Replayable Cooperative Game Design: Left 4 Dead

Michael Booth, Valve
Left 4 Dead is a replayable, cooperative, survival-horror game where four Survivors cooperate to escape environments swarming with murderously enraged “Infected” (ie: zombies).
Left 4 Dead: The Survivor Team
Left 4 Dead: Enraged Infected Mob
Left 4 Dead: The Special Infected
Left 4 Dead: The Boss Infected
Left 4 Dead
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Project Goals

Observations

• Perceived Gap in the Market for Co-op gaming
  • The major risk of the project
• Experience creating single player games epic in scale, narrative
• Multiplayer builds community, generates long-term retail sales
  • Still selling Counter-Strike 1.6 today
• Experience with online multiplayer AI technology
  • Counter-Strike Bot

Goal

• Using our AI tech, combine single player and multiplayer game mechanics into a new kind of replayable, cooperative, online experience
Strategy for Reaching our Goals

➢ Require Cooperation
  • Primary product risk
  • Crisp focus
    • Generate clear data on demand for feature
    • Explicitly fill perceived gap in market
  • Game design must clearly encourage coop to mitigate risk

➢ Replayability
  • Game design must encourage long-term replayability
  • Build online community
  • Entertainment as a Service
Left 4 Dead Game Mechanics

➢ Requiring Cooperation

➢ Replayability
  • Designing for Dramatic Potential
    • Dramatic Anticipation
    • Structured Unpredictability
  • Adaptive Dramatic Pacing
  • Procedurally Populated Environment
Requiring Cooperation

- **Encourage cooperation throughout game design**
  - Structure game so players *want* to do the right thing
  - Ensure cooperation is the only winning strategy
  - Treat entire Survivor team as “the player”
- **Penalize non-cooperative behavior harshly**
  - Abandoning the team = death
- **Avoid artificial/arbitrary enforcement**
  - Players rebel against overtly heavy-handed punishments
  - No invisible leashes, teleporting stragglers closer, dealing “out of bounds” damage, etc
Survival Horror genre is an excellent fit

- Well established mainstream genre
- Everyone knows “The Rules”:
  - The Good Guys work together
  - The Jerks selfishly abandon the group (and die horribly)
  - The Enemies are ruthless and nearly unstoppable
Requiring Cooperation: Enemy Design

➤ You Are Clearly Outnumbered: The Horde
  • Obviously too many enemies for one Survivor to handle alone
  • “Grabby” Infected stop Survivors when they hit, making even a single Infected dangerous
  • Enforces cooperation in an implicit manner without seeming heavy-handed because it fits the expected genre behavior
Don’t Go Out Alone: The Special Infected

- Tougher Infected with special abilities
- Adds a layer of variation to the homogeneity/predictability of battling the horde
- Each special ability exists to address specific gameplay issues
- Each has an overwhelming or incapacitating attack which create dramatic cooperative moments for the Survivor team
Requiring Cooperation: Enemy Design

➢ The Hunter

• Purpose: Outrun and kill stragglers and “lone wolf” players
• Completely incapacitating Pounce attack
The Smoker

- Purpose: Pull apart tightly coordinated teams to create unexpected moments of chaos
- Completely incapacitating long range Tongue attack
Requiring Cooperation: Enemy Design

- The Boomer
  - Purpose: Break the rule of “shoot everything that moves”, forcing players to think a bit before firing
  - Boomer’s Vomit/Explosion creates excellent moments of Dramatic Anticipation where you know the mob is coming to get you, soon...
The Special Infected Incapacitating attacks

- Make players fear becoming separated from the group, reinforcing team cohesion
- Give players near the incapacitated victim the opportunity to be the hero and save them
- Players really enjoy helping each other
“OH $#*!!”: The Boss Infected

- Boss Infected force the Survivors to immediately re-evaluate their tactics
- Breaks Survivor team out of their familiar pattern of behavior
- Forces the Survivors to re-think whole-team situation and current strategy, encourages team talk
- Generates Dramatic Anticipation
The Tank

- Halts forward momentum while Survivors focus on the imminent danger of the Tank
- Requires full attention of entire team
- Forces Survivors to defend instead of assault
- Tank throw ability makes Survivors reevaluate their environment
- Music change, Tank’s yells and heavy footfalls create powerful moment of Dramatic Anticipation
Requiring Cooperation: Enemy Design

➢ The Witch

• Breaks the rule of “shoot everything that moves” with higher contrast than the Boomer
• Forces Survivors to move stealthily and take extra care with flashlights and weapons
• Danger is communicated by broadcasting Witch presence via disturbing crying sound effects
• Creates powerful moments of Dramatic Anticipation
Survivor characters automatically emit various vocalizations

- Improves situational awareness
  - “Behind you!”
  - “Hunter’s got Zoey!”
  - “Witch!”
  - “Here they come!”
  - “Grenade!”
  - Rebukes for friendly fire
- Communicates short term goals
  - “The subway is just up the street”
  - “Can you let me out? I’m stuck!”
  - “Get to the chopper!”
- Encourages cooperation via baseline of camaraderie
  - “Thanks for that”
  - “Don’t worry I got ya…”
  - Friendly, supportive tone of voice (usually)
Limited resources that are required for success encourage cooperation

- Effective because the game clearly can't be won alone
- Obvious benefit to sharing (keep extra gun alive)
- Minimal sharing UI doesn't get in the way
- Sharing behavior breaks the ice, builds group solidarity
- Another opportunity for Players to directly help each other
A player in a clearly helpless and dependent state demands cooperation

- Effective because the game can’t be won alone
- Obvious benefit to sharing (keep extra gun alive)
- Obvious that you will likely be in a similar situation soon
- Easy to assist helpless player
- Benefit clearly outweighs cost (usually)
- Another opportunity for Players to directly help each other
Left 4 Dead Game Mechanics

- Requiring Cooperation
- Replayability
  - Designing for Dramatic Potential
    - **Dramatic Anticipation**
    - Structured Unpredictability
  - Adaptive Dramatic Pacing
  - Procedurally Populated Environment
Designing for Dramatic Potential

Dramatic Anticipation

- Set up moments where event X implies interesting event Y after a short delay
- Anticipation of imminent reward/punishment is very powerful
- Example: Old Boomer vs New Boomer
Many Dramatic Anticipation examples in Left 4 Dead

- **Infected Breaking Through Doors**
  - Classic horror movie moment of anticipation

- **Boomer Vomit/Explosion**
  - A big attack coming in a few seconds. Anticipation enhanced via distinctive music and vision obscuring screen effect

- **Tank Incoming!**
  - Distinctive music, Tank’s distant yelling and pounding footsteps build anticipation as he approaches

- **Witch Nearby**
  - Her sobbing in the distance creates anticipation, particularly when her position is unknown

- **Music**
  - Many events are preceded by a distinctive piece of music that builds anticipation

- **Finales/Crescendo Events**
  - These start with a angry crowd shrieking in the distance, implying chaos is on the way soon

- **Finale Escape Vehicle**
  - Watching the escape vehicle arrive while fighting for your life
Dramatic Anticipation examples in Left 4 Dead (continued)

- **Incoming Mobs**
  - Seeing a huge mob of Infected running down the street or climbing over a fence
- **“Third Strike”**
  - Survivor has been revived twice will die next time – on “last legs”
- **Moving slowly when injured**
  - Limping into the safe room with a mob hot on your heels
- **Ledge hanging**
  - Classic example of anticipation – the “cliff hanger”
- **Incapacitation**
  - Lying helpless and bleeding on the ground generates anticipation for both the victim and his teammates
- **Rescue Closets**
  - Hearing trapped friends creates anticipation – especially if you are the only one left alive
- **Car Alarms**
  - Double anticipation: Of not setting it off, and of the mob that comes when you do
Designing for Dramatic Potential

➢ Dramatic Anticipation
Left 4 Dead Game Mechanics

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Designing for Dramatic Potential

- **Structured Unpredictability – What is it?**
  - Collections of interesting possibilities selected at runtime using intentionally designed randomized constraints

- **The value of Structured Unpredictability**
  - **Low probability + High drama = Memorable**
  - Designers often want everything to be experienced, every time - resist the temptation
  - Set up many *possible* moments, knowing few will happen at any run
  - Unpredictability greatly enhances replayability and drama
  - Combinations of randomized events generate memorable stories
Left 4 Dead Game Mechanics

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Adaptive Dramatic Pacing

- Algorithmically adjusting game pacing on the fly to maximize “drama”

Inspired by Observations from Counter-Strike

- Natural pacing of CS is "spiky", with periods of quiet tension punctuated by unpredictable moments of intense combat
- Constant, unchanging combat is fatiguing
- Long periods of inactivity are boring
- Unpredictable peaks and valleys of intensity create a powerfully compelling and replayable experience
- Same scenario, often the same map, yet different and compelling experience each round
The AI Director algorithmically drives overall pacing

- Creates peaks and valleys of intensity similar to the proven pacing success of Counter-Strike

- Pacing Algorithm
  - Estimate the “emotional intensity” of each Survivor
  - Track the max intensity of all 4 Survivors
  - If intensity is too high, remove major threats for awhile
  - Otherwise, create an interesting population of threats
Adaptive Dramatic Pacing

- Estimating the “emotional intensity” of each Survivor
  - Represent Survivor Intensity as a single floating point value
  - Increase Survivor Intensity
    - When injured by the Infected, proportional to damage taken
    - When the player becomes incapacitated
    - When player is pulled/pushed off of a ledge by the Infected
    - When nearby Infected dies, inversely proportional to distance
  - Decay Survivor Intensity towards zero over time
  - Do NOT decay Survivor Intensity if there are Infected actively engaging the Survivor
Use Survivor Intensity to modulate the Infected population

- **Build Up**
  - Create full threat population until Survivor Intensity crosses peak threshold
- **Sustain Peak**
  - Continue full threat population for 3-5 seconds after Survivor Intensity has peaked
- **Peak Fade**
  - Switch to minimal threat population ("Relax period") and monitor Survivor Intensity until it decays out of peak range
  - This state is needed so current combat engagement can play out without using up entire Relax period. Peak Fade won’t allow the Relax period to start until a natural break in the action occurs.
- **Relax**
  - Maintain minimal threat population for 30-45 seconds, or until Survivors have traveled far enough toward the next safe room
Adaptive Dramatic Pacing

- **“Build Up” = Full Threat Population**
  - Wanderers
  - Mobs
  - Special Infected

- **“Relax” = Minimal Threat Population**
  - No Wanderers until team is calm
  - No Mobs
  - No Special Infected (although existing Specials may attack)

- Boss Encounters NOT affected by adaptive pacing
Adaptive Dramatic Pacing reacts to Survivor team actions

- Generates reliable peaks of intensity without completely overwhelming the team
- Because of player variation, timing and location of peaks will differ each time game is played
Adaptive Dramatic Pacing

➢ A procedurally generated population
Adaptive Dramatic Pacing

- How the AI Director modulates the population based on the Survivor team’s “emotional intensity”
Adaptive Dramatic Pacing

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Adaptive Dramatic Pacing

- Comparing population after modulation by the AI Director
Left 4 Dead Game Mechanics

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    - Dramatic Anticipation
    - Structured Unpredictability
  - Adaptive Dramatic Pacing
  - **Procedurally Populated Environment**
Procedurally Populated Environment

- How do we fill the environment with interesting distributions of threats?
  - Layers of Structured Unpredictability

- How to populate world with hundreds of enemies efficiently?
  - Reuse a limited number of entities
  - Only populate the environment immediately surrounding the Survivor team via the Active Area Set
Layers of **Structured Unpredictability** create interesting populations

- **Wanderers**
  - Common Infected that wander around in a daze, sit down, or lay down until alerted by a Survivor

- **Mobs**
  - A large group (20-30) of enraged Common Infected that rush the Survivors at unexpected times

- **Special Infected**
  - Infected with special abilities that skirmish with the Survivor team periodically

- **Bosses**
  - Powerful Infected encountered a few times per map that force the Survivors to change their strategy

- **Weapon Caches**
  - Collections of “2nd tier” weapons

- **Scavenge Items**
  - Pipe bombs, Molotovs, Pain Pills, Extra Pistols
The Navigation Mesh

- Originally created for Counter-Strike Bot pathfinding
- Useful for general spatial reasoning and spatially localized information
  - Has an area been seen by an actor?
  - Is area X potentially visible by area Y?
  - “Flow” distance – distance to this area from the Survivor team start location in the map
  - Etc
The Active Area Set (AAS)

- The set of Navigation Areas surrounding the Survivor team
- The AI Director creates/destroys Infected as the AAS moves through the environment
Procedurally Populated Environment

➢ The Active Area Set
Procedurally Populated Environment

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Procedurally Populated Environment

Populating Wandering Infected

- Stored as a simple count, C, in each area
- Counts are randomly determined at map (re)start
- When an area enters the AAS
  - Create C Infected (if possible)
- When an area leaves the AAS, or a pending Mob needs more members
  - Wanderers in the area are deleted and C is increased accordingly
- Wanderer count is zeroed:
  - When an area becomes visible to any Survivor
  - When the Director is in Relax mode
Procedurally Populated Environment

- **Populating Mobs**
  - Created at randomized intervals (90-180 seconds on Normal difficulty)
  - No mobs during Relax periods
  - Boomer Vomit forces Mob spawn, resets random interval
  - Mob size grows from minimum just after spawn to maximum after a duration to balance difficulty of successive, frequent Mobs
Procedurally Populated Environment

Where to create Mobs

- **Behind Survivors**
  - Only select valid areas in the AAS that are at or behind the Survivor team’s “flow” distance
  - 75% of Mobs come from behind, since wanderers and Special/Boss Infected are usually engaged ahead of the team

- **Near Boomer Vomit Victim**
  - Only select valid areas in the AAS that are near the Boomer Vomit Victim’s “flow” distance

- **Anywhere**
  - Any valid area in the AAS
  - Default if there are no valid areas in the more specific sets
Procedurally Populated Environment

Populating the Special Infected
- Created at individually randomized intervals
- No Specials during Relax periods
- Use any valid area not currently visible by the Survivor team
- Cleared status of areas ignored
- Smokers attempt to select areas above the Survivor team
Procedurally Populated Environment

**Boss Population**

- Created every N units along "escape path" +/- random amount.
- Three Boss events are shuffled and dealt out: Tank, Witch, and Nothing.
- Successive repeats are not allowed (ie: Tank, then Tank again)
Avoid manually placed scripts/triggers

• Specifically with respect to "when" and "where"
  • "what" can be ok
• Kills replayability
  • Players learn all script locations quickly
  • Removes suspense of not knowing what will happen next
• Kills cooperation
  • Players expect everyone to have memorized all encounters
  • Becomes a race
Procedurally Populated Environment

- **Weapon Caches**
  - Map designer creates several possible weapon caches in each map, the AI Director chooses which will actually exist

- **Scavenge Items**
  - Map designer creates many possible item groups throughout the map, the AI Direction chooses which groups actually exist

- **Why designer-placed?**
  - Prediction of possible locations beneficial in this case
  - Allows visual storytelling/intention
  - Solves item placement issues (leaning against wall, mounted in gun rack, etc)
Other Supporting Technologies

- **Voice over IP**
  - “Open mic” allows spontaneous and rapid communication
  - Hearing friend’s reactions increases drama and camaraderie

- **Game Instructor**
  - System of hints and visual directives allows new players to learn the game “on the fly”

- **In-game Voting**
  - Allow community to police itself

- **Split screen**
  - Supports casual “living room couch” cooperative play
  - Introduces a friend to the game

- **Achievements**
  - Reinforces desired co-op behaviors
  - Poses challenges for future play sessions

- **Steam/Matchmaking**
  - Friend lists
  - Groups
  - Free weekend passes
  - Matchmaking

- **Robust AI “Actors”**
  - CPU controlled Common, Special, and Boss Infected as well as Survivors
A procedural, adaptive system like the AI Director needs a roster of robust AI agents to direct

- Humans don’t like to be explicitly directed (VS mode)

**Complex 3D Environment Navigation**

- Climb fences, rubble
- Use ladders
- Jump across rooftops

**Rich Behaviors**

- Custom HCSM system with integrated event processing

**Survivor Bots**

- Allowed us to assume baseline 4 player Survivor team for game tuning
- Drop in/out (“Take a Break”) incredibly valuable in the wild
- Automated testing
Random players in the wild will actually cooperate!
- If game is structured to facilitate it (ie: no way to win otherwise)
- Players enjoy helping each other

Procedural Content
- Generates replayability
- Solution for replayable multiplayer experiences
- Greatly multiplies output of development team
- Improves community created content

Dramatic Anticipation
- If an event is exciting, it will be more so if it broadcasts its impending arrival

Structured Unpredictability
- Low probability + High drama = Memorable

Simple algorithms can generate compelling pacing schedules
- Survivor Intensity estimation is crude, yet the resulting pacing works
Do These Techniques Work?

In the six months since release, Left 4 Dead has

• ... sold more than 2,500,000 retail units
• ... received over 40 industry awards
• ... become the #1 new IP on the PC and Xbox 360
For more information...

- www.L4D.com
- www.valvesoftware.com
- mike.booth.gdc09 AT gmail.com
THANK YOU!