Optimizing balance in video games with asymmetrical choices

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Historically

- Relatively Simple
- Relatively little competition
- Relatively cheap to produce
- Relatively small market
Modern Day

- Relatively complicated
- Relatively high competition
- Relatively expensive to produce
- Relatively large market
Same Basic Idea

- Complete in-game tasks
- Gain more power
- Complete harder tasks more quickly
Old Paradigm

- Costs are upfront.
- Profit comes later.
- Short lifespan.

Development

Game
(Cheap to manufacture)
New Paradigm

- Upfront costs.
- Maintenance costs.
- Pay to play
- Pay for additional content
- Pay to win

Need people to keep playing!
Keeping the game interesting: Build Diversity

- Many player options
- Many choices
- Often no clear “best” choice

Start vs End vs Many different user experiences
Build Diversity in action role-playing games

**Player Choices**
- Character classes
- Items
- Skills
- Spells
- Abilities
- Dungeon level

**Examples**
- Dragon Slayer
- Zelda
- Secret of Mana
- Torchlight
- League of Legends
- Diablo
Build Diversity in action role-playing games

Key Assumption
Players will choose the most efficient path

Goal
All paths will be equally efficient
Build Diversity in action role-playing games

Minimize: Differences in efficiency
Subject to: Varying character classes
Varying character skills
Varying character spells
Varying character abilities

Note that character advancement (experience, items, dungeon level) are not part of this problem
Example: Diablo III

- A recent action role-playing game
- Pay-to-win
- Characters advance through:
  - Experience
  - Items

**Key Player Choice: Skills**
- 6 per game
- 100 options
Example: a Diablo III model for attack skills

Define the following:

\( \mathcal{P} \) is the set of primary attack skills
\( \mathcal{S} \) is the set of secondary attack skills

\( T(p, s): \mathcal{P} \times \mathcal{S} \rightarrow (0, \infty) \) is the amount of time it takes to destroy a pack of enemies using primary attack skill \( p \) and secondary attack skill \( s \).

\( A(p, s): \mathcal{P} \times \mathcal{S} \rightarrow (0, \infty) \) is the actual amount of time it takes including deaths

\( K(p, s): \mathcal{P} \times \mathcal{S} \rightarrow (0,1] \) is a factor characterizing time lost due to kiting.

\( D(p, s): \mathcal{P} \times \mathcal{S} \rightarrow (0,1] \) is a factor characterizing chance of death.

\( U(p, s): \mathcal{P} \times \mathcal{S} \rightarrow (0,1) \) is the percentage of time that \( s \) can be used.

\( S(x): \mathcal{P} \times \mathcal{S} \rightarrow (0, \infty) \) is a factor characterizing splash damage.

\( X(x): \mathcal{P} \times \mathcal{S} \rightarrow (0, \infty) \) is the damage of a skill.

\( d \in (0, \infty) \) is the amount of time lost when dying

\( t \in (0, \infty) \) is the target time to destroy a pack of enemies.

\( h \in (0, \infty) \) is the amount of hit points a typical pack of enemies has.

\[
T(p, s) \cdot K(p, s) \cdot \left( X(p) \cdot U(p, s) \cdot S(p) + X(s) \cdot (1 - U(p, s)) \cdot S(s) \right) = h \\
A(p, s) = T(p, s) + d \cdot D(p, s)
\]
Example: a Diablo III model for attack skills

Minimize

$$\sum_{p \in P \times s} (A(p, s) - t)^2$$

Subject to

$$T(p, s) \cdot K(p, s) \cdot \left( X(p) \cdot U(p, s) \cdot S(p) + X(s) \cdot (1 - U(p, s)) \cdot S(s) \right) = h$$

$$A(p, s) = T(p, s) + d \cdot D(p, s)$$

for every $p \in P$ and $s \in S$.

Variables: $A, T, D$
Parameters: $K, U, S, h, d$
A small problem: approximately 600 variables and constraints.
Example: Comparing damage to skill usage

Actual Game Values: maximum damage for secondary skills

- Zombie Charger: Zombie Bears
- Zombie Charger: Explosive Beast
- Zombie Charger: Leperous Zombie
- Zombie Charger: Wave of Zombies
- Zombie Charger: Undeath
- Acid Cloud: Acid Rain
- Acid Cloud: Slow Burn
- Acid Cloud: Lob Blob Bomb
- Acid Cloud: Corpse Bomb
- Acid Cloud: Kiss of Death
- Firebats: Dire Bats
- Firebats: Vampire Bats
- Firebats: Plague Bats
- Firebats: Hungry Bats
- Firebats: Cloud of Bats
Example: Comparing damage to skill usage

Actual Usage

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Example: Comparing damage to skill usage

NLP values: maximum damage for secondary skills
Example: Comparing damage to skill usage

Blizzard vs NLP comparison

- Blizzard Max Damage
- NLP Max Damage
- Usage With Blizzard Values

Skills and Abilities:
- Zombie Charger: Zombie Bears
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Blizzard vs NLP comparison graph.
Thank You!