Optimizing balance in video games with asymmetrical choices

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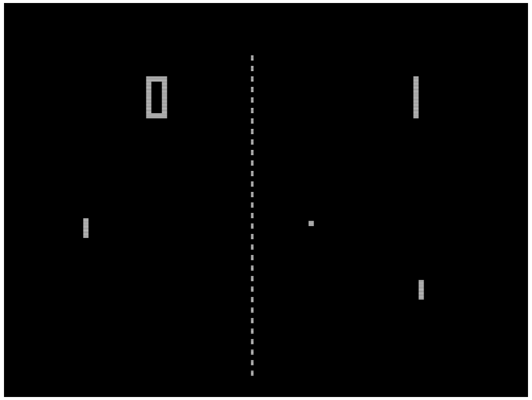
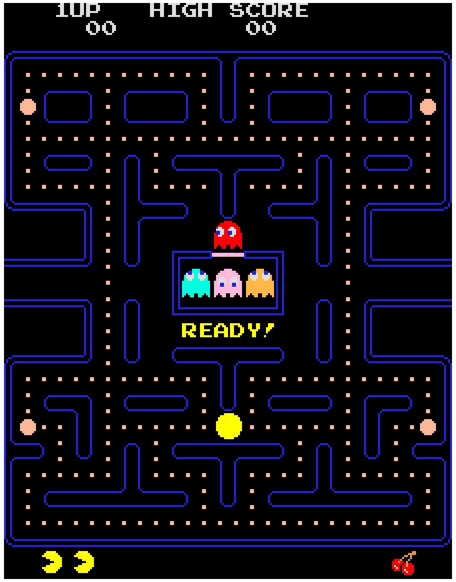
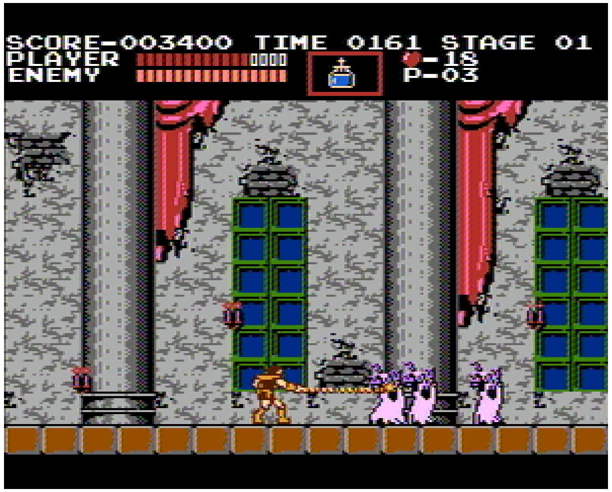
January 9, 2013

Historically

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





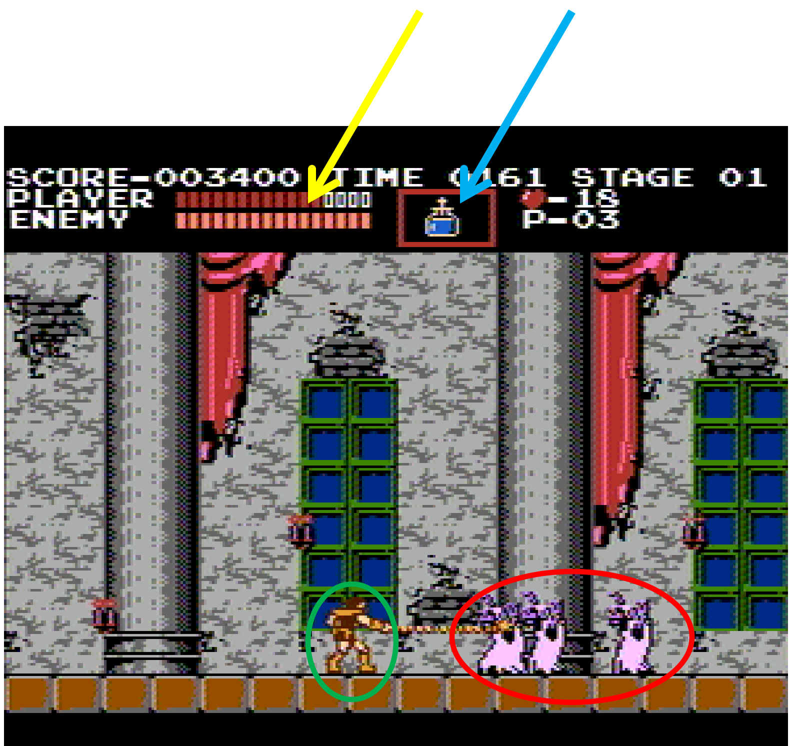


Modern Day

- Relatively complicated
- Relatively high competition
- Relatively expensive to produce
- Relatively large market

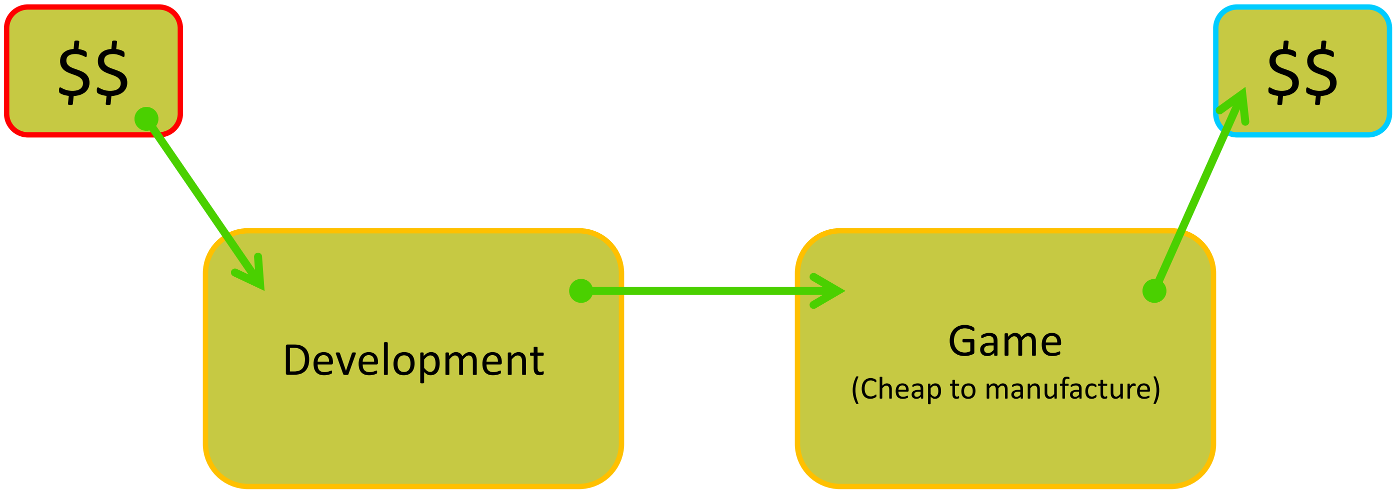
Same Basic Idea

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



Old Paradigm

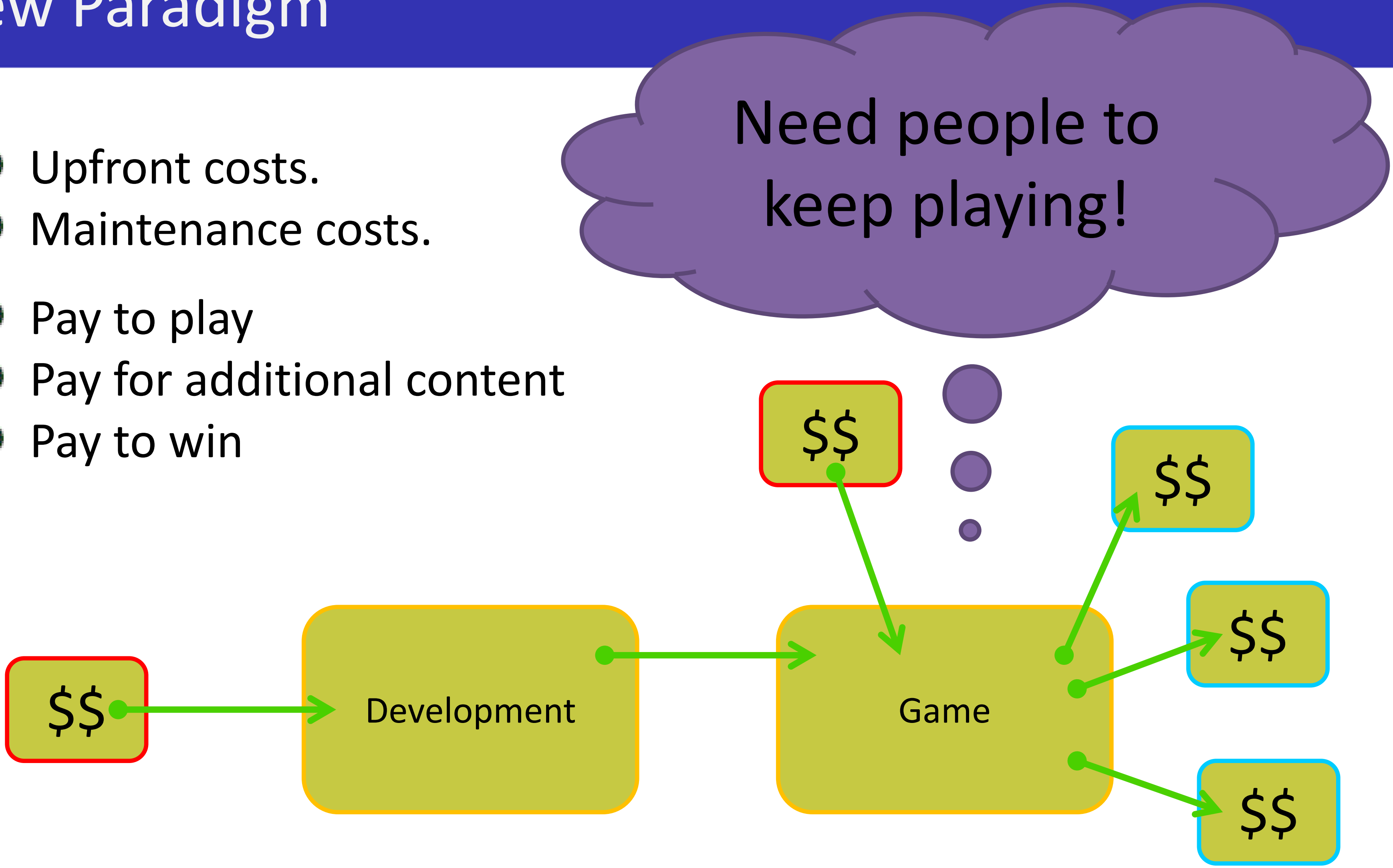
- Costs are upfront.
- Profit comes later.
- Short lifespan.



New Paradigm

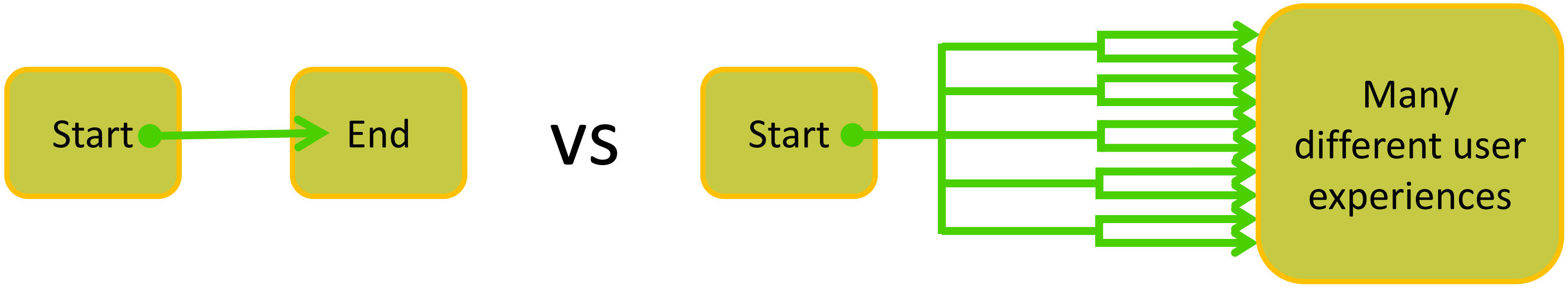
- Upfront costs.
- Maintenance costs.

- Pay to play
- Pay for additional content
- Pay to win



Keeping the game interesting: Build Diversity

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



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

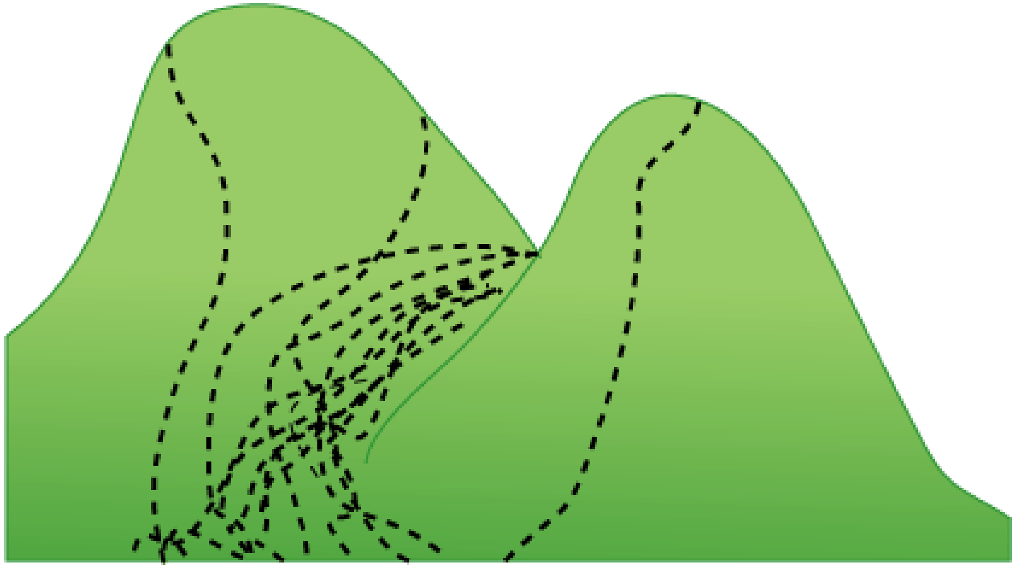
Build Diversity in action role-playing games

Key Assumption

- Players will choose the most efficient path

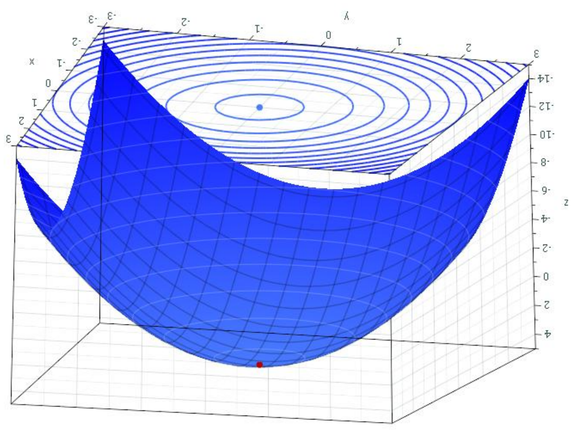
Goal

- 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



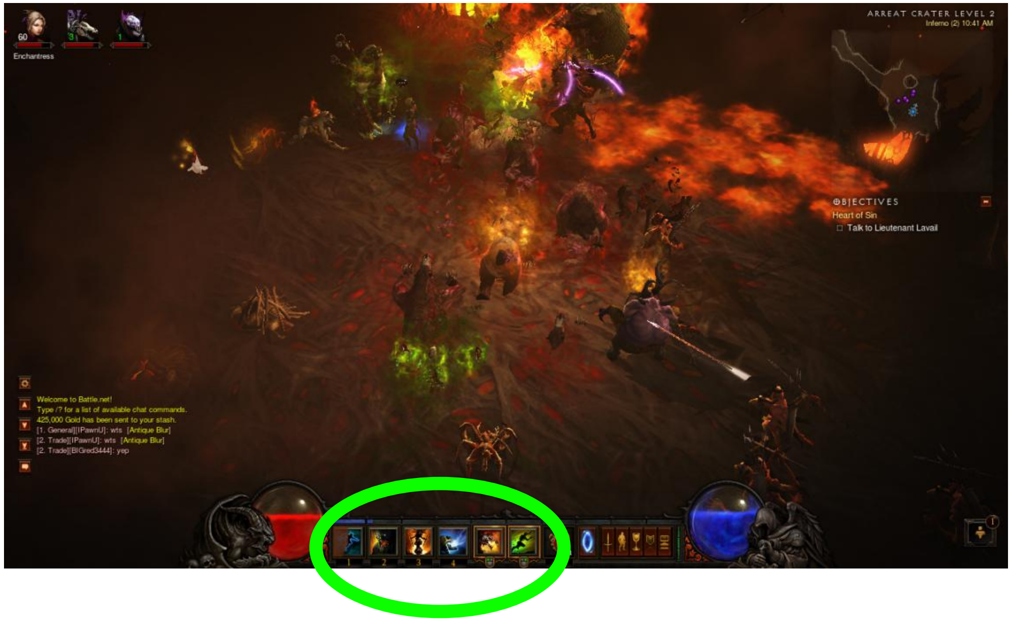
Note that character advancement (experience, items, dungeon level) are not part of this problem

Example: Diablo III

- A recent action role-playing games
- 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

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

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

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

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

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

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

$X(x)\colon \mathcal{P} \times \mathcal{S} \to (0,\infty)$ 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.

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

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

Example: a Diablo III model for attack skills

Minimize

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

Subject to

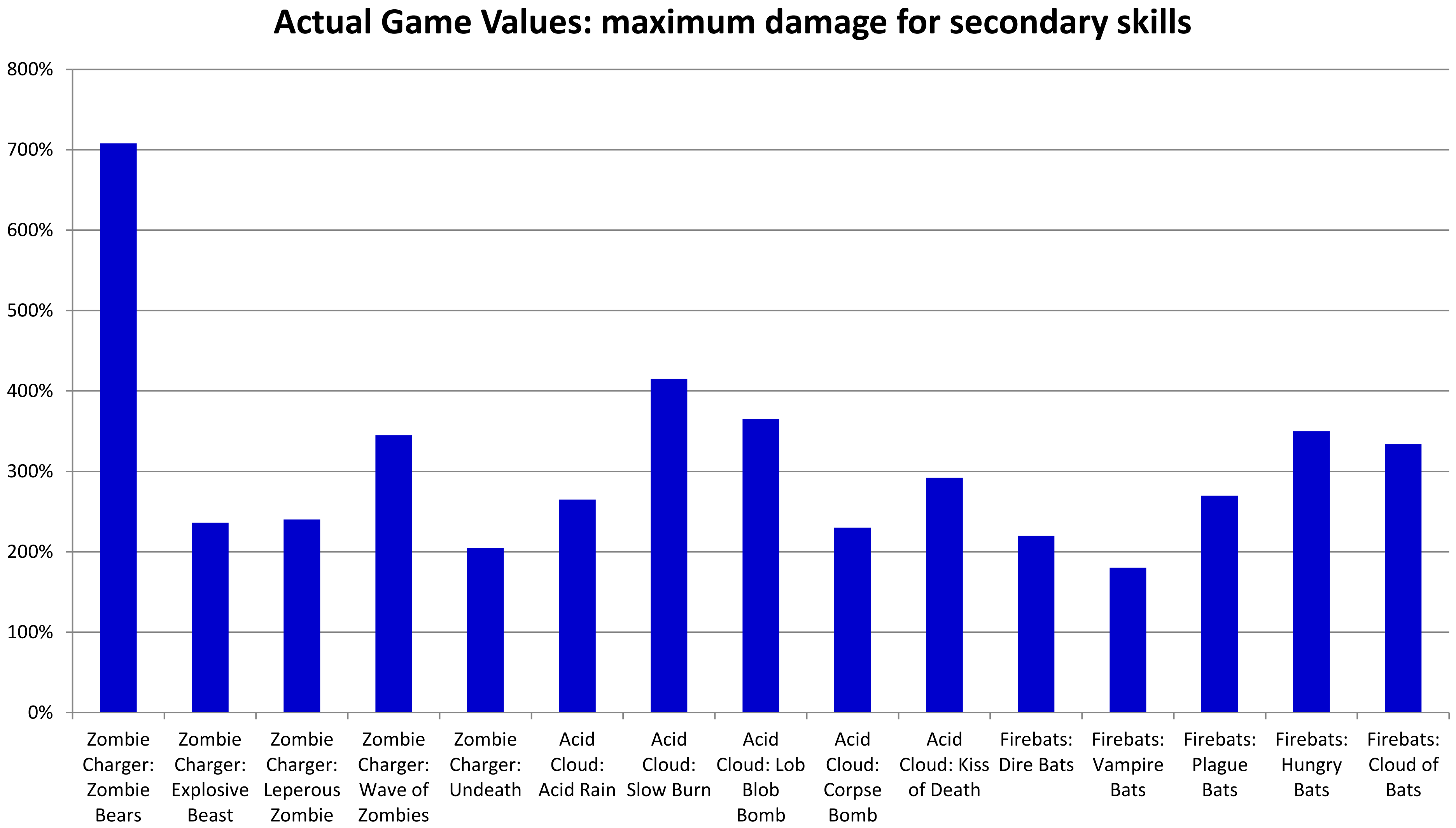
$$T(p,s) \cdot K(p,s) \cdot \Big(X(p) \cdot U(p,s) \cdot S(p) + X(s) \cdot \big(1 - U(p,s)\big) \cdot S(s) \Big) = h$$

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

for every $p \in \mathcal{P}$ and $s \in \mathcal{S}$.

Variables: A, T, D
Parameters: K, U, S, h, d
A small problem: approximately 600 variables and constraints.

Example: Comparing damage to skill usage



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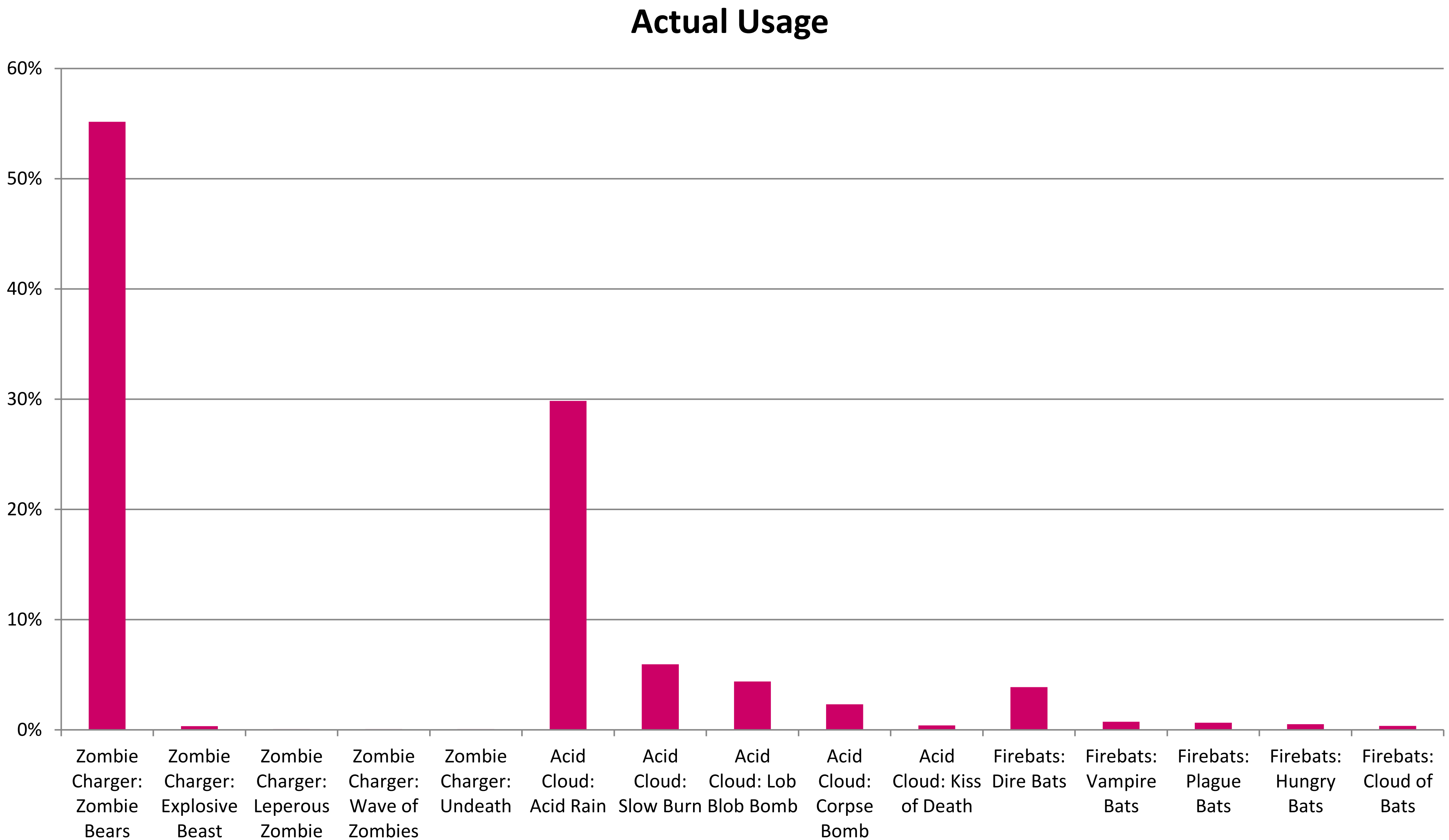

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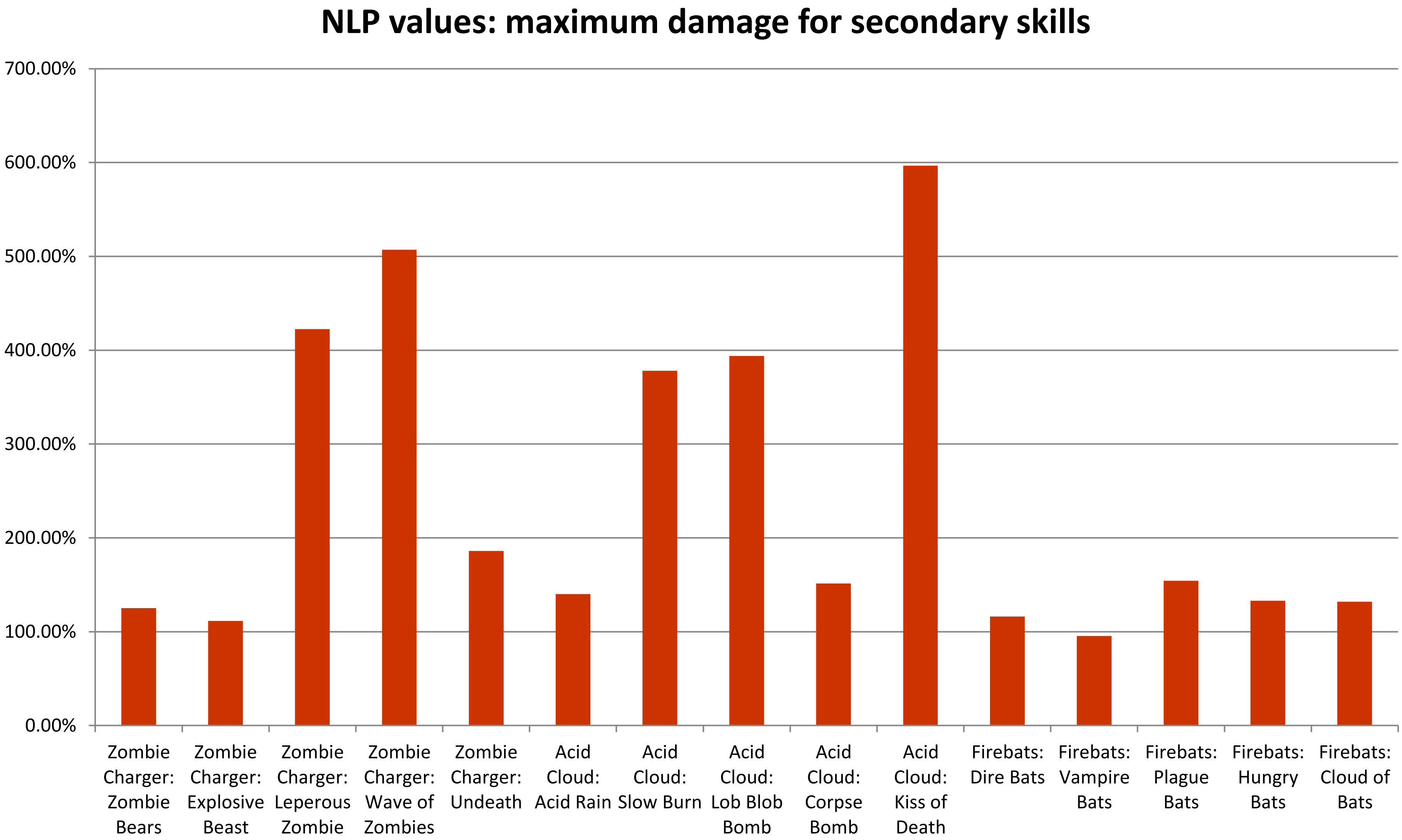

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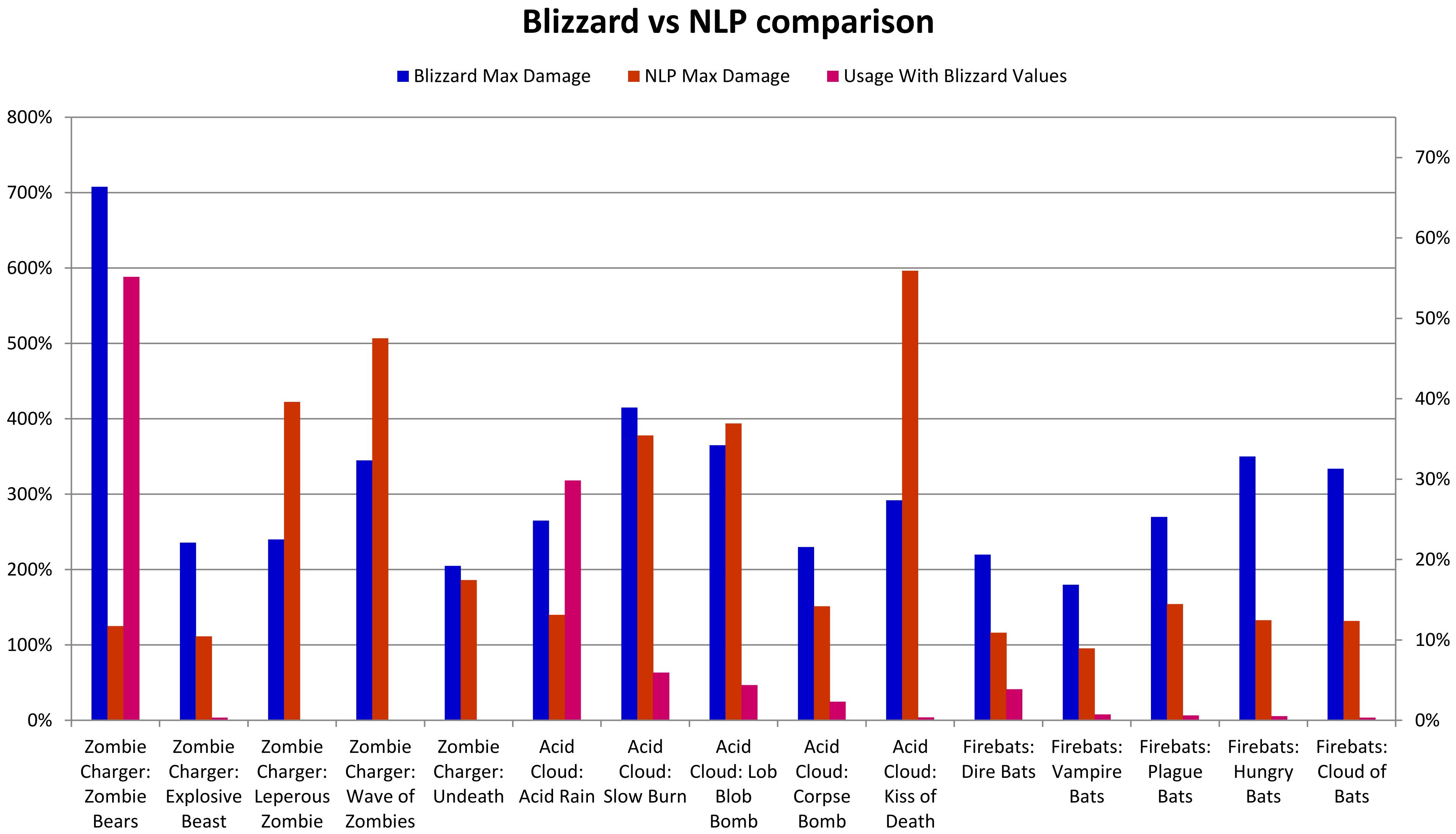

Thank You!