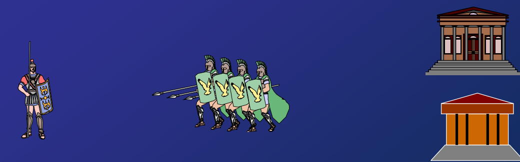
§9.4 Local Perception Filters

- exploiting human's perceptual limitations
  - level-of-detail: less details where they cannot be observed
  - image, video and audio compression
- local perception filters
  - exploits temporal perception
  - shows possibly out-of-date information (≠ dead reckoning)
  - ensures consistent interaction
  - allows to introduce artificial delays (e.g., bullet time)

Exploiting Perceptual Limitations

- Humans have inherent perceptual limitations



Two approaches to exploit

- Information can provided at multiple levels of detail and at different update rates
- Mask the timeliness characteristics of information

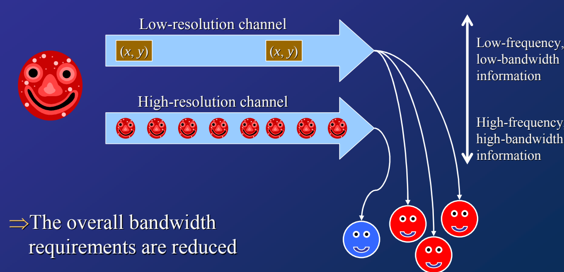
Exploiting Level-of-Detail Perception

- Nearby viewers
  - expect full graphical details
  - accurate structure, position, orientation
  - update rate → local frame rate
- Distant viewers
  - can tolerate less graphical details
  - less accurate structure, position, orientation

- User's focus is typically nearby
- Many inaccuracies cannot even be detected on a fine-resolution display

Multiple-Channel Architecture

- Multiple independent data channels for each entity



⇒The overall bandwidth requirements are reduced

Implementation Examples

- Client-server
  - each transmission identifies its channel
  - server dispatches data from channels to clients
- Multicast group for each region
  - assign multiple addresses for each region
    - one group provides all of the entities' high-resolution channels, another group provides all of the entities' low-resolution channels
- Multicast group for each entity
  - assign multiple addresses for each entity

- Different reliabilities to each channel
  - low-frequency updates are important
    - lost packets can have a significant impact

Selecting the Channels to Provide

- How many channels to provide for an entity?
  - more channels: better service for subscribers
  - each channel imposes a cost (bandwidth and computational)
- To satisfy the trade-off, three channels for each entity is typically needed
  - channels provide order-of-magnitude differences in
    - structural and positional accuracy
    - packet rate

Rigid-body channel	↕	Far-range viewers
Approximate-body channel		Mid-range viewers
Full-body channel		Near-range viewers

Rigid-Body Channel

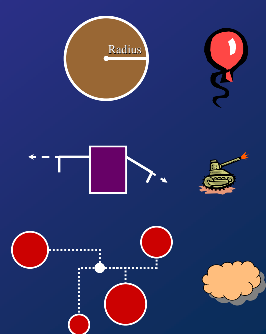
- Demands the least bandwidth and computation
- Represents the entity as a rigid body
- Ignores changes in the entity's structure
- Update types:
  - position
  - orientation
  - structure

Approximate-Body Channel

- More frequent position and orientation updates
- Hosts can render a rough approximation of the entity's dynamic structure
  - appendages and other articulated parts
- Provided information is entity-specific
  - corresponds to the dominant changes of the structure

Common Approximations

- Radial length
  - motion towards and away from a centre point
  - update packets include the current radius
- Articulation vector
  - the current direction of the appendage
  - models a rotating turret, arms and legs
- Local co-ordinate system points
  - subset of the entity's significant vertices relative to the entity's local co-ordinate system
  - the entity is composed of multiple components



Full-Body Channel

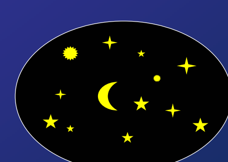
- Highest level of detail
- High bandwidth and computational requirements
  - viewer can subscribe to a limited number of full-body channels
- Frequent transmissions
- Position and orientation
- Accurate structure information

Local Perception Filters (LPFs)

- introduced by Sharkey, Ryan & Roberts (1998)
- a method for hiding communication delays in networked virtual environments
- exploits the human perceptual limitations by rendering entities slightly out-of-date locations based on the underlying network delays
  - causality of events is preserved
  - rendered view may have temporal distortions
  - rendered view ≠ real view

Active and Passive Entities

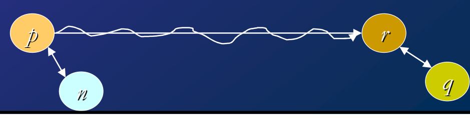
- An active entity (i.e., player)
  - takes actions on its own
  - generates updates
  - human participants, computer-controlled entities
  - cannot be predicted typically
  - rendered using state updates adjusted for the latency



- A passive entity
  - reacts to events from the environment, does not generate its own actions
  - inanimate objects (e.g., rocks, balls, books)
  - active entities interact with passive entities
  - rendered according to the latency of its nearest active entity
  - reacts instantaneously to the actions of a nearby active entity

Rules of LPFs

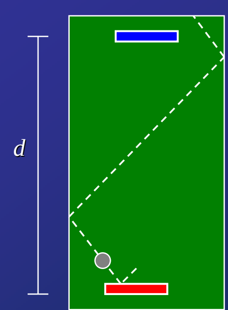
1. Player should be able to interact in real-time with the nearby entities.
2. Player should be able to view remote interactions in real-time, although they can be out-of-date.
3. Temporal distortions in the player's perception should be as unnoticeable as possible.



Interaction Between Players

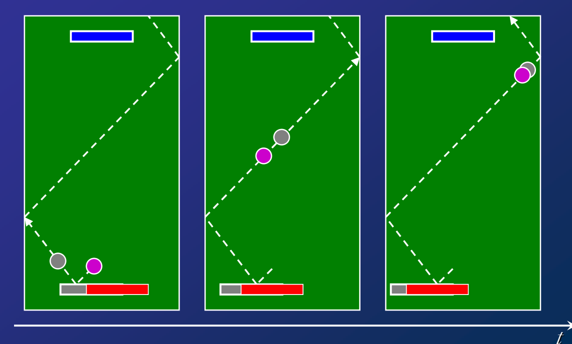
- interaction = communication between the players
  - local players: immediate
  - remote players: subject to the network latency
    - time frame = current time – communication delay
- interaction = players exchanging passive entities
  - passive entities are predictable ⇒ they can be rendered in the past (or in the future)
- a passive entity can change its time frame dynamically
  - the nearer to a local player, the closer it is rendered to the current time
  - the nearer to a remote player, the closer it is rendered to its time frame

Example: Pong

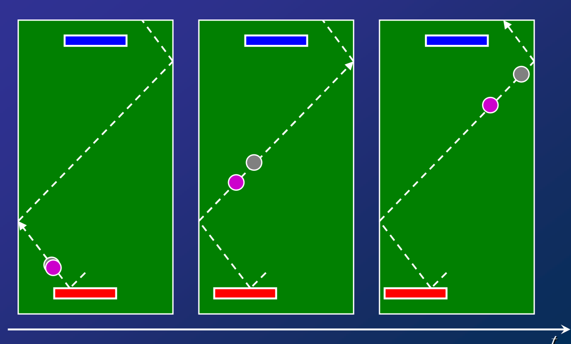


- Two active entities: paddles
  - movement unpredictable
- One passive entity: ball
  - movement predictable
- Latency of *d* seconds

The View of the Blue Player

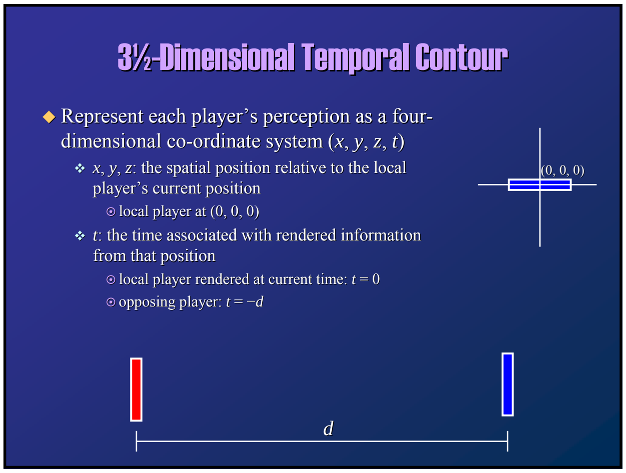


The View of the Red Player

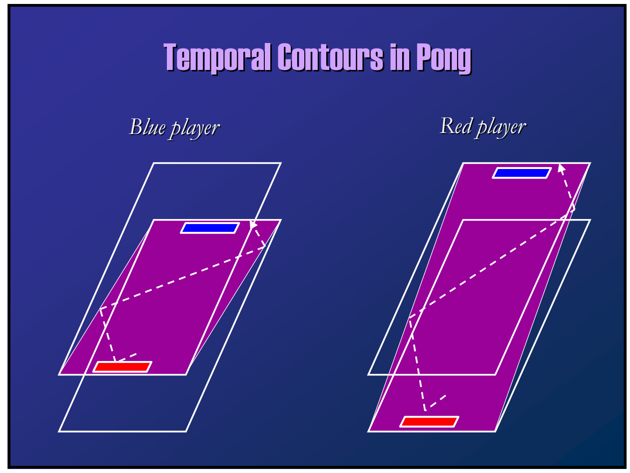


Pong: A Summary

- Each player sees a different representation of the same playing field
- The ball accelerates as it approaches the local player's paddle
- The ball decelerates as it approaches the remote player's paddle
- The ball's rendered position alternates between
  - the current time
    - meaningful interaction for local player
  - a past time reference
    - network latency
    - observing meaningful interaction for remote player



3½-Dimensional Temporal Contour
Represent each player's perception as a four-dimensional co-ordinate system (x, y, z, t)
x, y, z: the spatial position relative to the local player's current position
local player at (0, 0, 0)
t: the time associated with rendered information from that position
local player rendered at current time: t = 0
opposing player: t = −d
(0, 0, 0)
d



Temporal Contours in Pong
Blue player
Red player