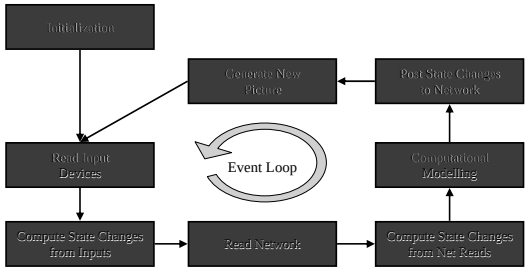
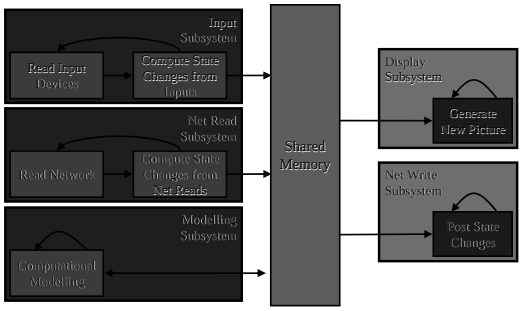
Single-Thread NVE



Multiple Subsystems, Multiple Threads



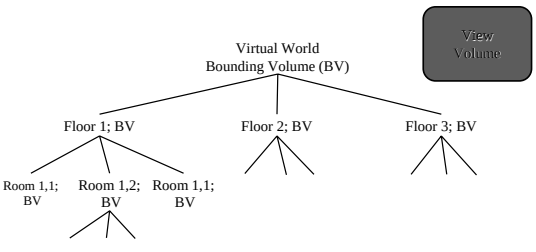
Real-Time Rendering

- Key problem: limitations in the performance of graphics hardware
  - frames per second
  - polygons per second
- Polygon culling
- Level-of-detail processing

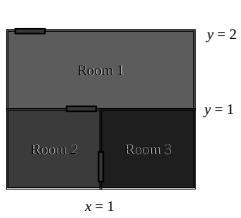
Polygon Culling

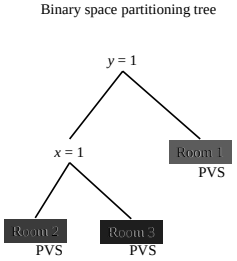
- Reduce the number of processed polygons
  - determine which polygons do not need to be drawn
- A wealth of research and methods exists
- Assumes that the underlying 3D model remains quite static
  - changes in the model ⇒ changes in the culling data structures

Culling Tree



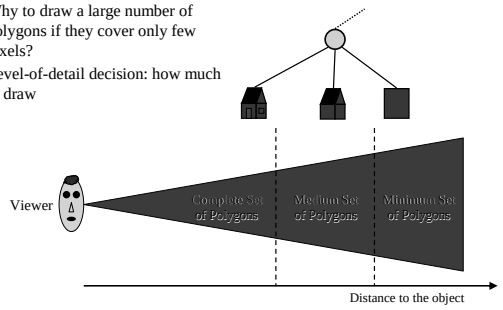
Potentially Visible Sets (PVSs) of Polygons





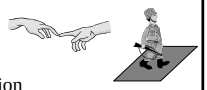
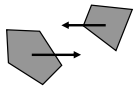
Levels of Detail (LOD)

- Why to draw a large number of polygons if they cover only few pixels?
- Level-of-detail decision: how much to draw



Real-Time Collision Detection and Response

- Interacting with the VE
  - touching, grasping, standing,…
- Take some action in response to the collision
- Is there an intersection with the polygons of an object and the polygons of any other object?
  - test bounding boxes
  - utilize hierarchical data structures
- Where are the precise contact points?


Real-Time Collision Detection Solutions

- Approaches to collision detection
  - geometric reasoning
  - bounding volume hierarchy
  - analytical methods
  - hybrid
- Fast, approximate collision detection
  - ownship: static object collisions
  - ownship: moving object collisions
- Fast, accurate collision detection

Fast, Approximate Collision Detection

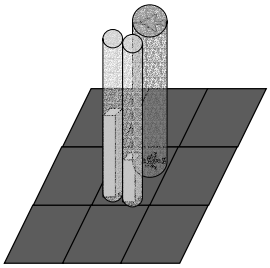
- Important to recognize that a collision has occurred
- The precise location of the collision is unimportant
- Example: NPSNET
  - moving objects can collide with each other and with fixed, static objects
  - upon collision over a certain speed ⇒ the moving object dies
  - no sophisticated physics
- Ownship = the local player in the VE
  1. Moving object (ownship) against static objects
  2. Moving object (ownship) against moving objects (other players)
- Up to the ownship to report its collisions and its death

Ownship: Static Object Collisions

- Occurs when an object has moved and its position is updated
- Reduce the set of static objects that must be considered

1. Is the ownship below the a threshold elevation?
2. Calculate 2D distance to all objects in the grid square
3. Is the ownship's ground elevation less than the height of the static object?

- Issue a detonation PDU or an entity state PDU

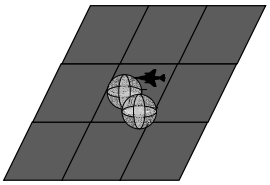


Ownship: Moving Object Collisions

- The ownship did not collide with any static object
- Reduce the collision comparison space

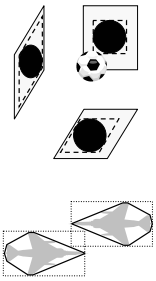
1. Check current and neighbouring squares
2. Calculate 3D distances to objects
3. Cast a ray from the ownship's origin to the moving object's origin

- The host managing moving object also performs collision detection and issues PDUs

Fast, Accurate Collision Detection

- Sweep-and-prune algorithm
- An axially aligned 3D bounding box for each object
- Sort the bounding boxes
- Are the bounding boxes overlapping?
  - for 3D bounding boxes to collide, their projections must overlap
- Are the the convex hulls overlapping?
- Compute the actual area of collision

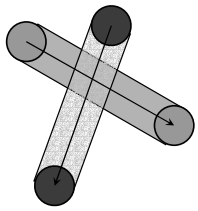


Problems of Collision Detection in NVEs

- Who determines collision in an NVE?
- The object that has collided
  - DIS does not require that the hosts use the same collision detection algorithm
  - what if one decides to die, whilst another decides that there was no collision
  - fair play requires a standard for collision detection
- What about collisions that happen
  - in between time steps, or
  - for dead-reckoned objects?

Collisions in between Time Steps

- The objects are moving too fast
- The time steps between frames are too large
- Requires additional computation



Collisions for Dead-Reckoned Objects

- The ownship may determine collision with a dead-reckoned object and issue a packet
- The object collided with is at a slightly different actual position
  - no collision
  - collision with different results

- Mechanism for establishing an agreement on which the objects reach an acceptable conclusion
- Recognize arriving packets that indicate mutual collision
  - the object that missed the collision must also realize it
  - problem between the time of real collision and the learning time
  - how to correct the past?

Computational Resource Management

- How to allocate processor time for the processes
  - do we leave it to the operating system?
- A blocked thread should yield the processor to the threads in waiting
- Subsystems in separate threads
  - input subsystem
  - net read subsystem
  - display subsystem
  - net write subsystem
  - modelling subsystem