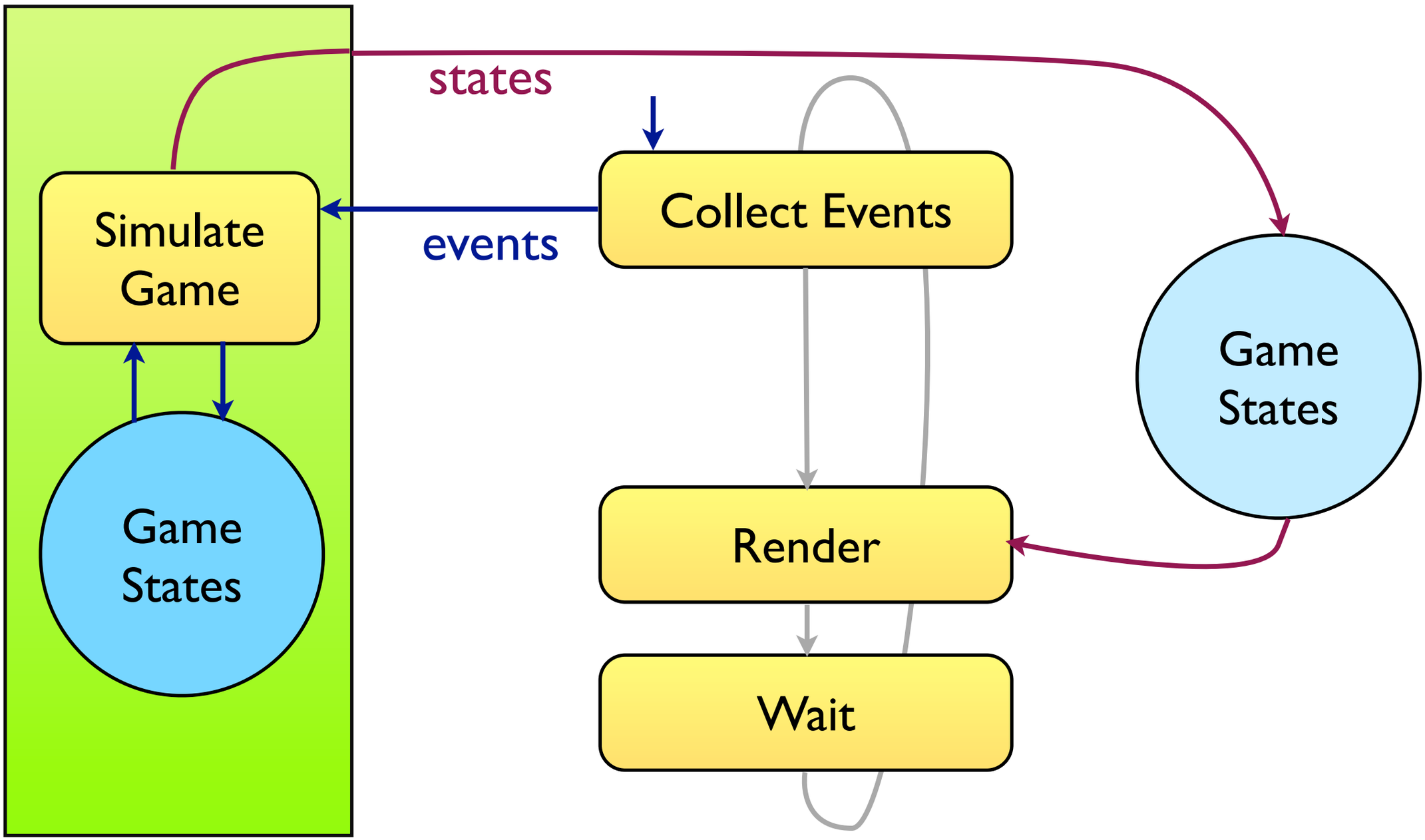
Lecture 3

Dead Reckoning

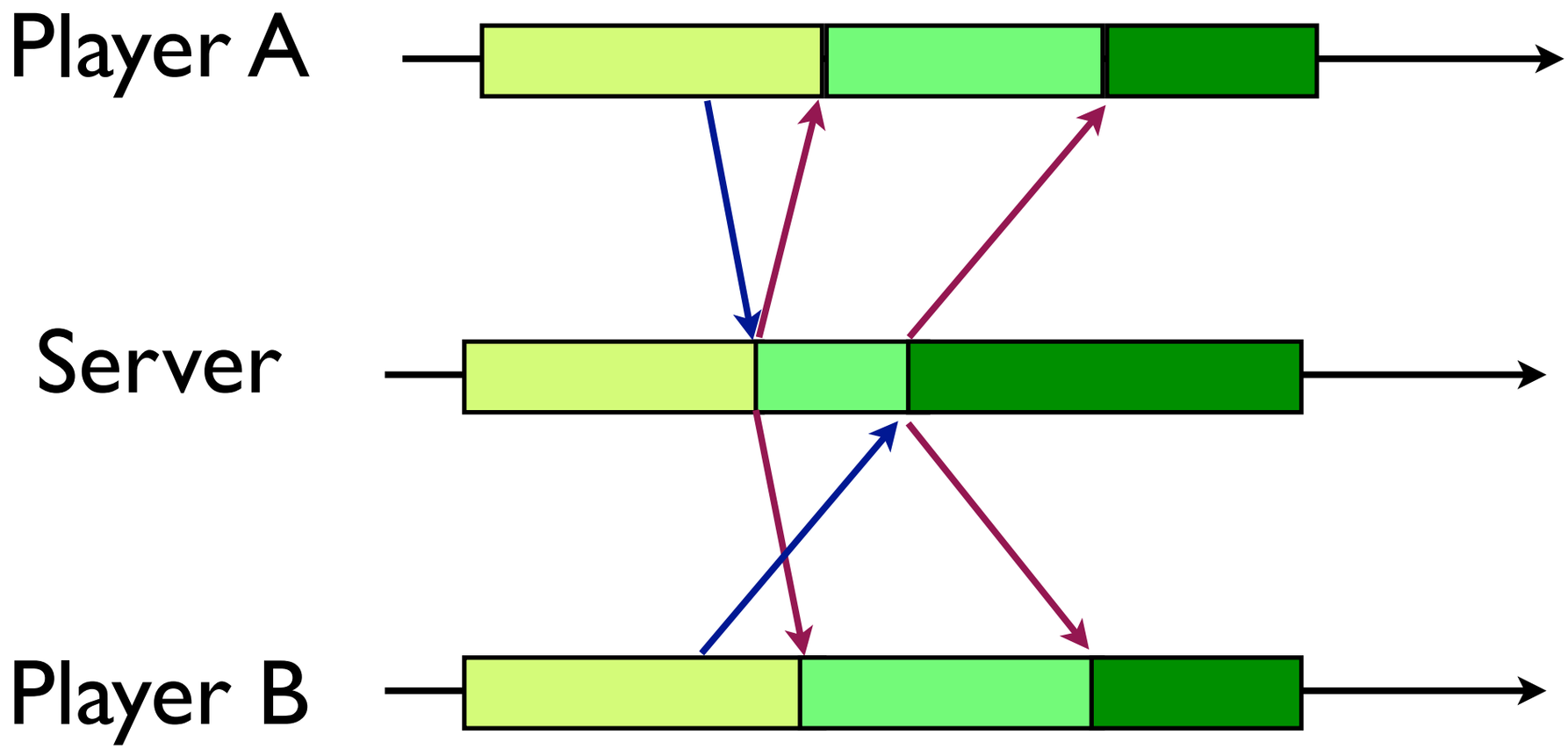
and

Local Perception Filter

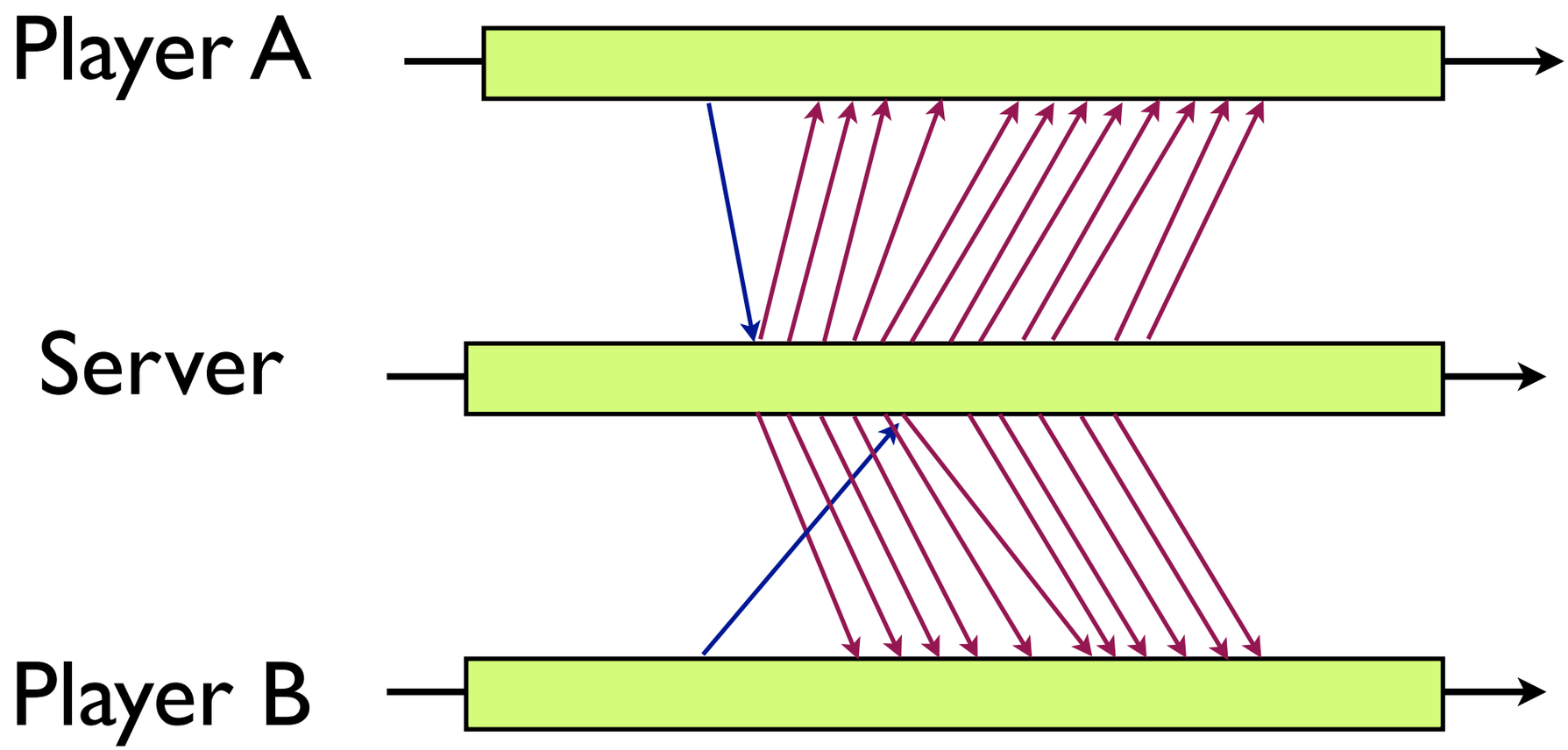
25 January 2010


states
Simulate Game
events
Collect Events
Game States
Game States
Render
Wait

What if a state changes continuously (i.e., is a function of time) ?



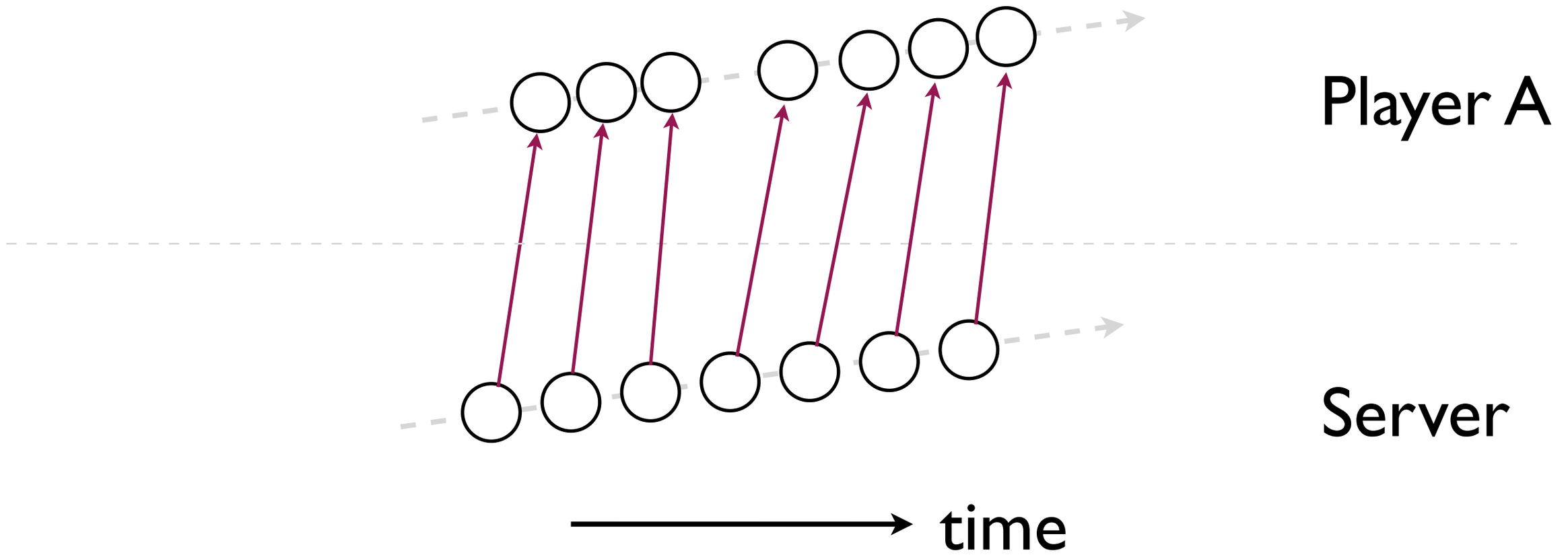
Consider position updates of players. Players send move command. Server replies with positions periodically.



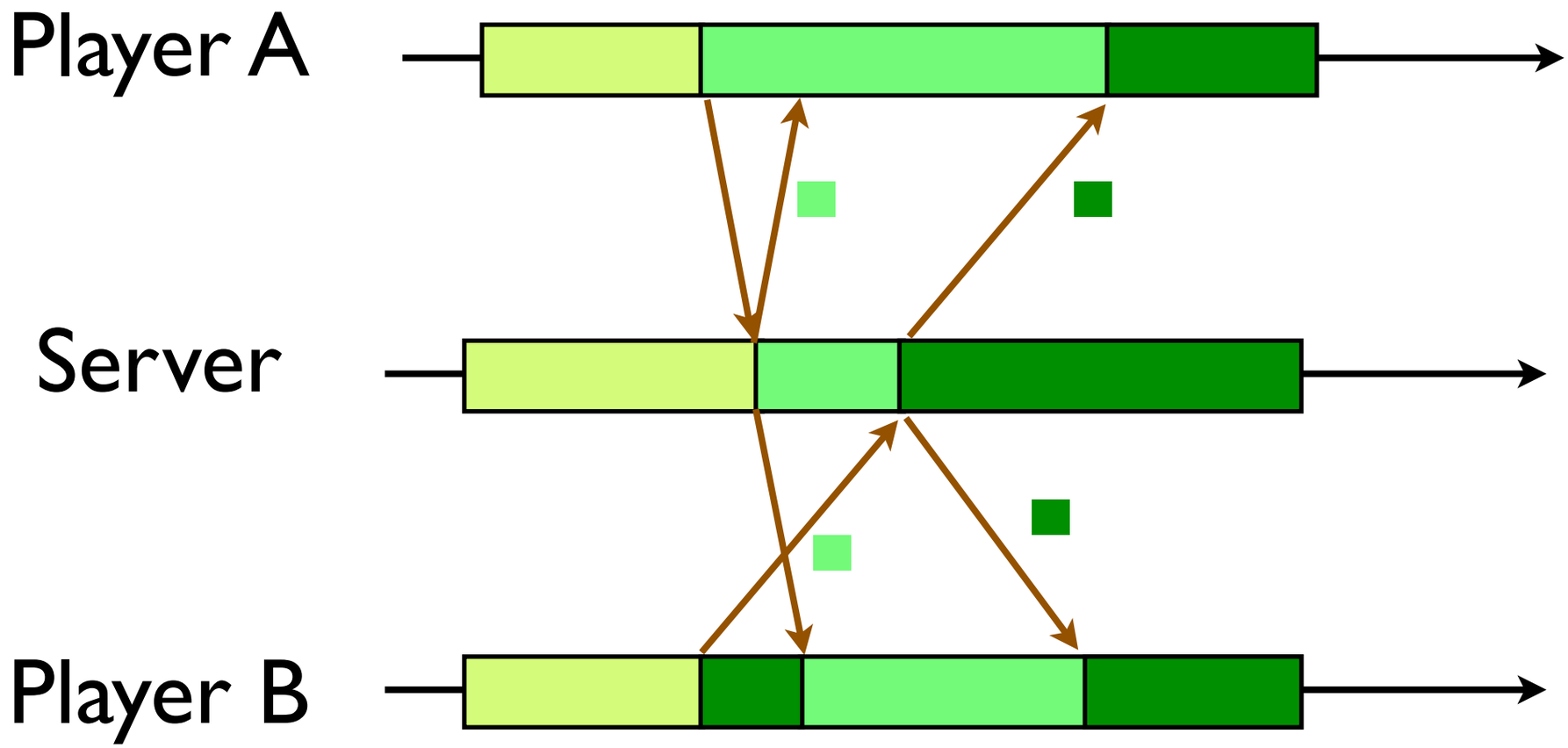
Two issues:

1. Message overhead
2. Delay jitter

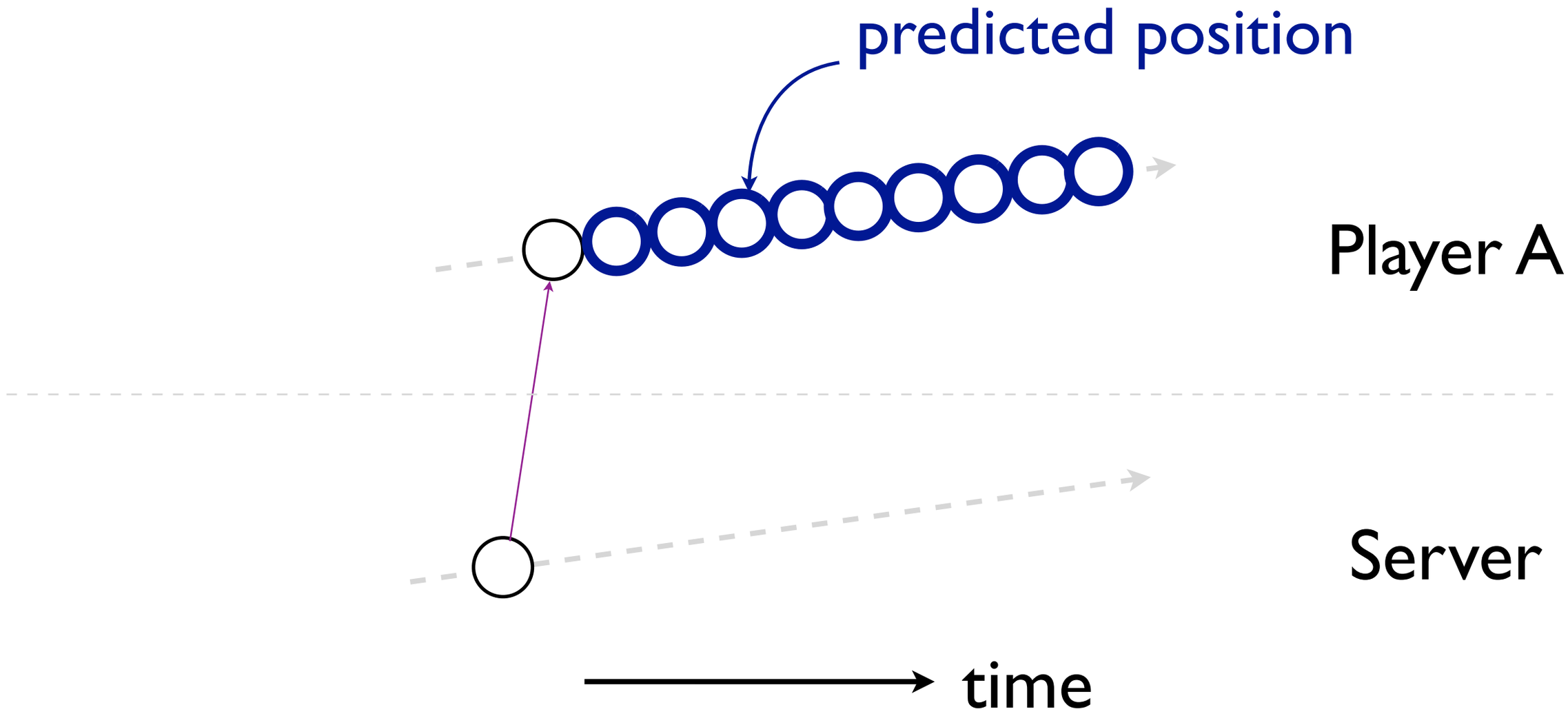
Delay jitter causes player's movement to appear erratic.



Recall: Short circuiting is used to predict own states. We can similarly predict opponent's state.



Suppose the velocity remains constant, then we can predict every position at all time.

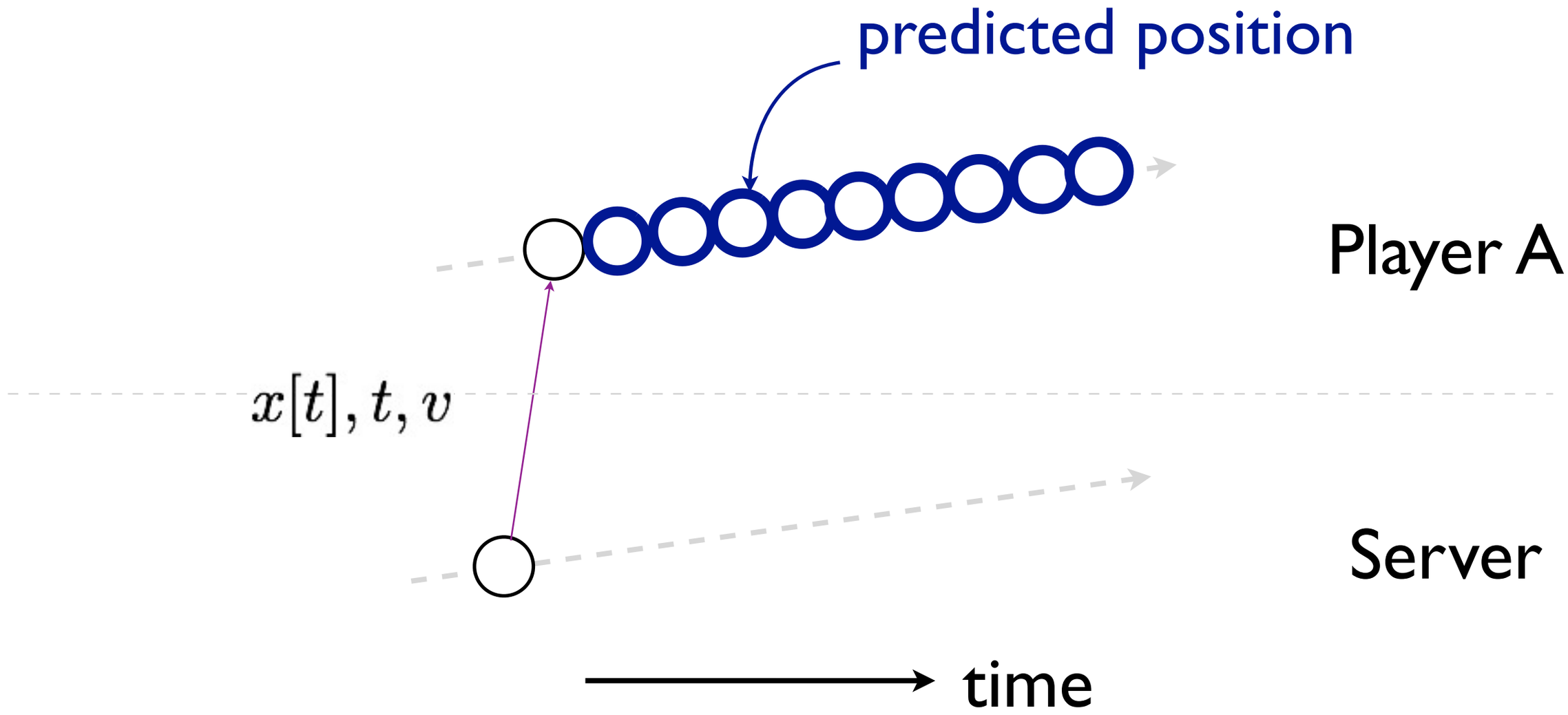


$x[t]$ position of entity at time t

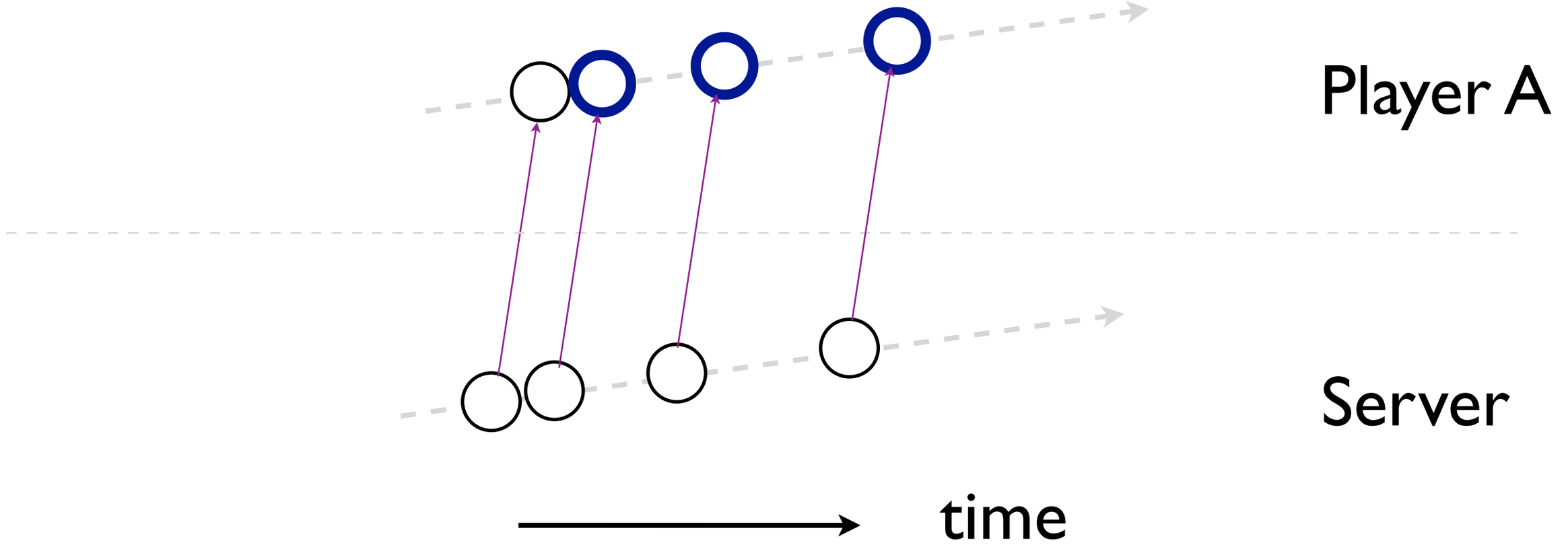
v velocity of the entity

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

We send over the initial position x[t], t, and velocity. (Why do we need to send t?)



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



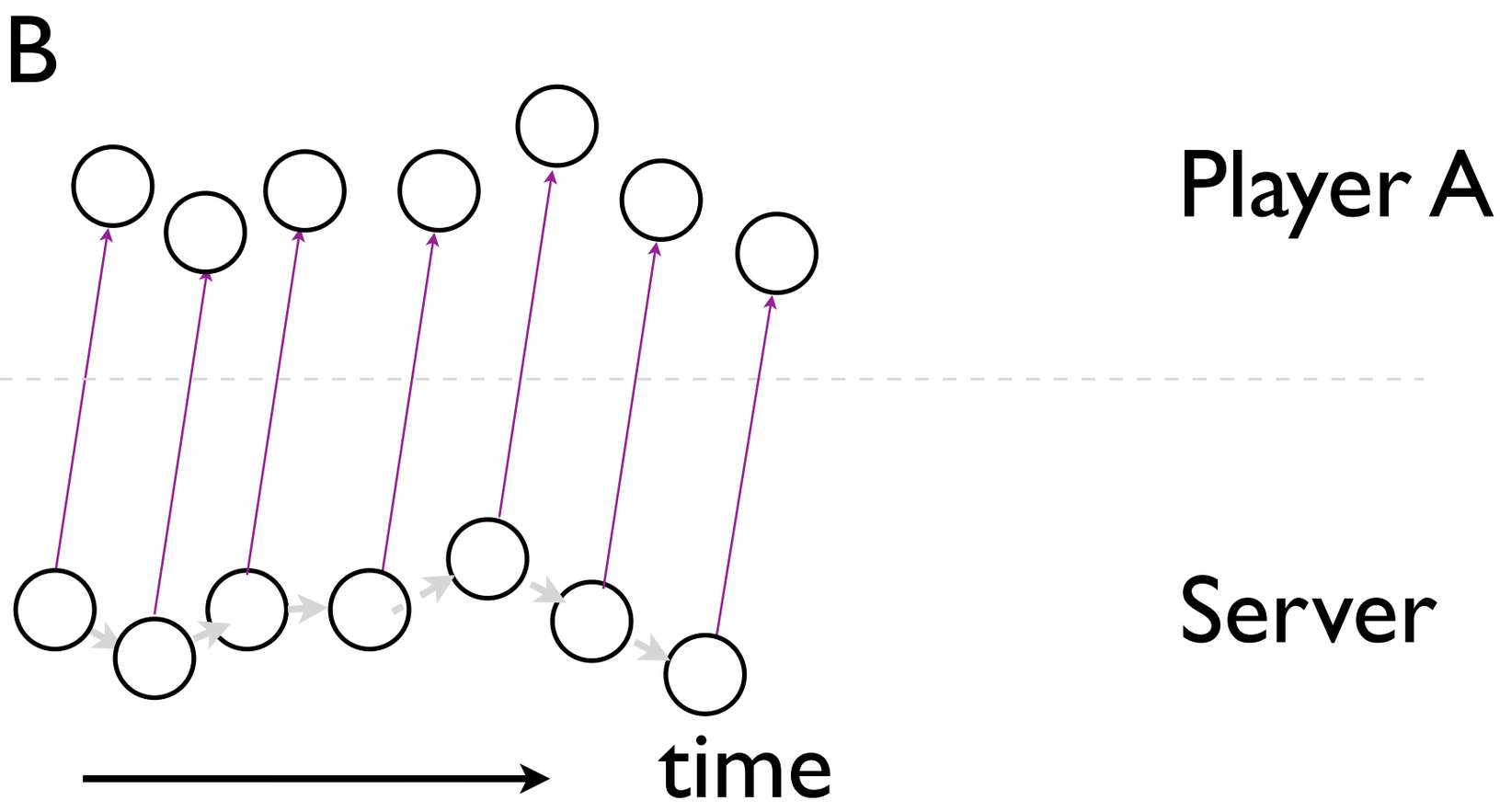
$x[t]$ position of entity at time t

v velocity of the entity

a acceleration of the entity

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

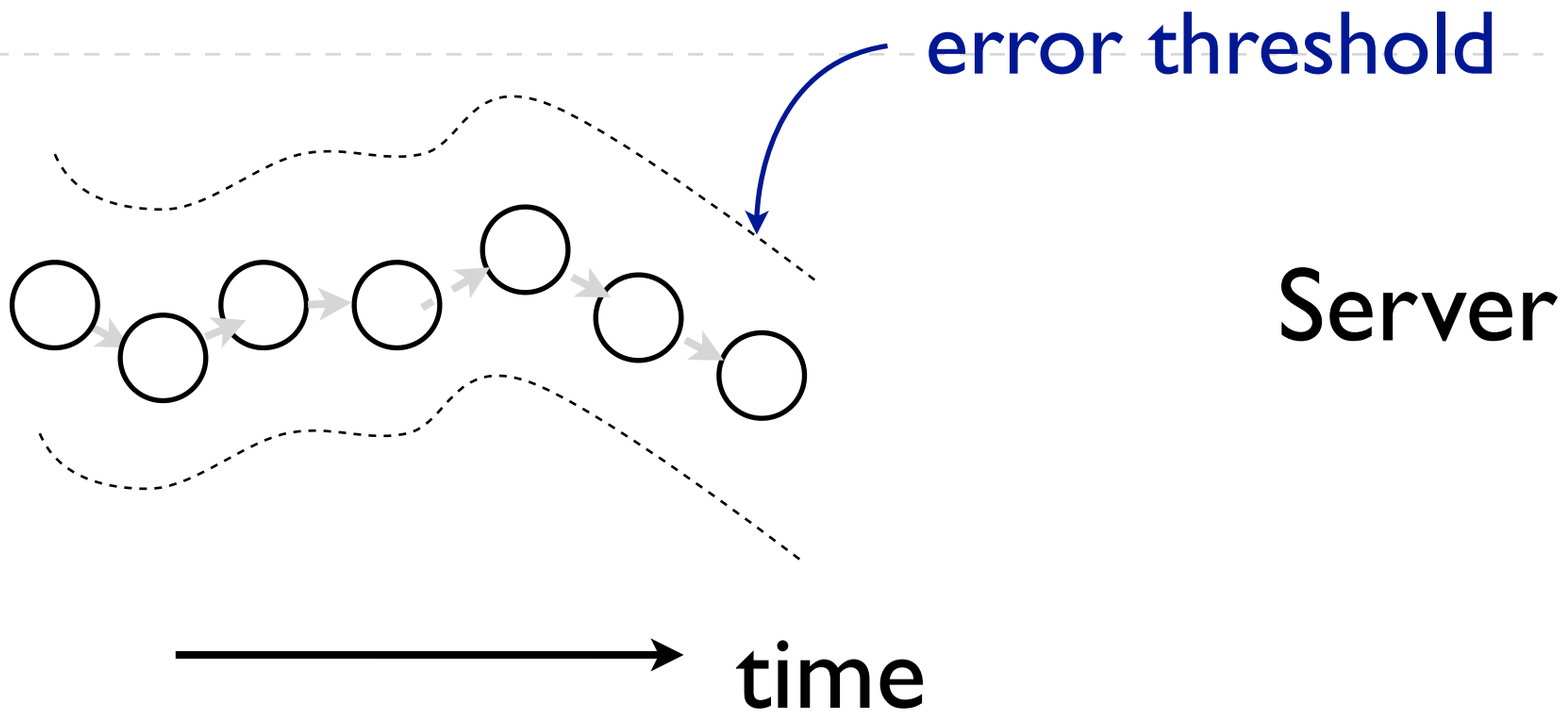
We will still need substantial number of updates if the direction changes frequently (e.g. in a FPS game).

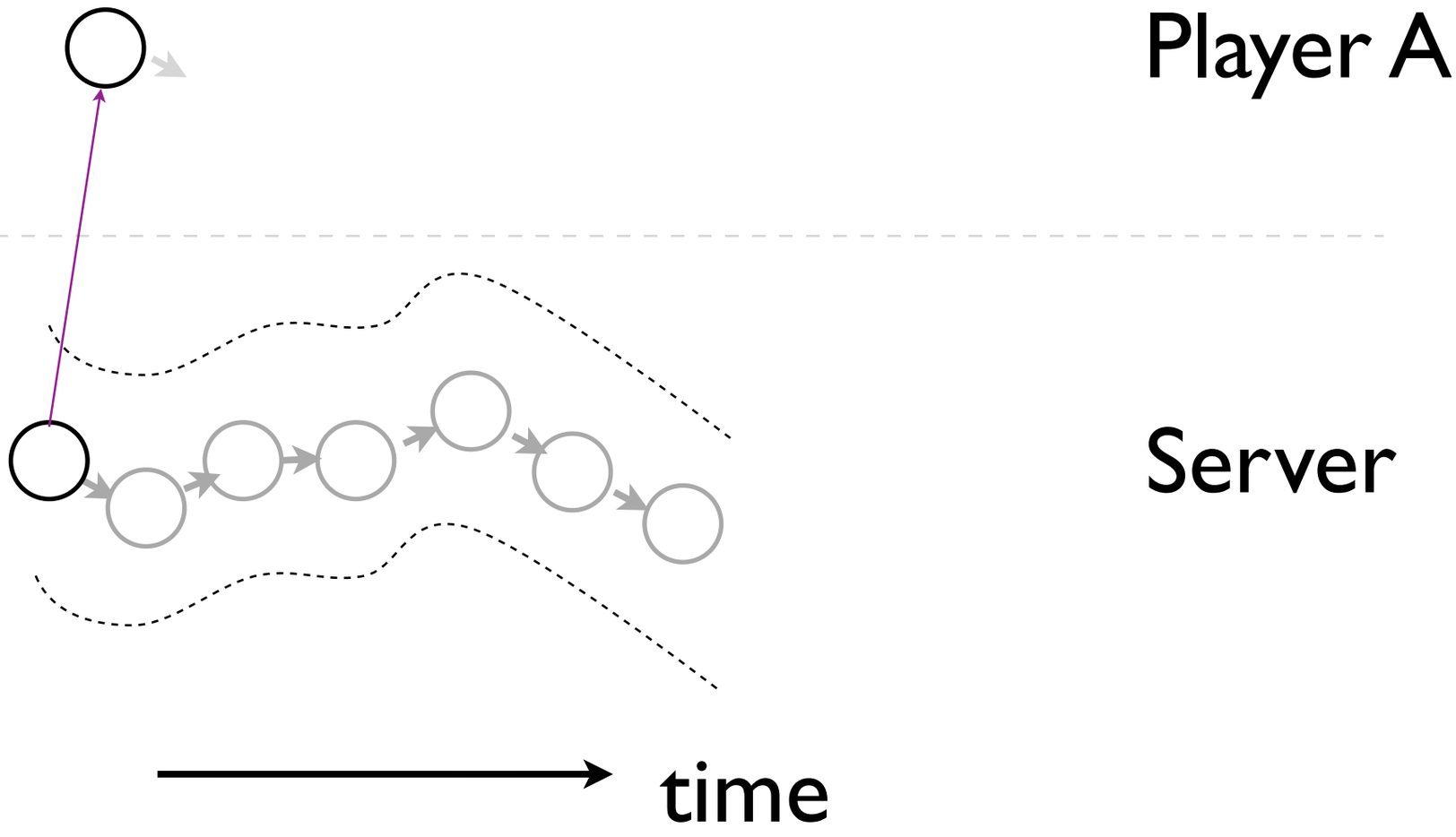


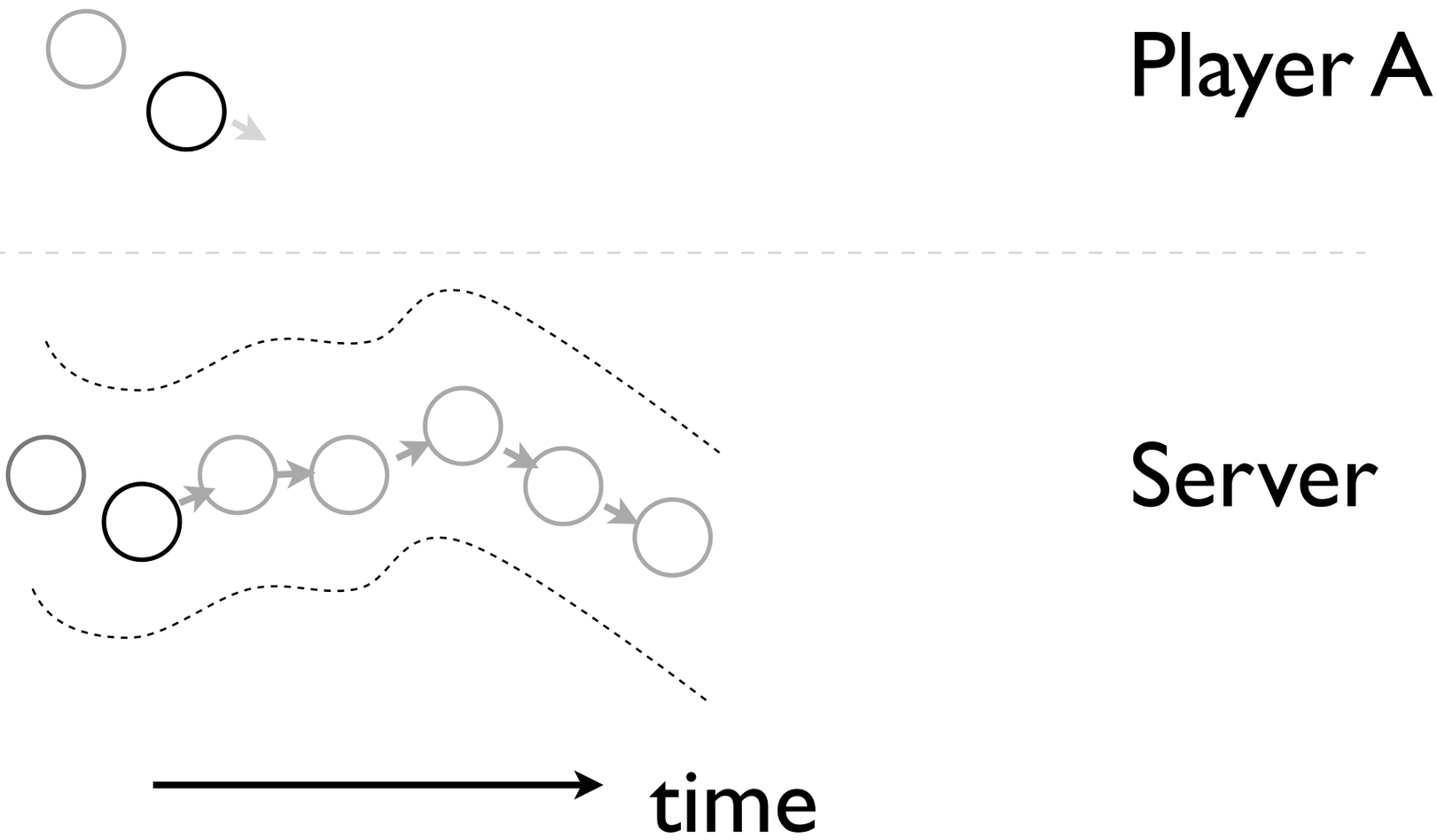
idea: trade-off message overhead and accuracy.

No need to update if error is small.

Player A

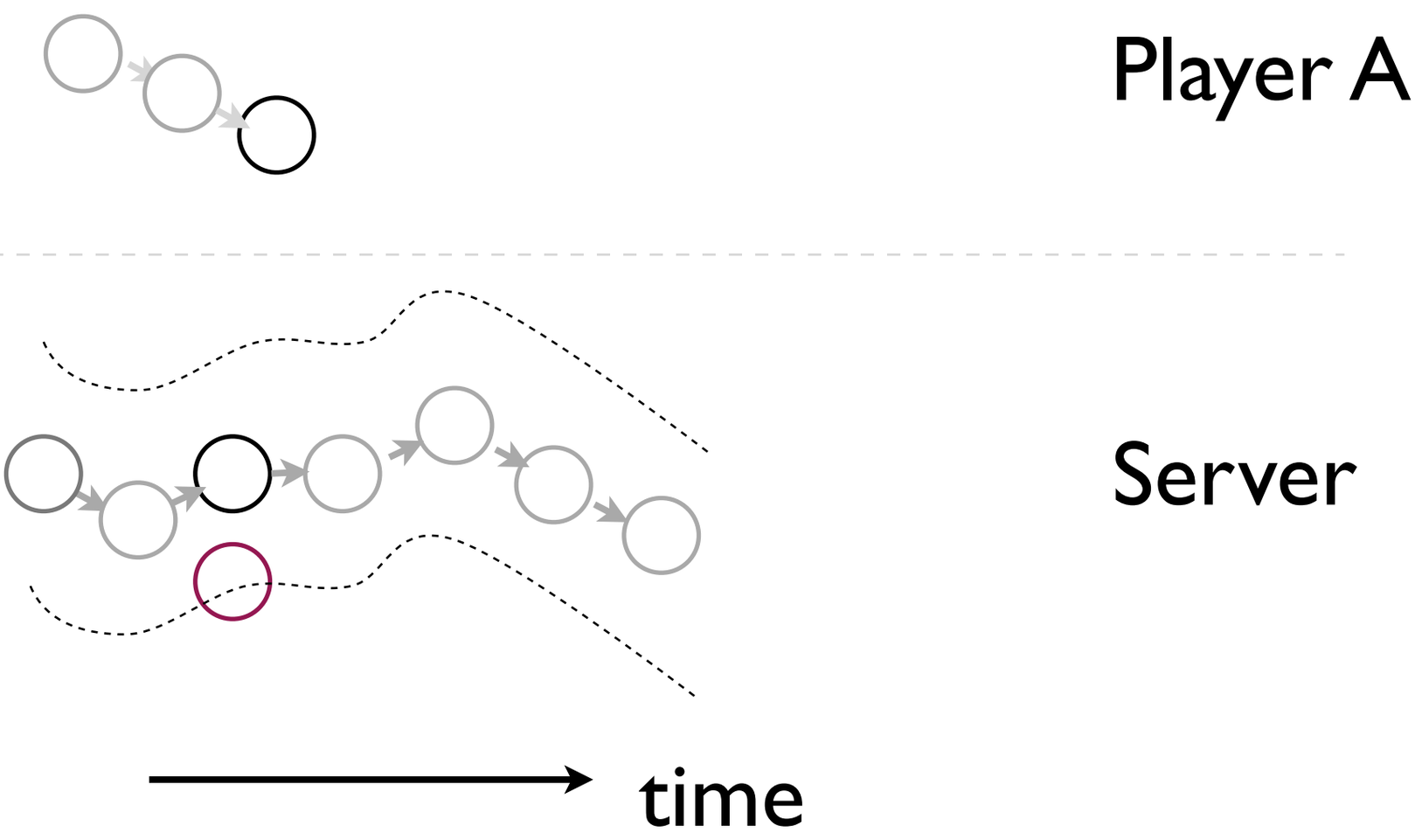



Player A
Server
time

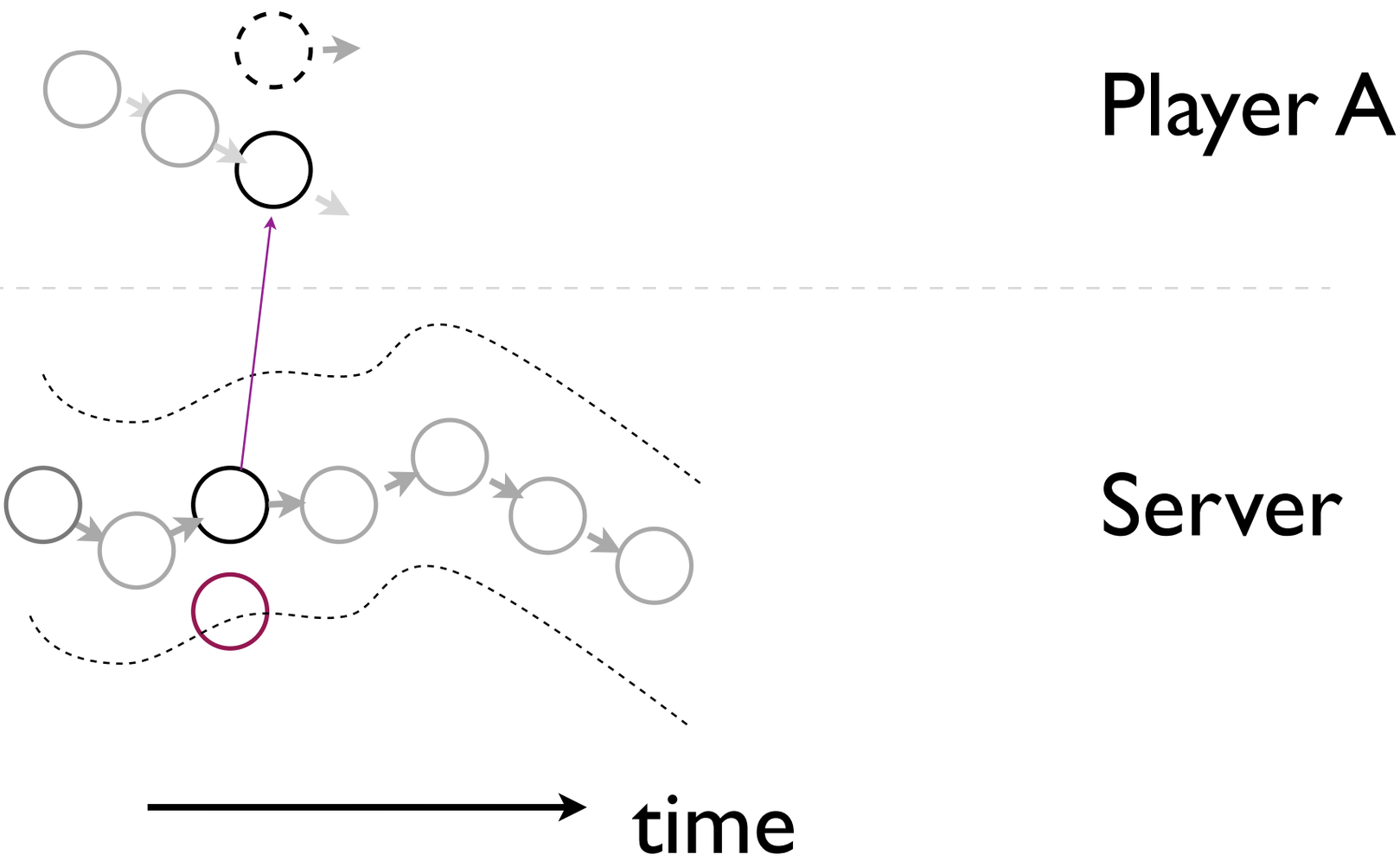

Player A
Server
time

predicted position at A

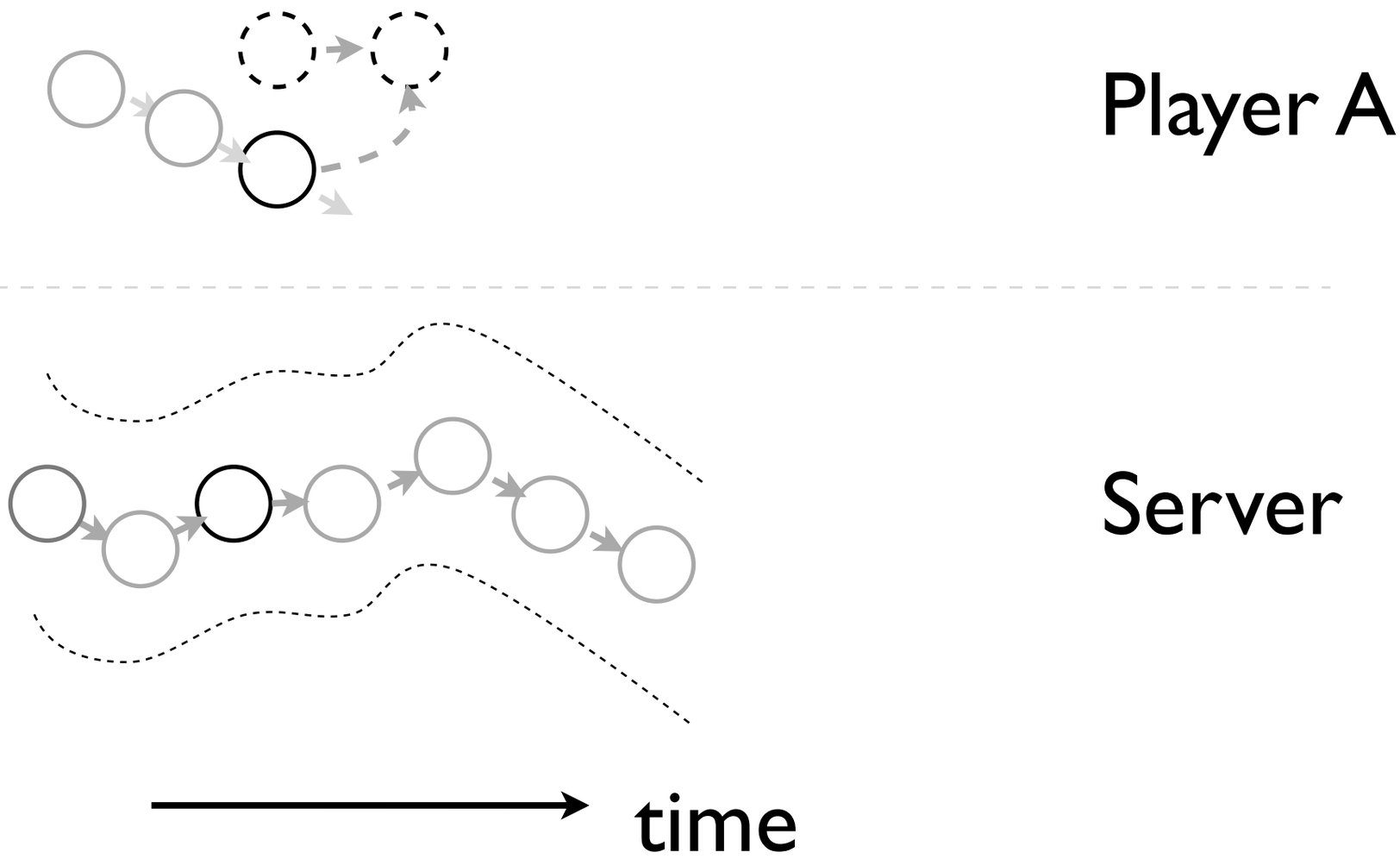
A's predicted position at the server



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.

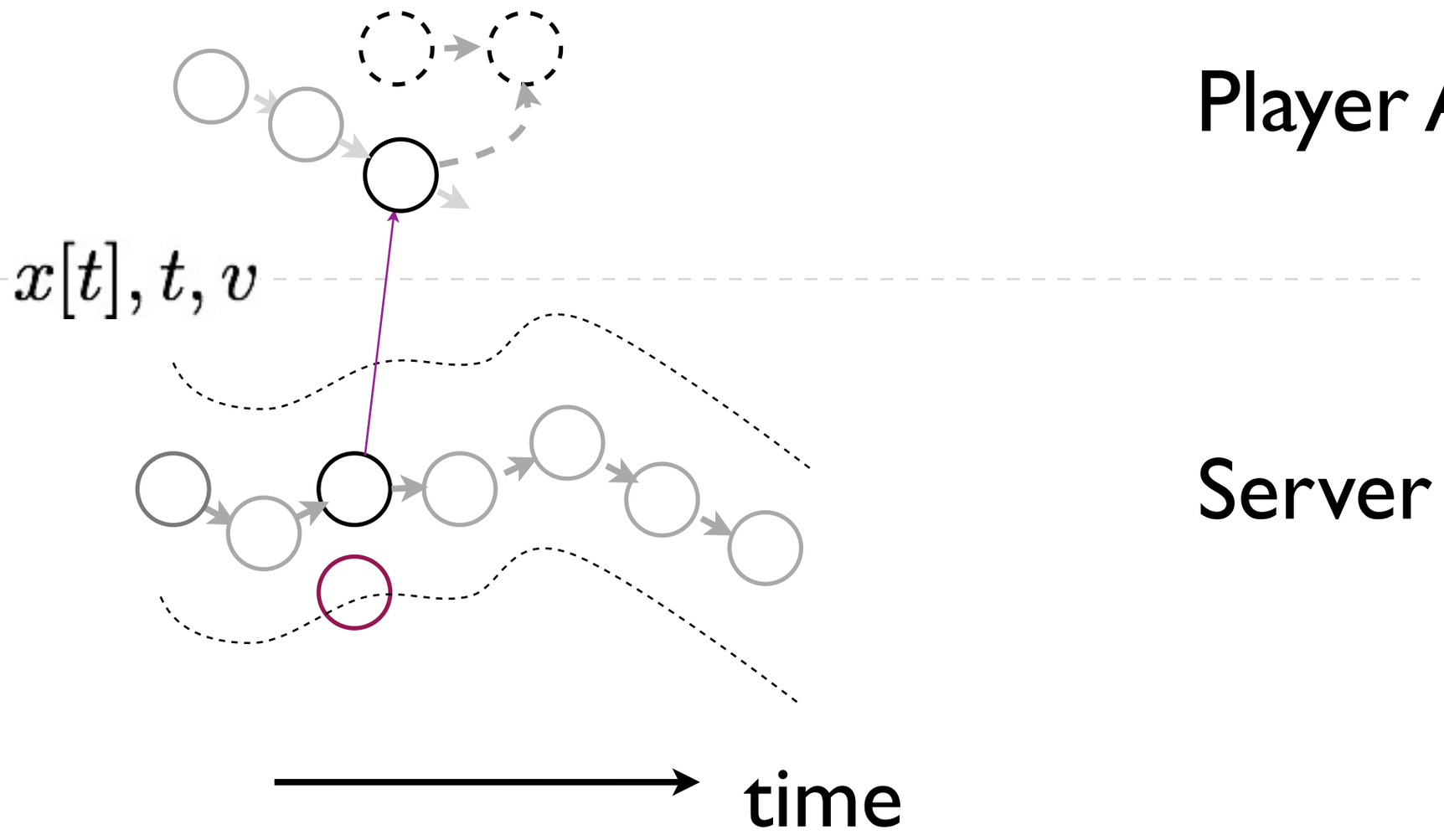


how to set error threshold?

adapt based on game requirement
(e.g. distance to other players)

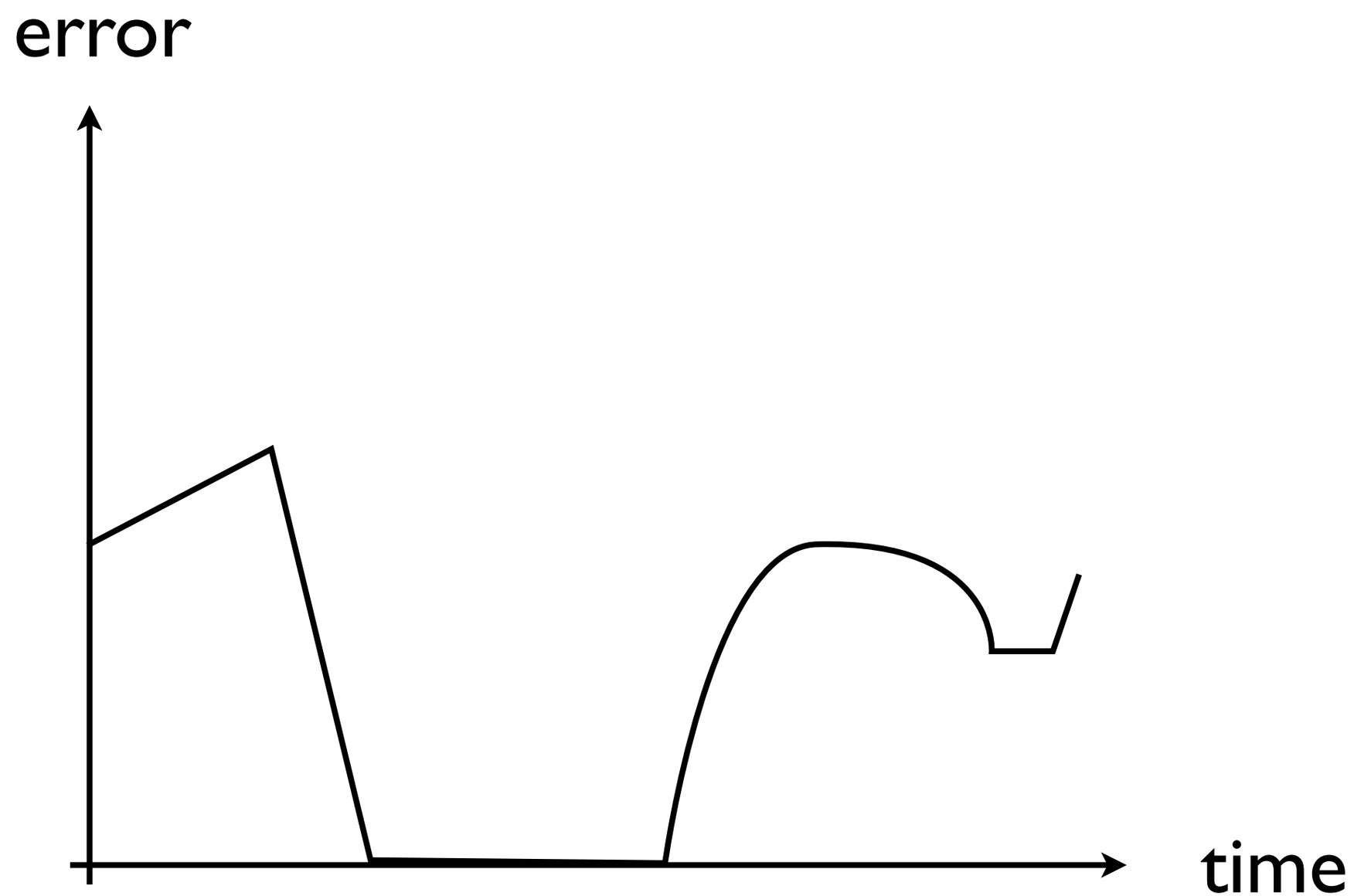
Space inconsistency: due to error threshold and convergence

Time inconsistency: due to message delay and clock asynchrony



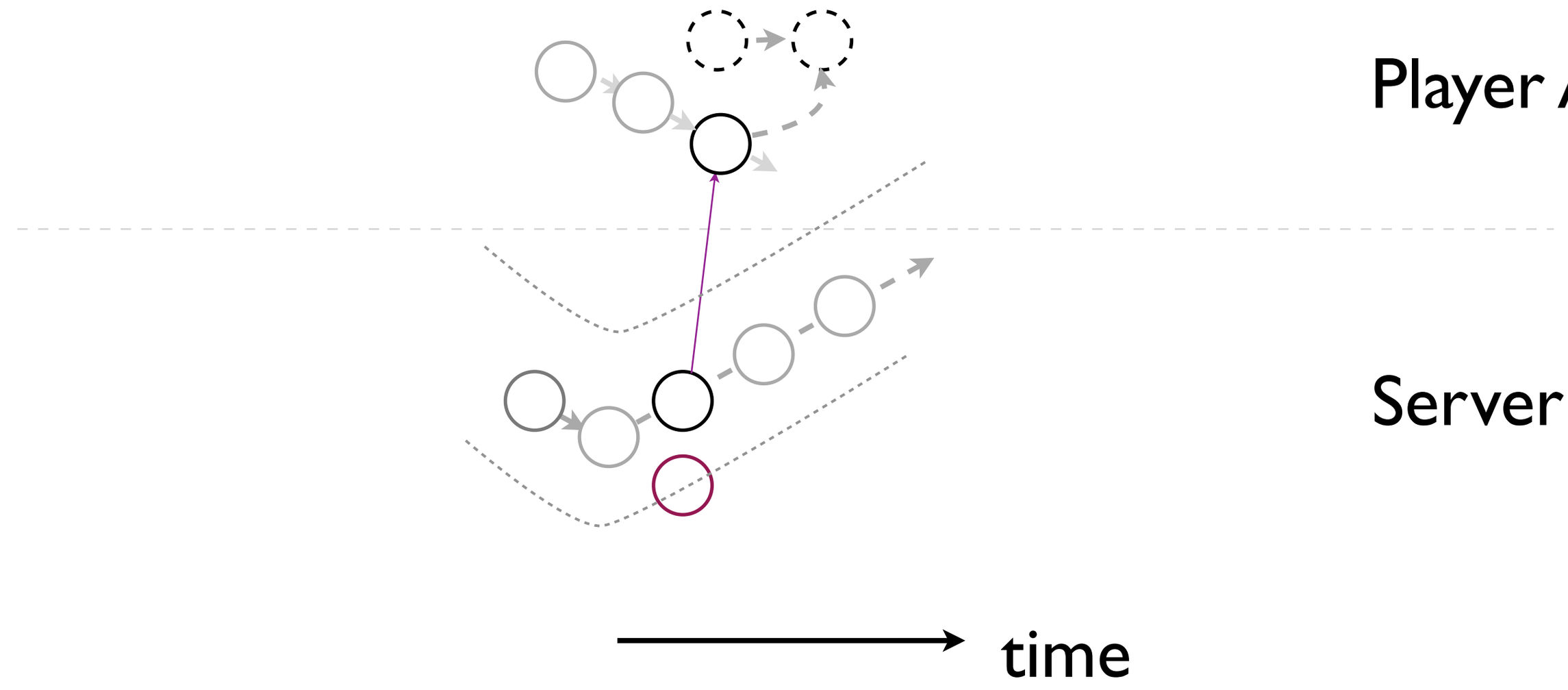
What is the difference between the actual and predicted position ?

How long does the difference last?



$$\text{inconsistency} = \int_0^T \Delta(t)dt$$

what are the different components of distance error?



Any drawbacks?

higher CPU cost

(needs to simulate other players)

unfair

(higher latency leads to larger error)

Dead Reckoning

Generalized Dead Reckoning : Prediction Contract

“return to base”

“drive along this road”

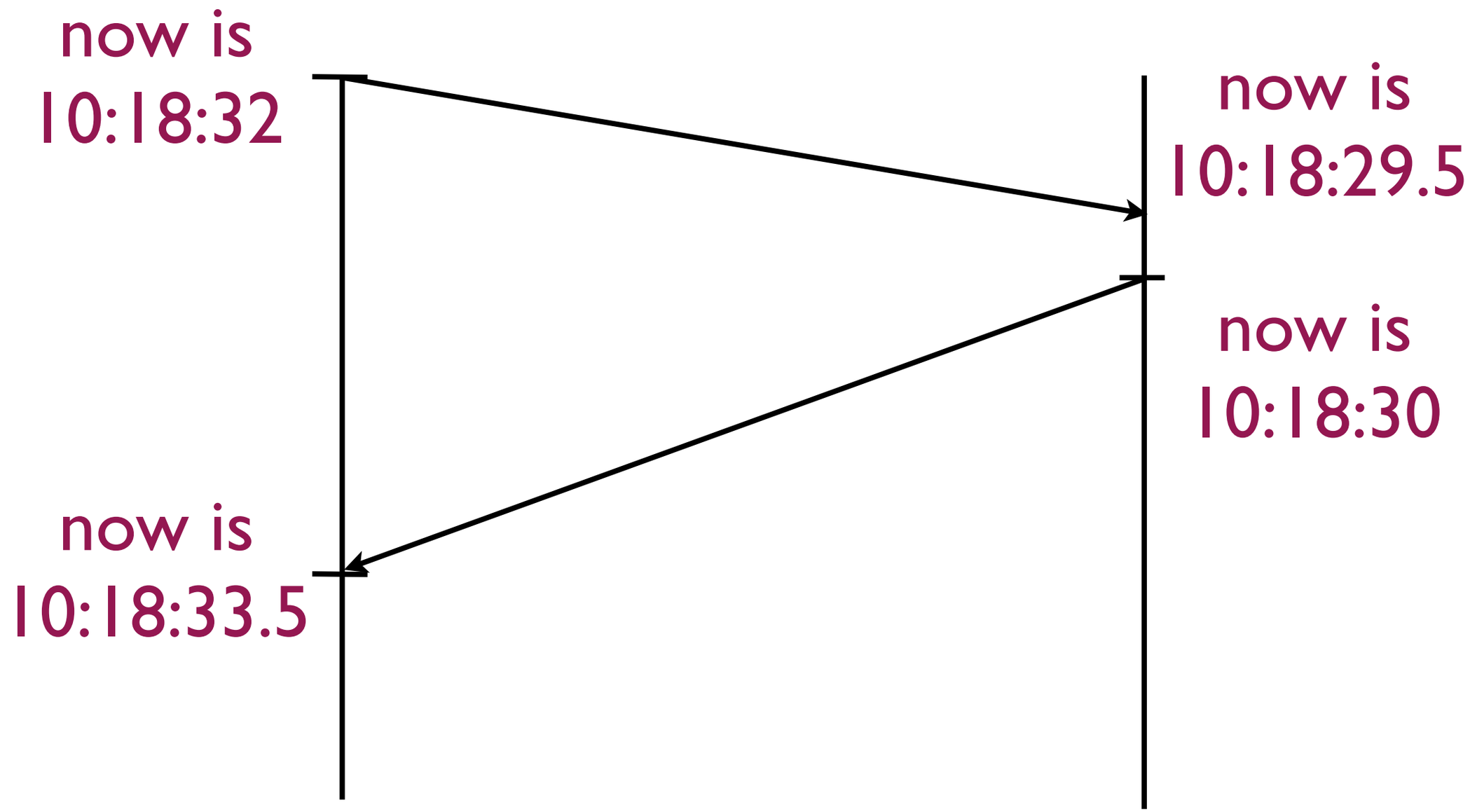
Server and clients must have a common notion of “time”

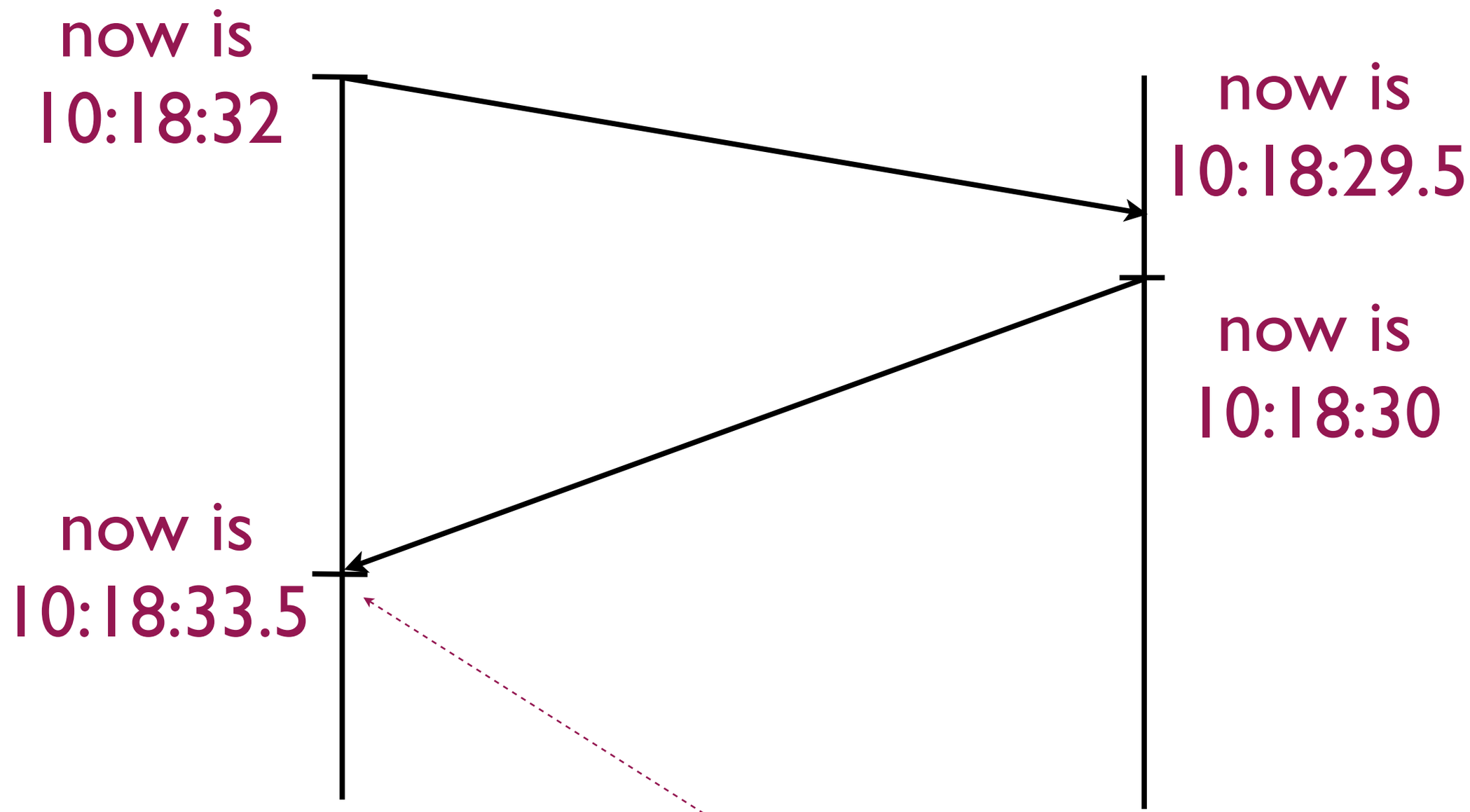
Two choices:

Wall Clock

Game Clock

Wall Clock: clients and server have to synchronize their physical clocks using NTP or SNTP.

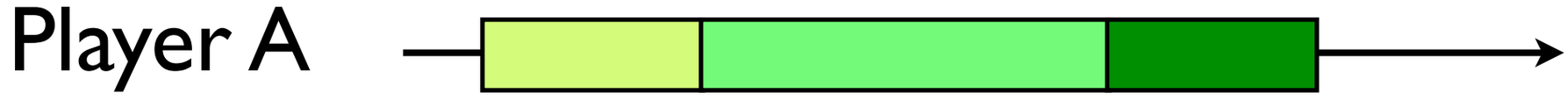

now is
10:18:32
now is
10:18:29.5
now is
10:18:30
now is
10:18:33.5



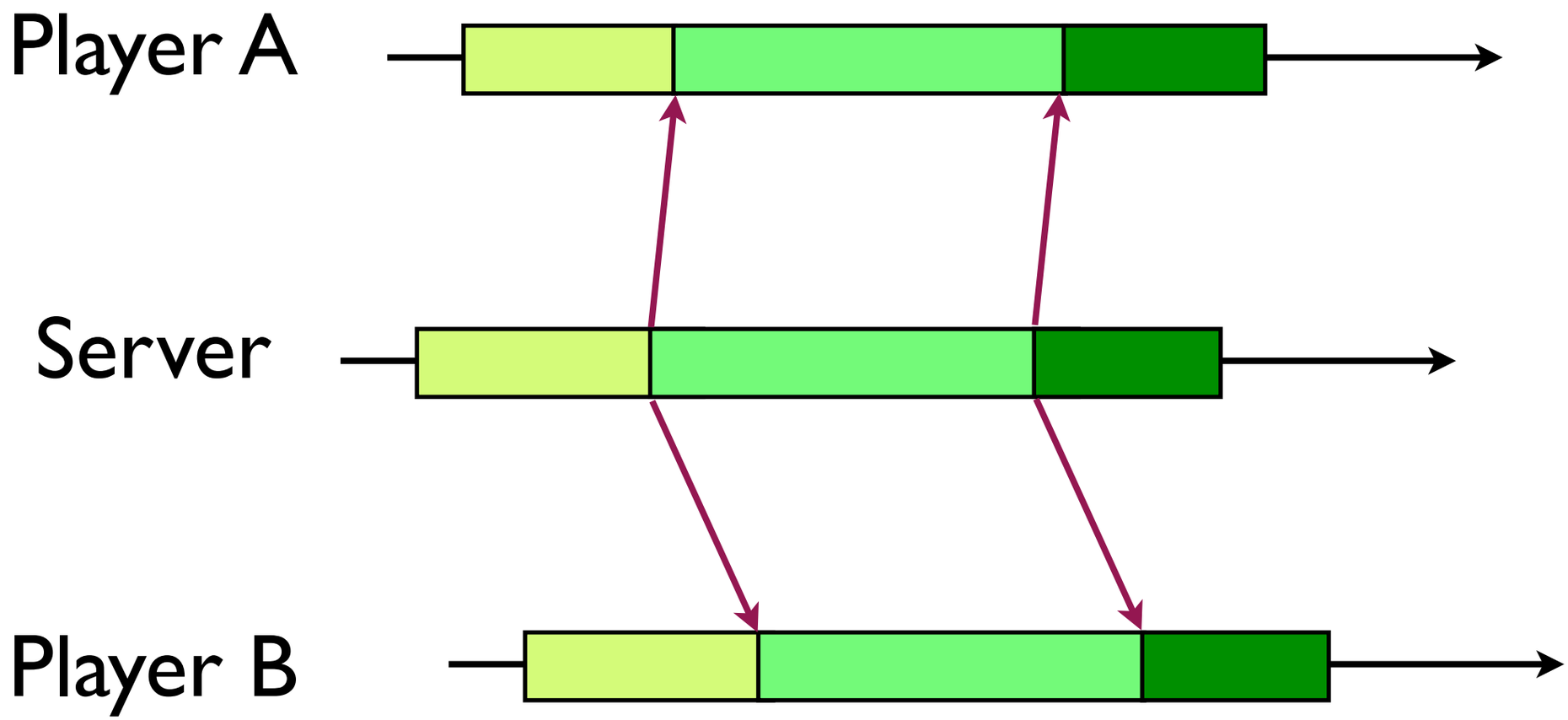
Time now should be
10:18:30.5

RTT = 1s
OWD = 0.5s

Players try to sync the game states with the server at the same wallclock time, and predict ahead with an amount of time equal to one-way delay.

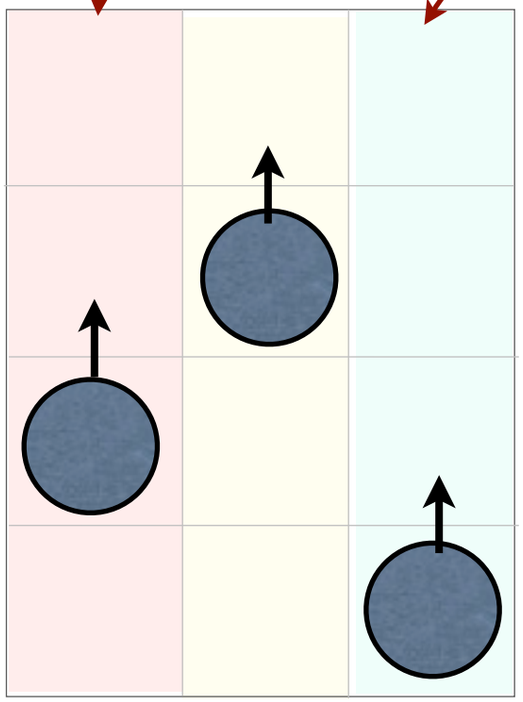


or: synchronize states to game clock, which runs behind the server by an amount of time equals to the one-way delay.



what A sees

what B sees

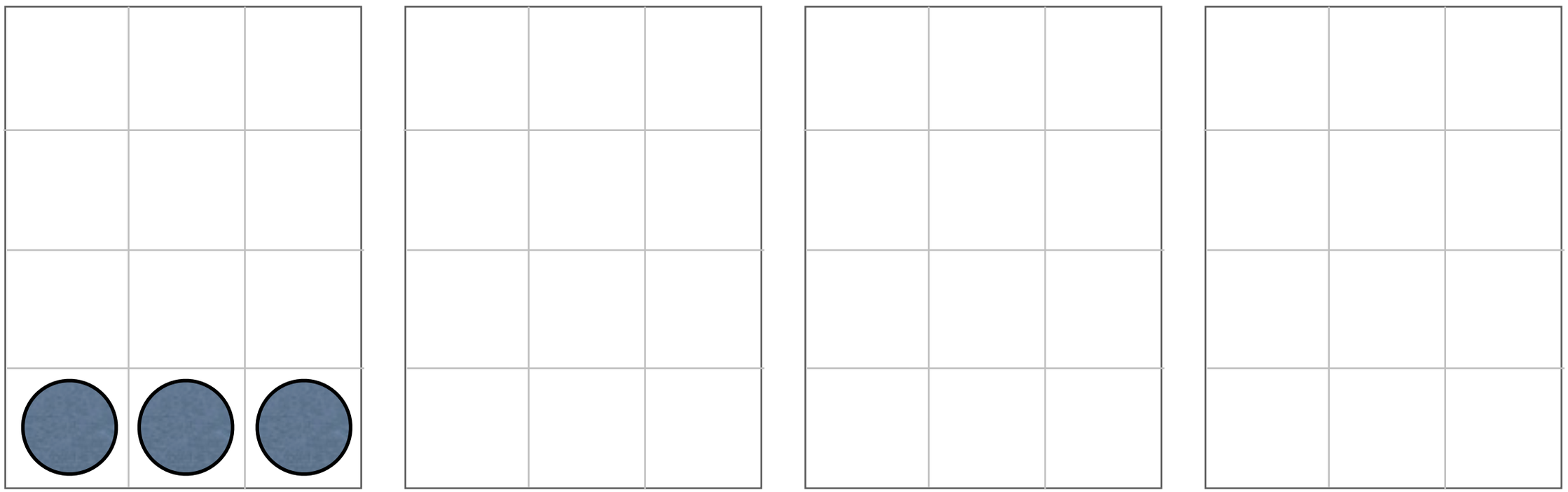


A S B

3 4 2 ← game clock

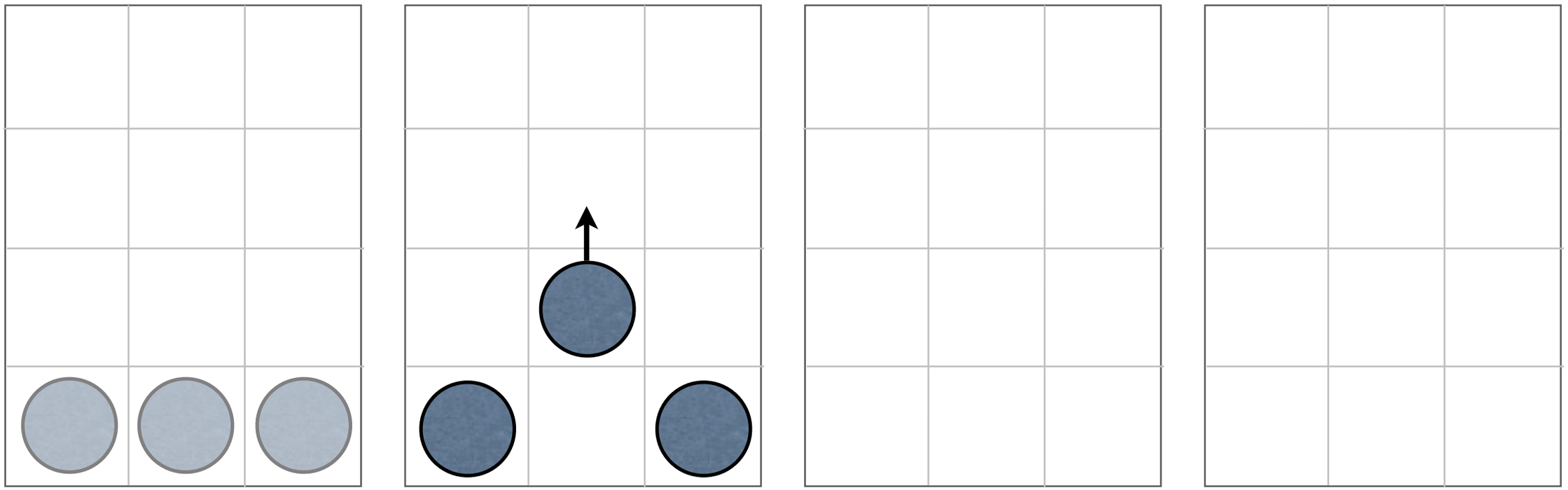
Example: using game clock

A decides to move. Send event to S.



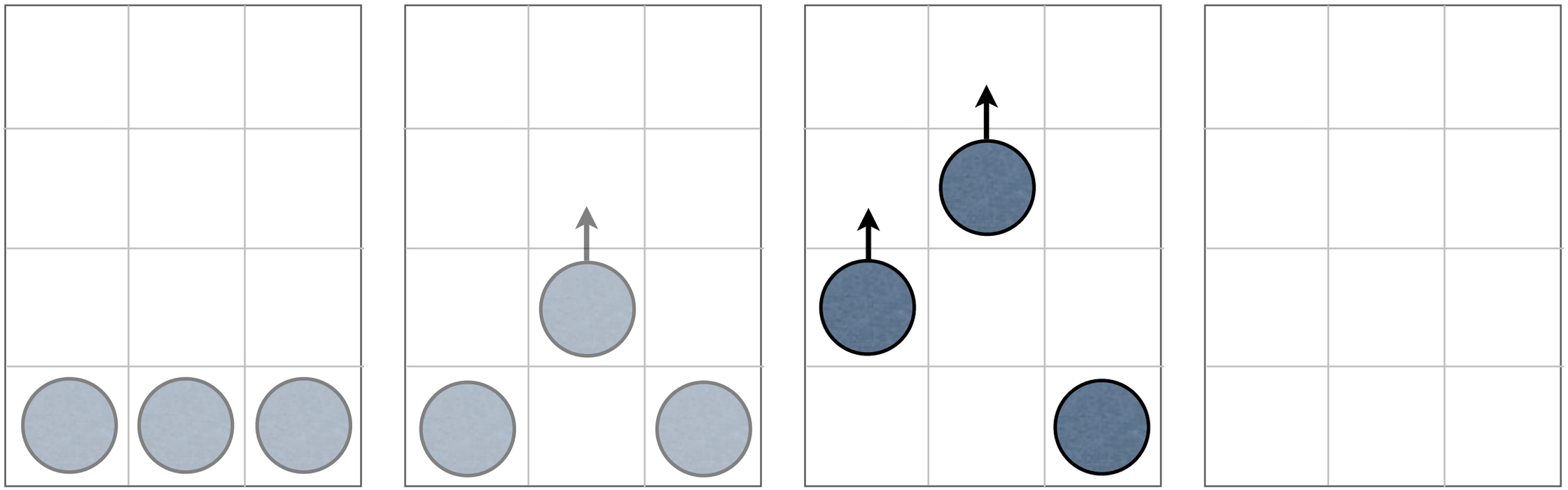
A	S	B
1	2	0

S receives event, moves A, and tells A and B that A is moving at t = 3



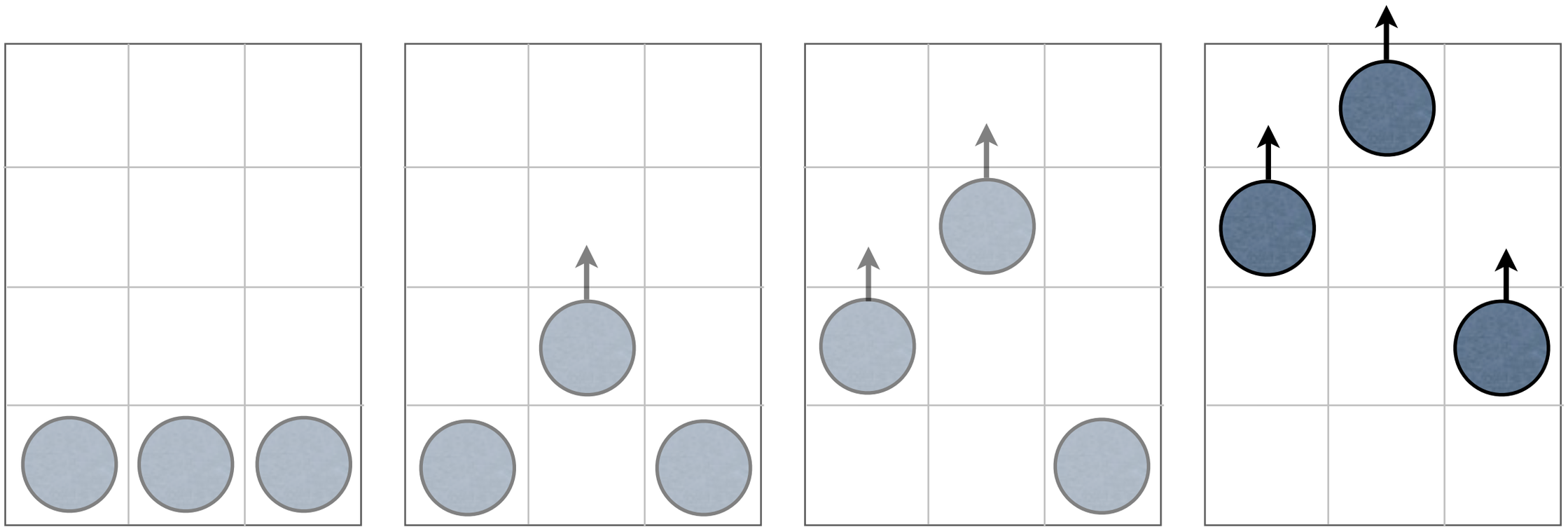
A	S	B	A	S	B
1	2	0	2	3	1

A moves itself at t = 3.



A	S	B	A	S	B	A	S	B
1	2	0	2	3	1	3	4	2

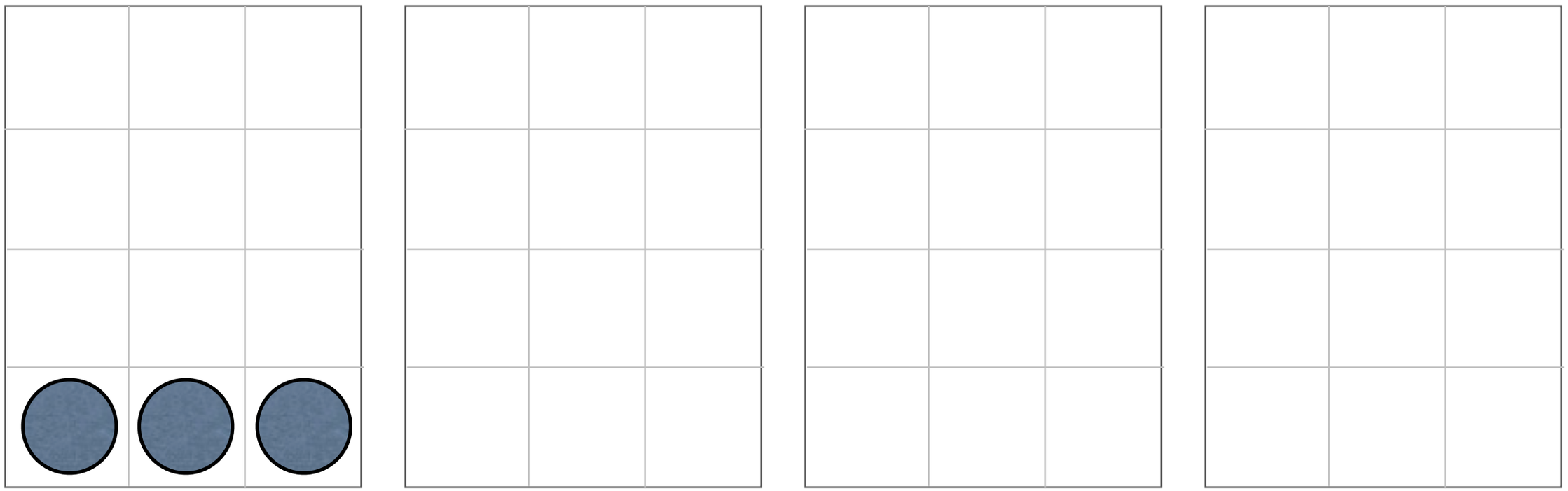
B moves A at t = 3.



A	S	B	A	S	B	A	S	B	A	S	B
1	2	0	2	3	1	3	4	2	4	5	3

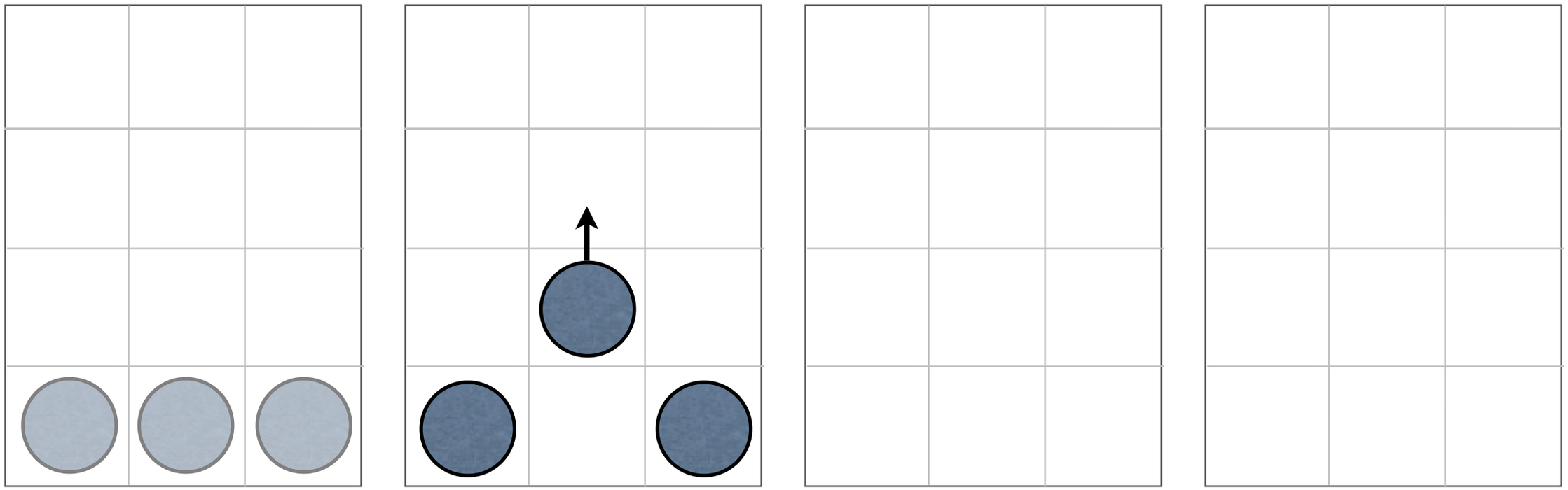
Example: using wallclock

A decides to move. Send event to S.



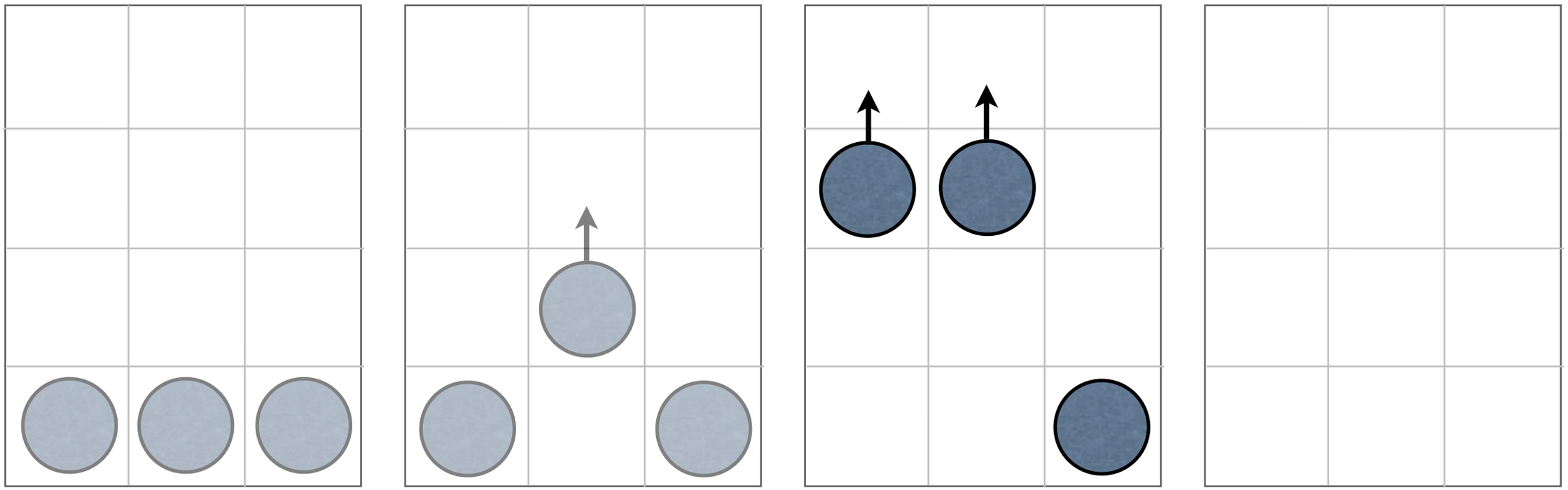
A	S	B
0	0	0

S receives event, moves A, and
tells A and B that A is moving at t = 1



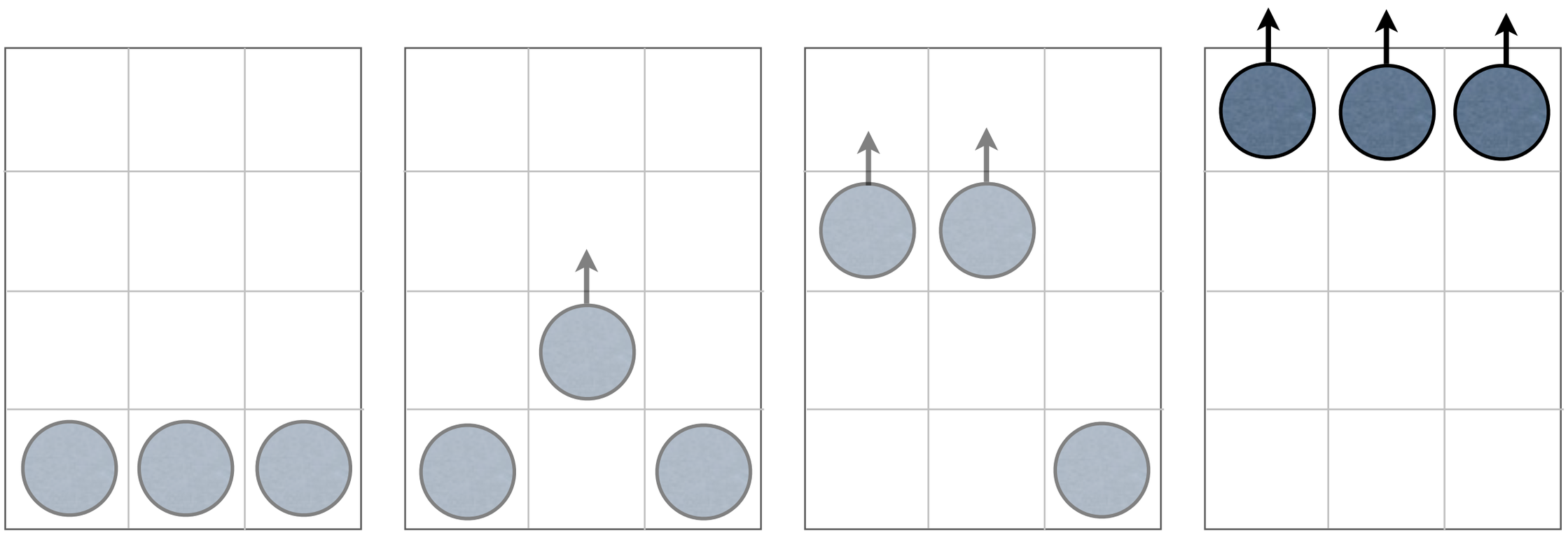
A	S	B	A	S	B
0	0	0	1	1	1

A moves itself to where it should be at t = 2.



A	S	B	A	S	B	A	S	B
0	0	0	1	1	1	2	2	2

B finds out A moves at t = 1 and moves A to where A should be at t = 3



A	S	B	A	S	B	A	S	B	A	S	B
0	0	0	1	1	1	2	2	2	3	3	3

Tight synchronization allows interaction but can lead to visual disruptions.

Asynchronization allows smooth movement but hinder interaction.

Local Perception Filter

Hybrid Model:

Render objects within real-time interaction range in real time, other objects in delayed time.

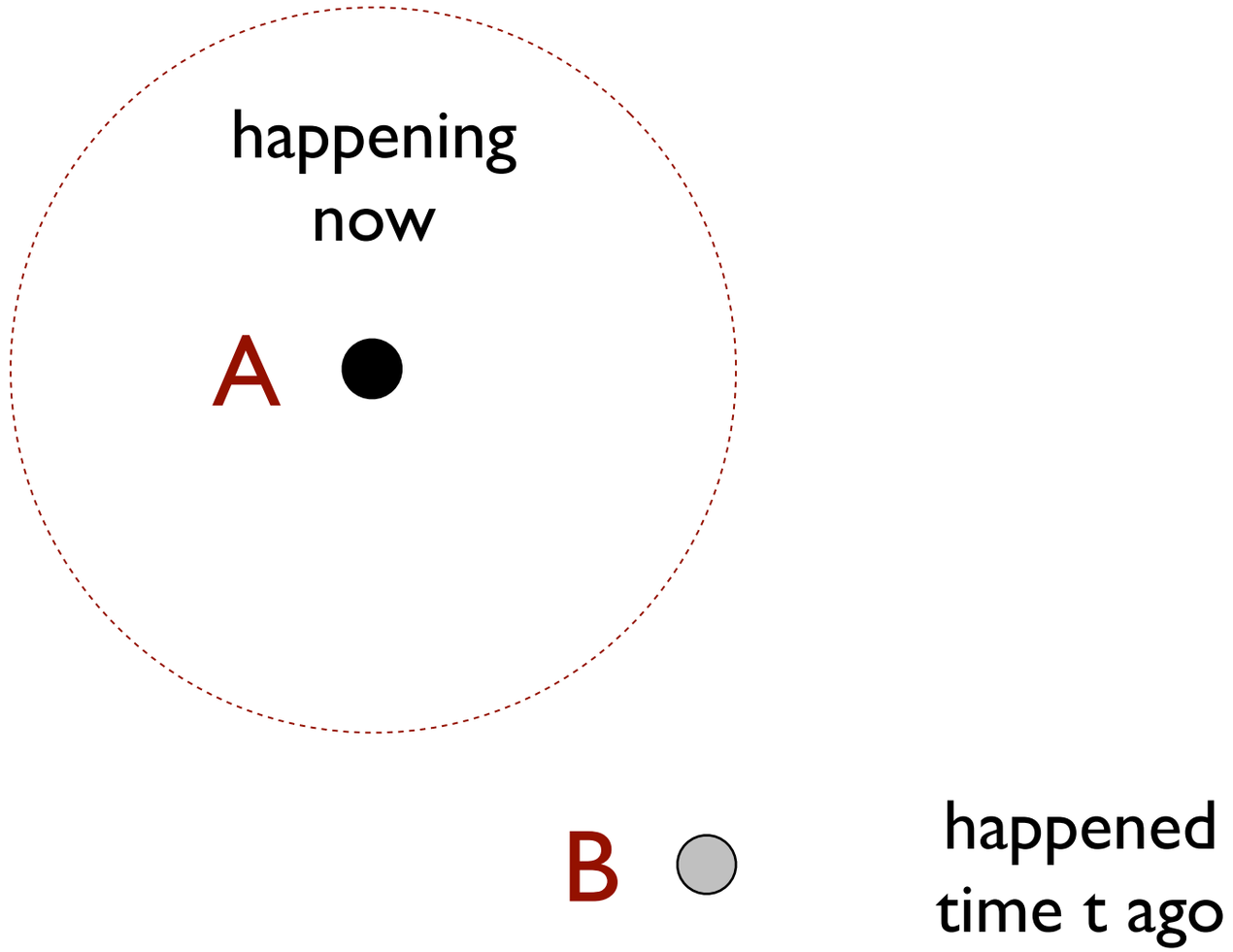
Two Kinds of Entities

Active:

players (unpredictable)

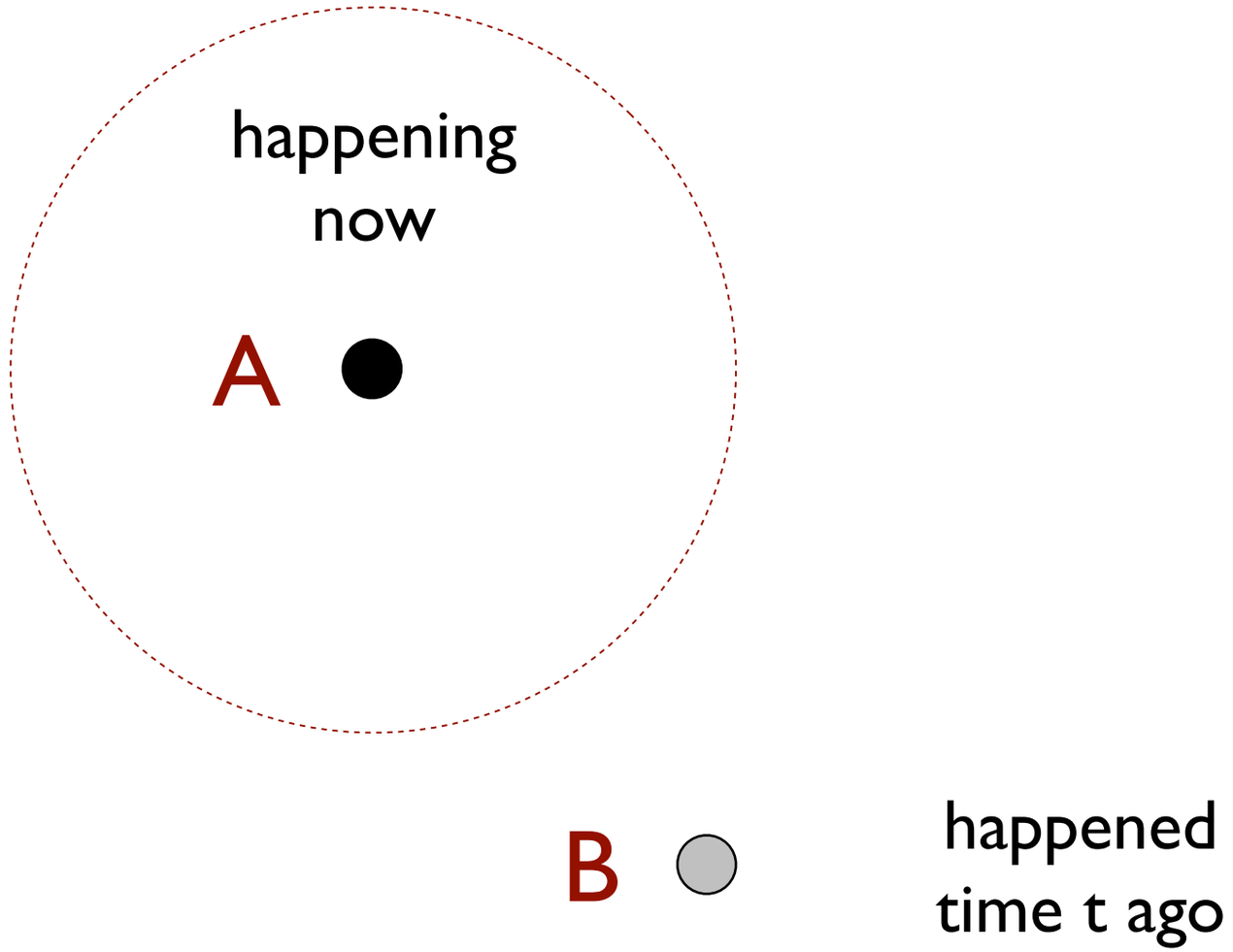
Passive:

ball, bullet (predictable)


happening
now
A
B
happened
time t ago

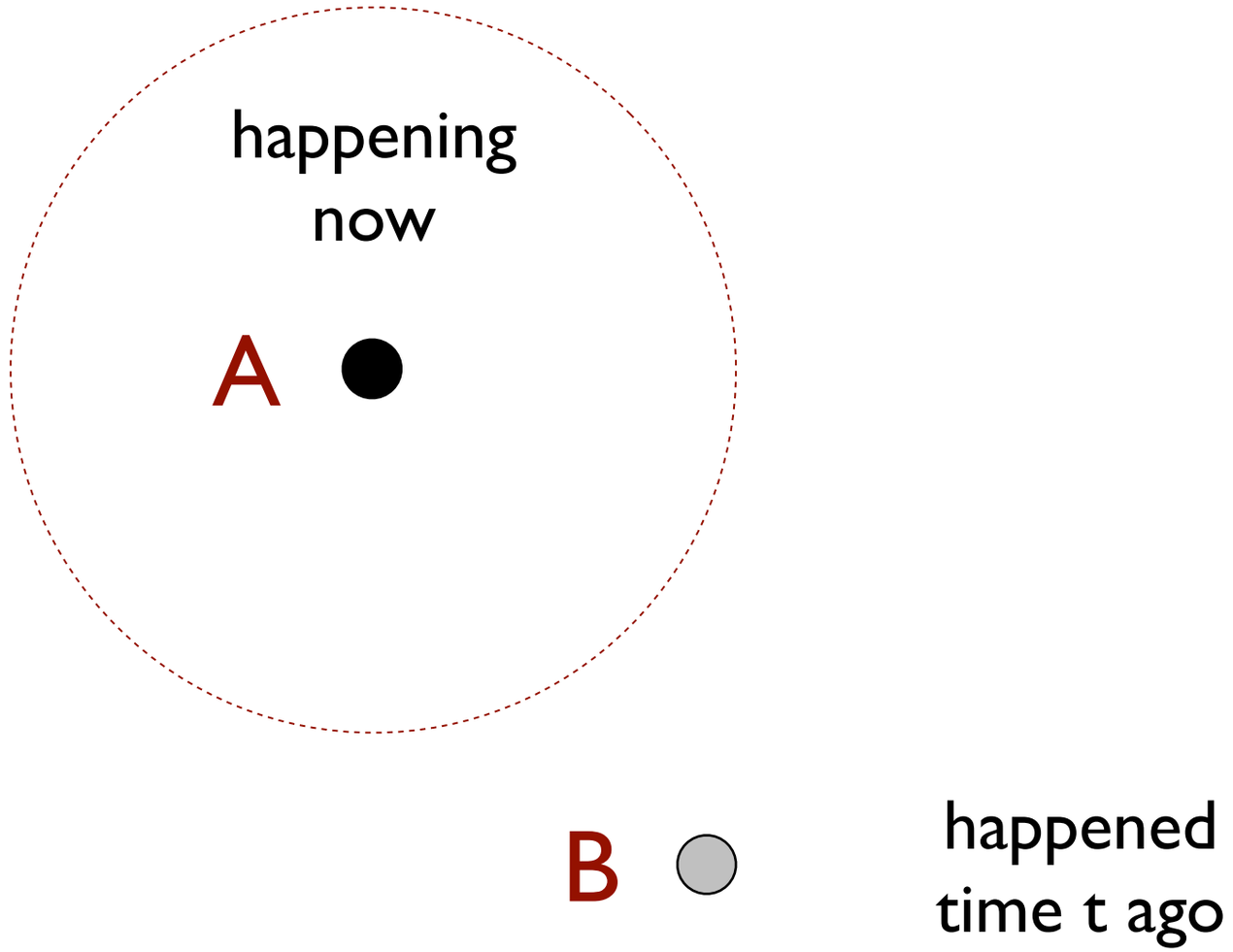
Question:

What if a player A throws a ball at player B?

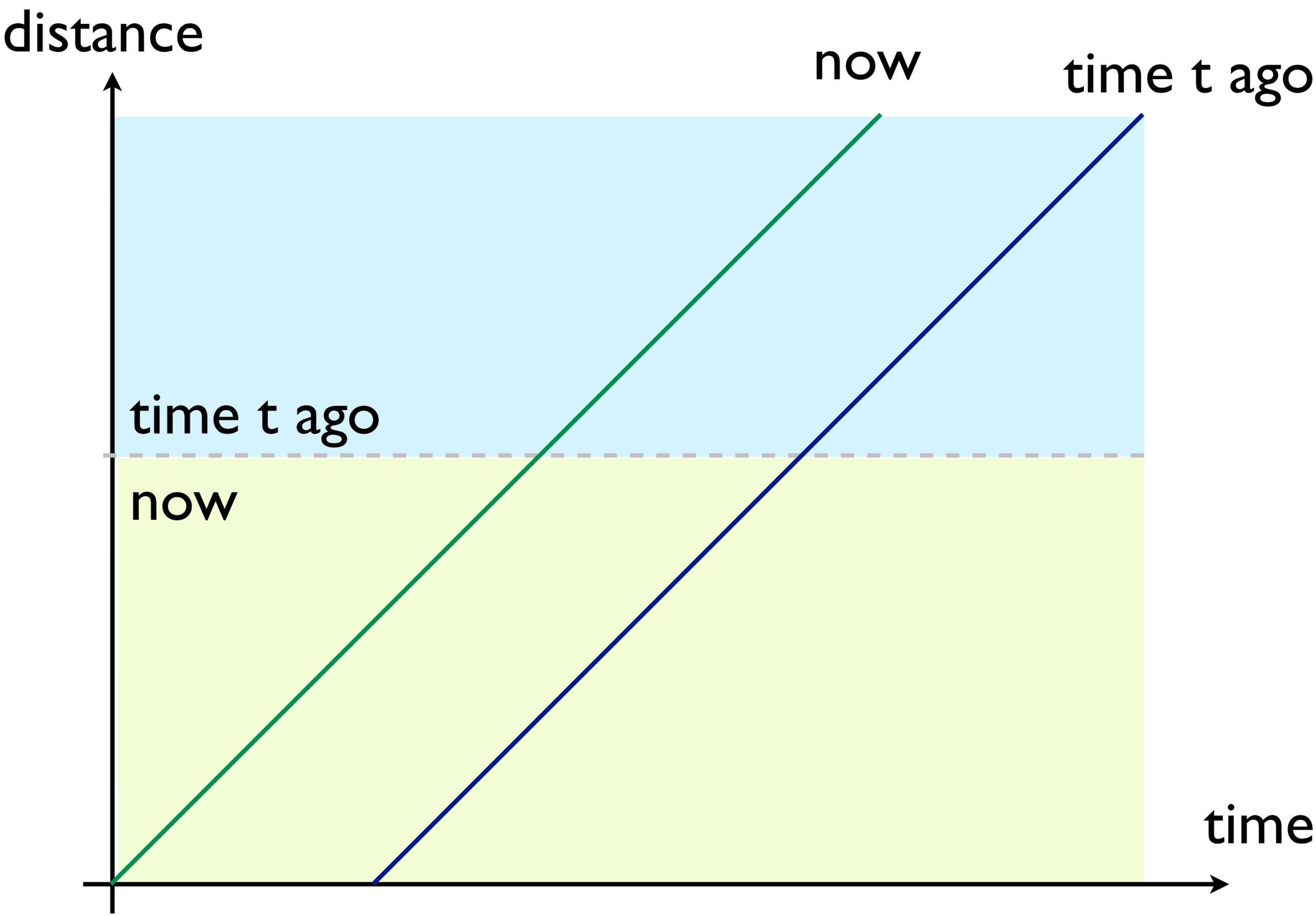

happening
now
A
B
happened
time t ago

Question:

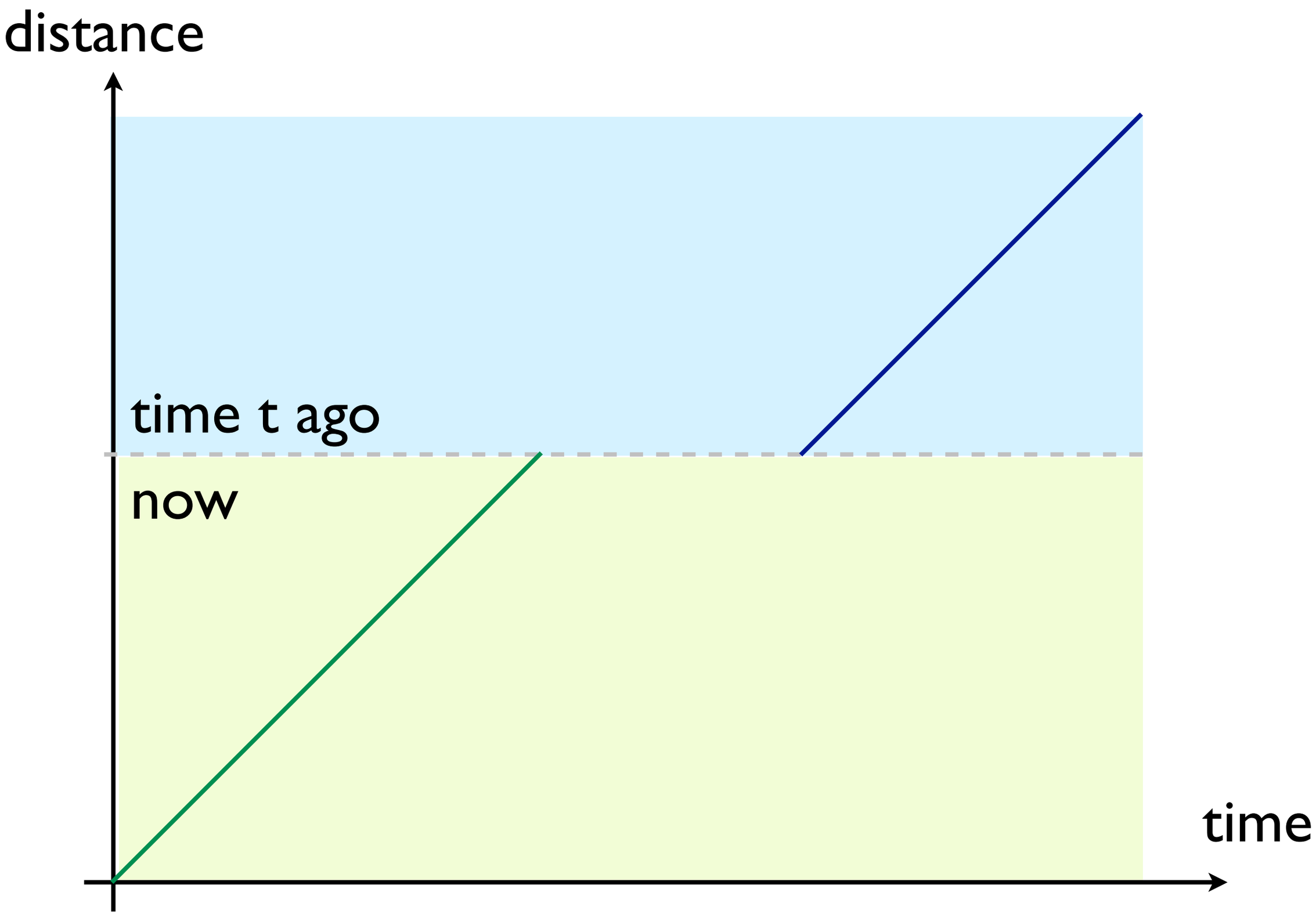
What if a player B throws a ball at player A?


happening
now
A
B
happened
time t ago

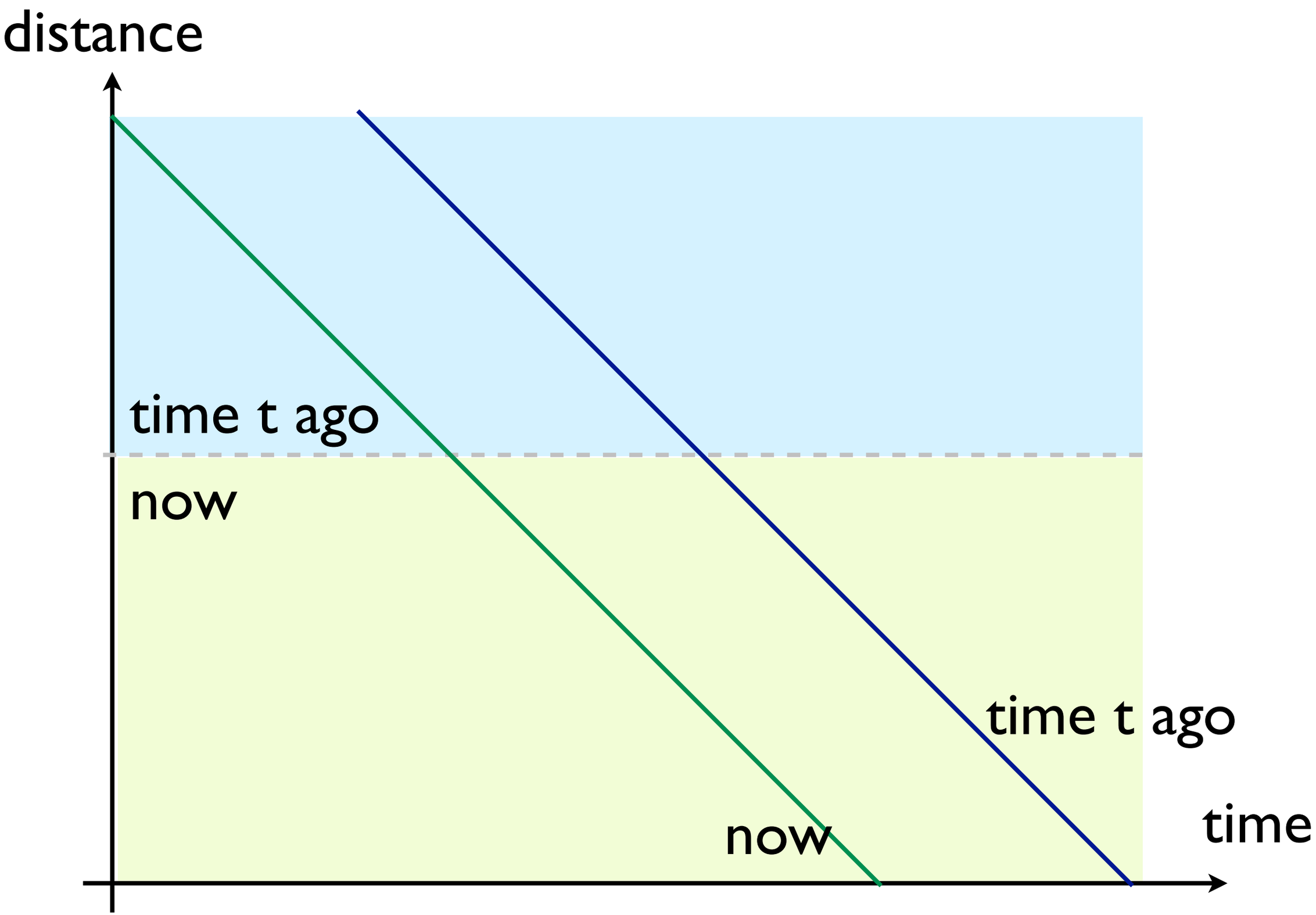
Distance of ball (thrown by A) from A versus time.



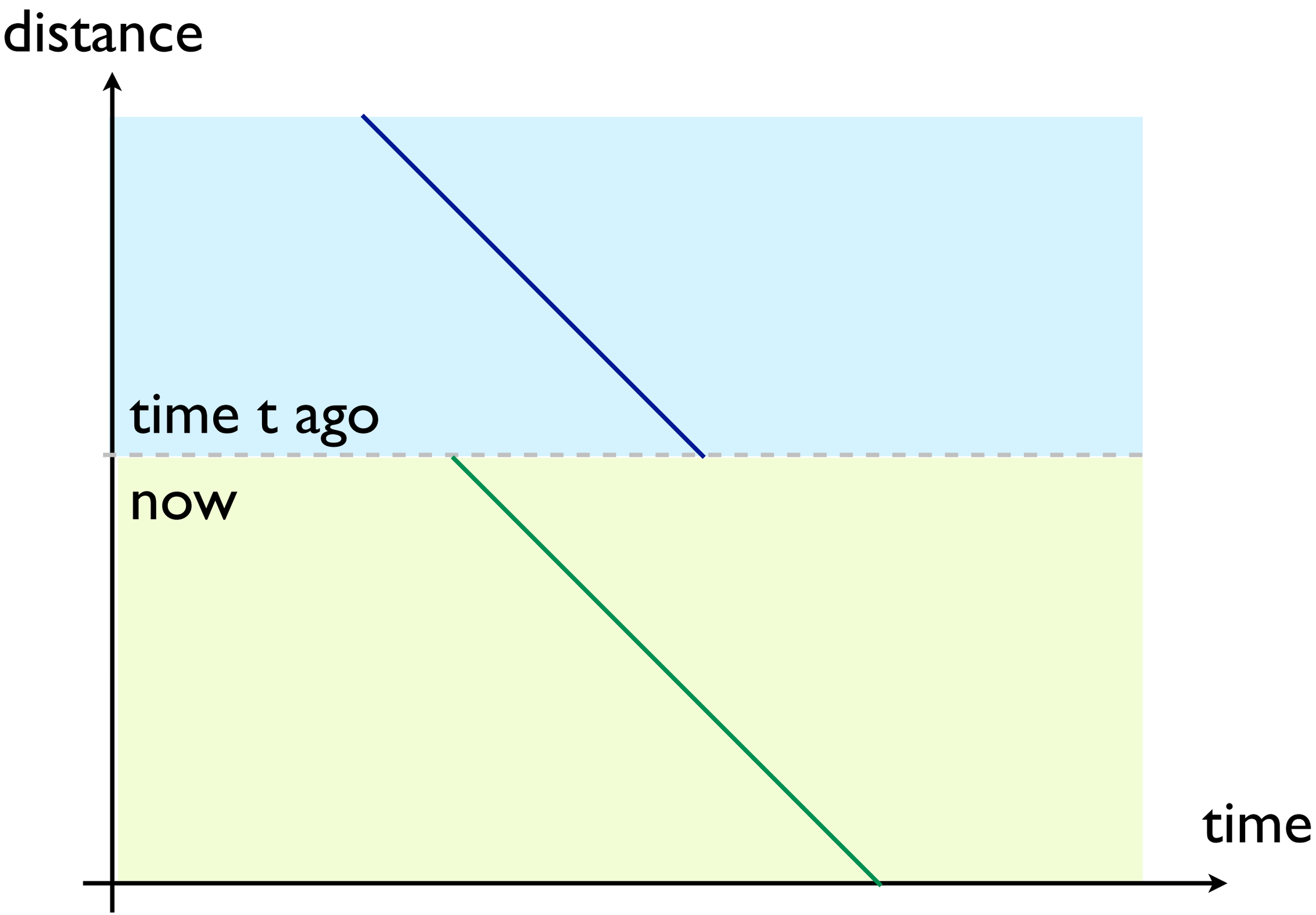
What A sees..

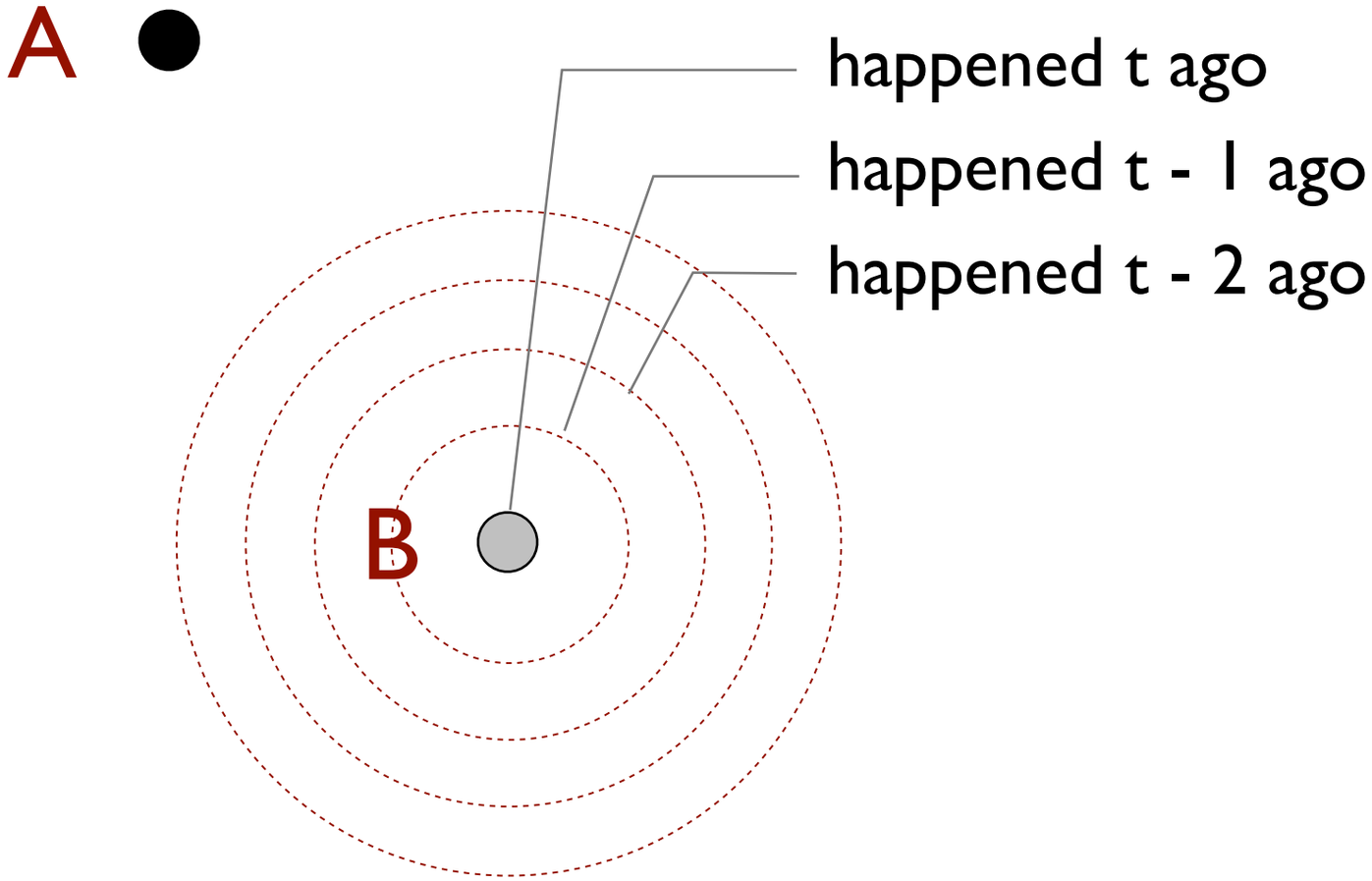


Distance of ball (thrown by B) from A versus time.



Distance of ball (thrown by B) from A versus time.

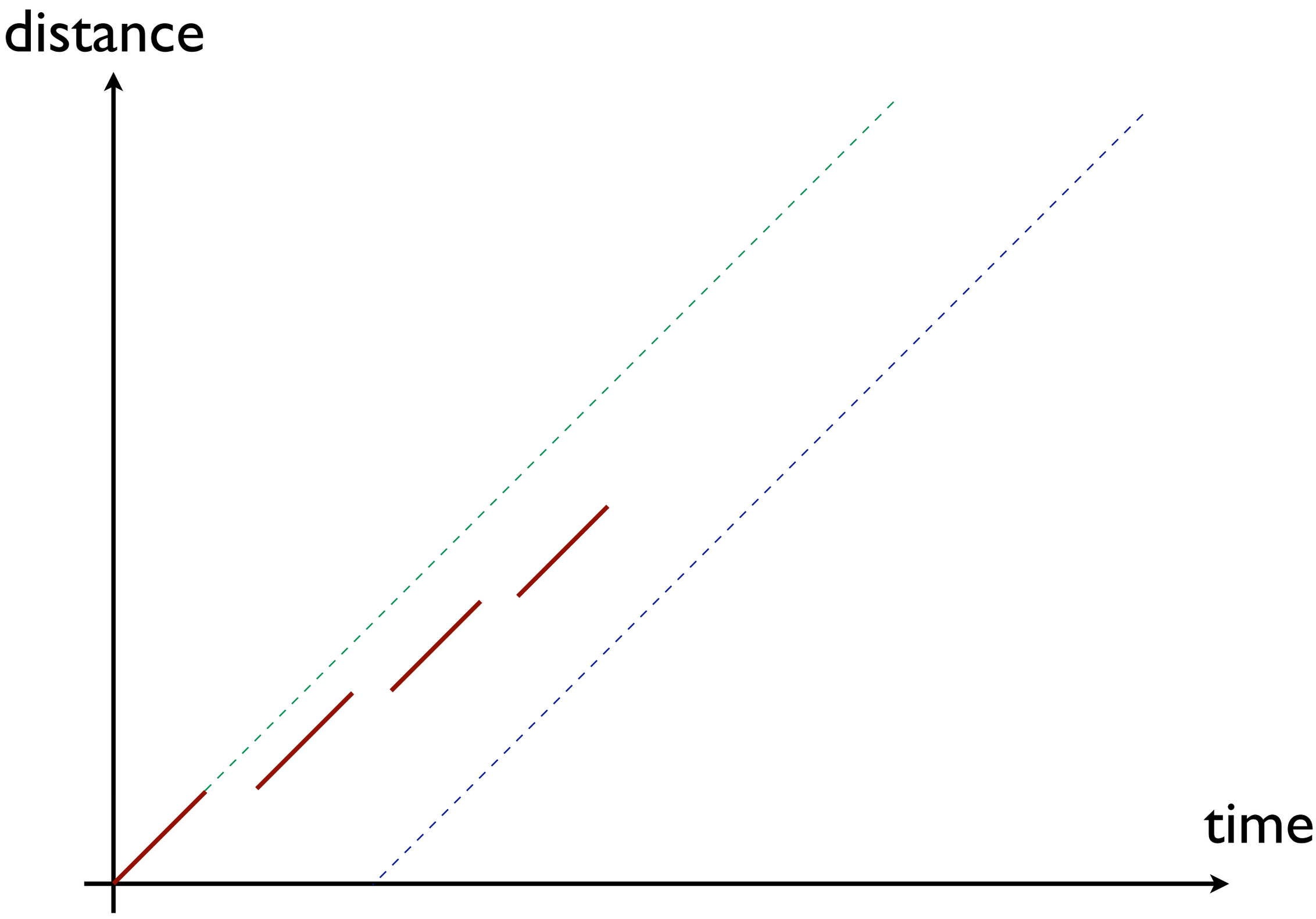



A
B
happened t ago
happened t - 1 ago
happened t - 2 ago

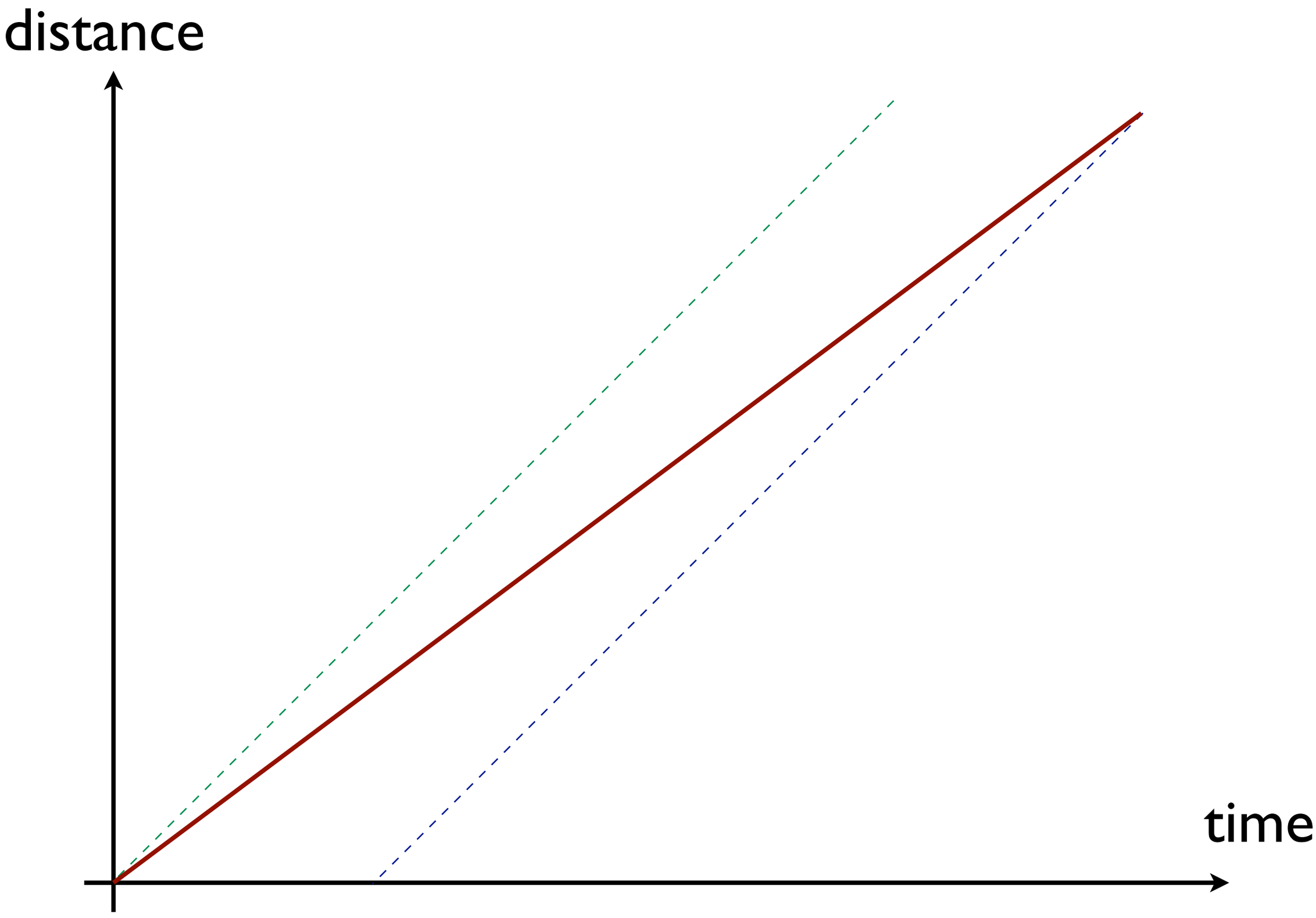
Question:

What if a player A throws a ball at player B?

What A sees..



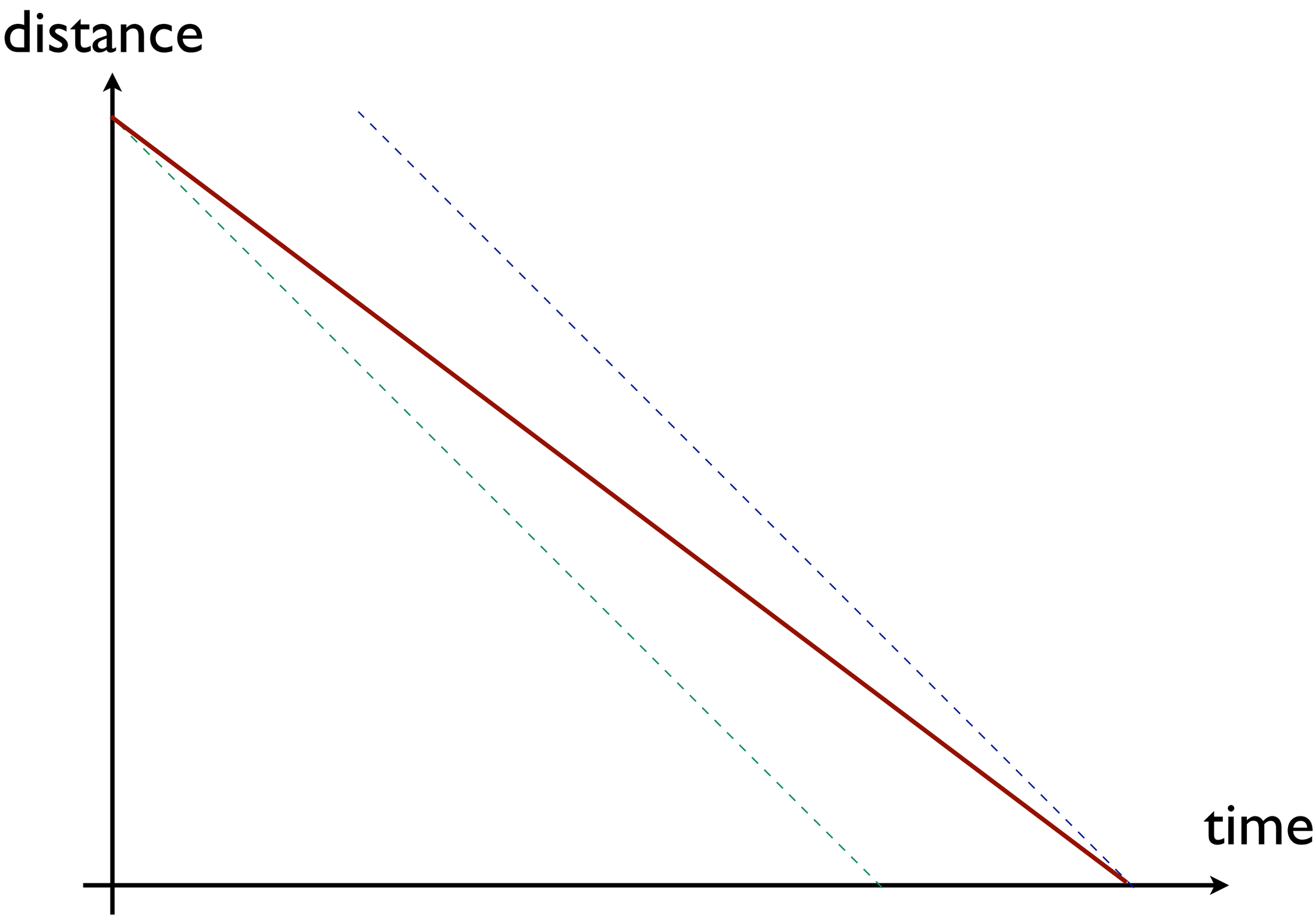
What A sees..

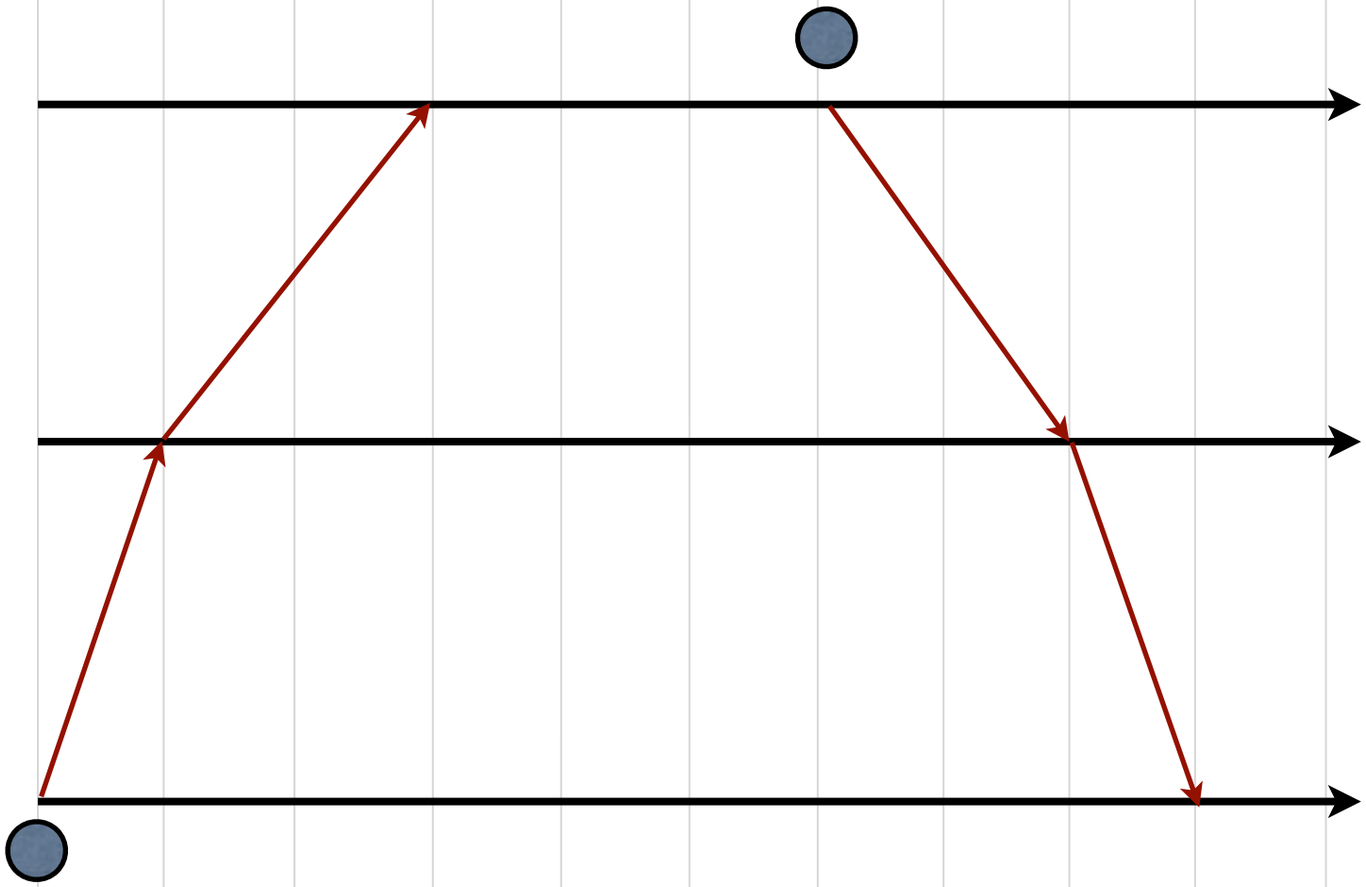


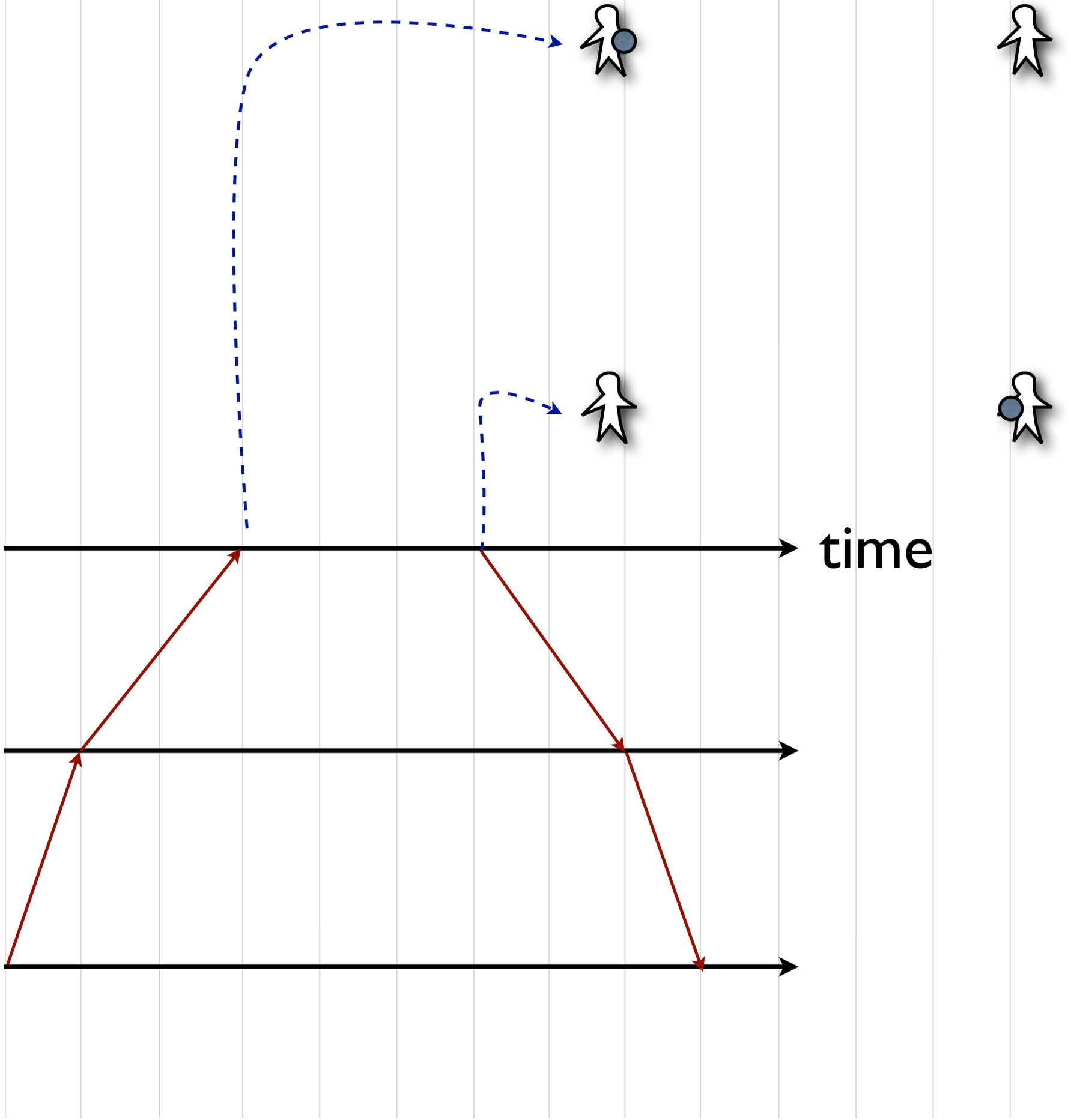
Question:

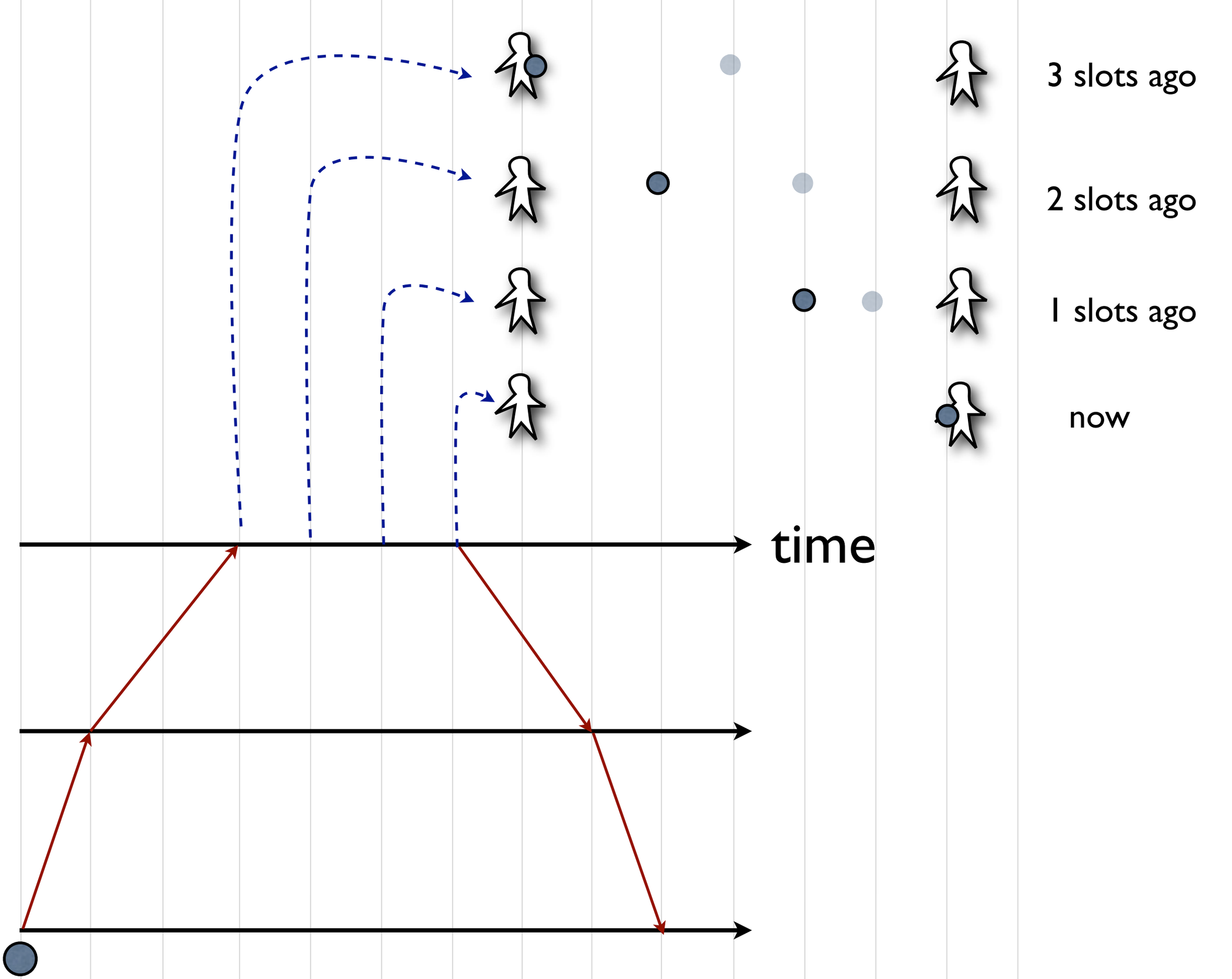
What if a player B throws a ball at player A?

Distance of ball (thrown by B) from A versus time.






time


3 slots ago
2 slots ago
1 slots ago
now
time

Assignment 1

Assignment 1