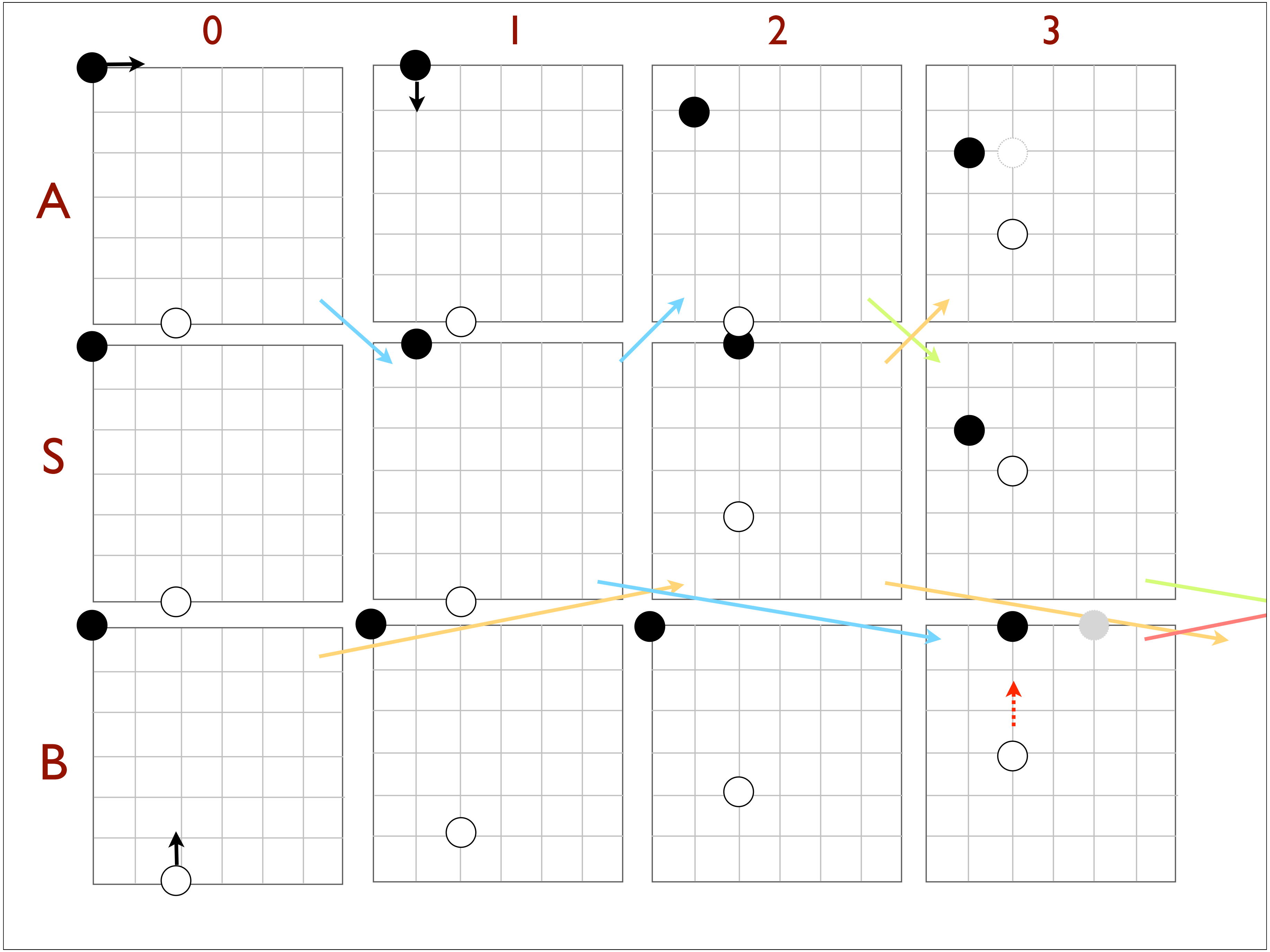
convergence period = 1

latency between A and S = 1

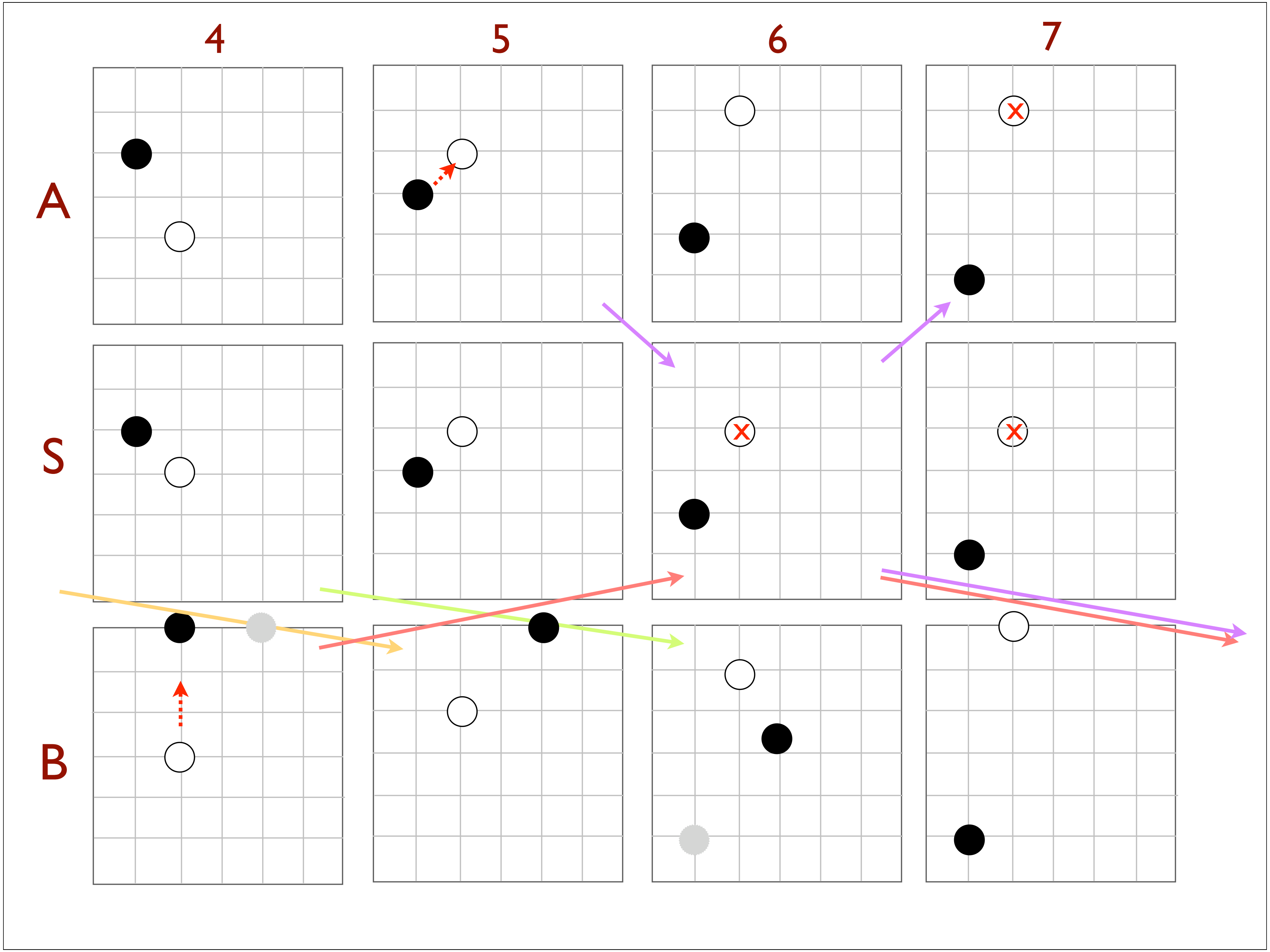
latency between B and S = 2

DR threshold = 1

latency is known



0
1
2
3
A
S
B


4
5
6
7
A
S
B