Procedural Content Generation
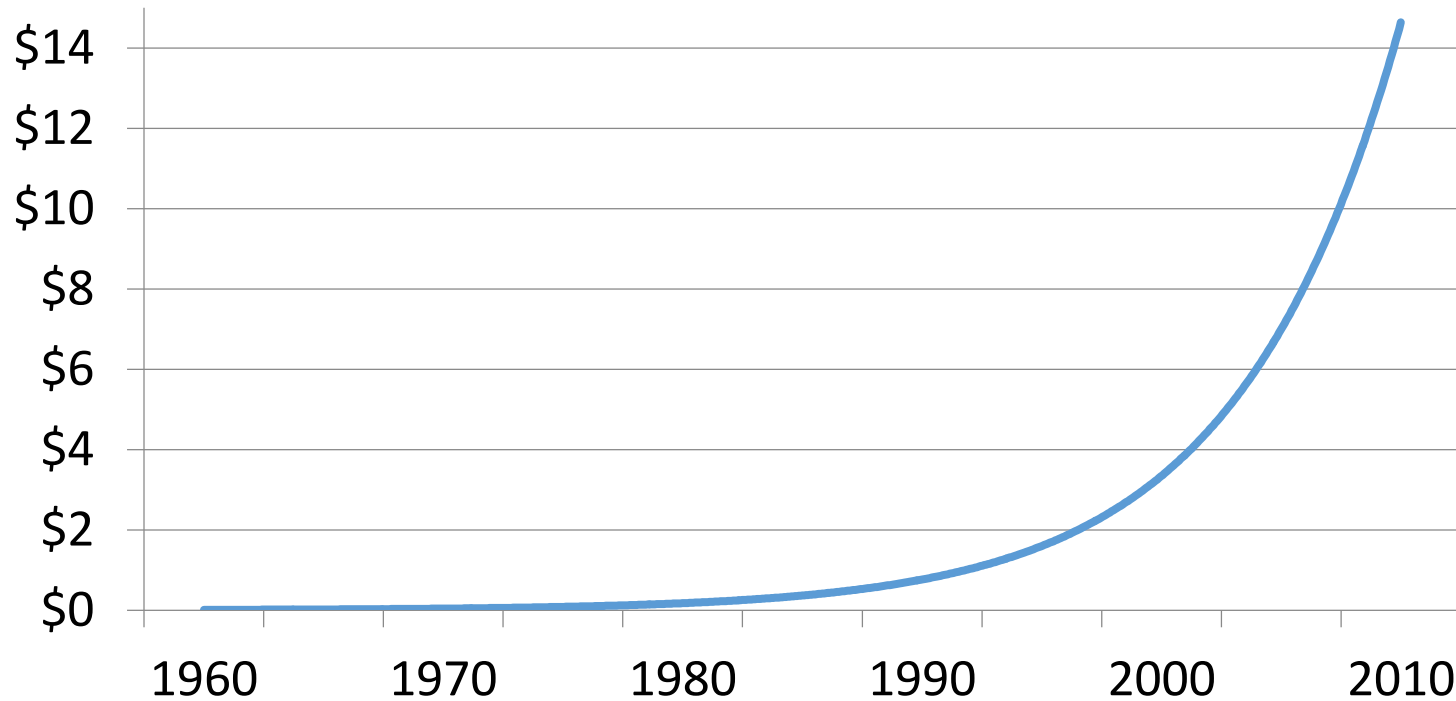
Metroid, 1986

Metroid Prime III: Corruption, 2007
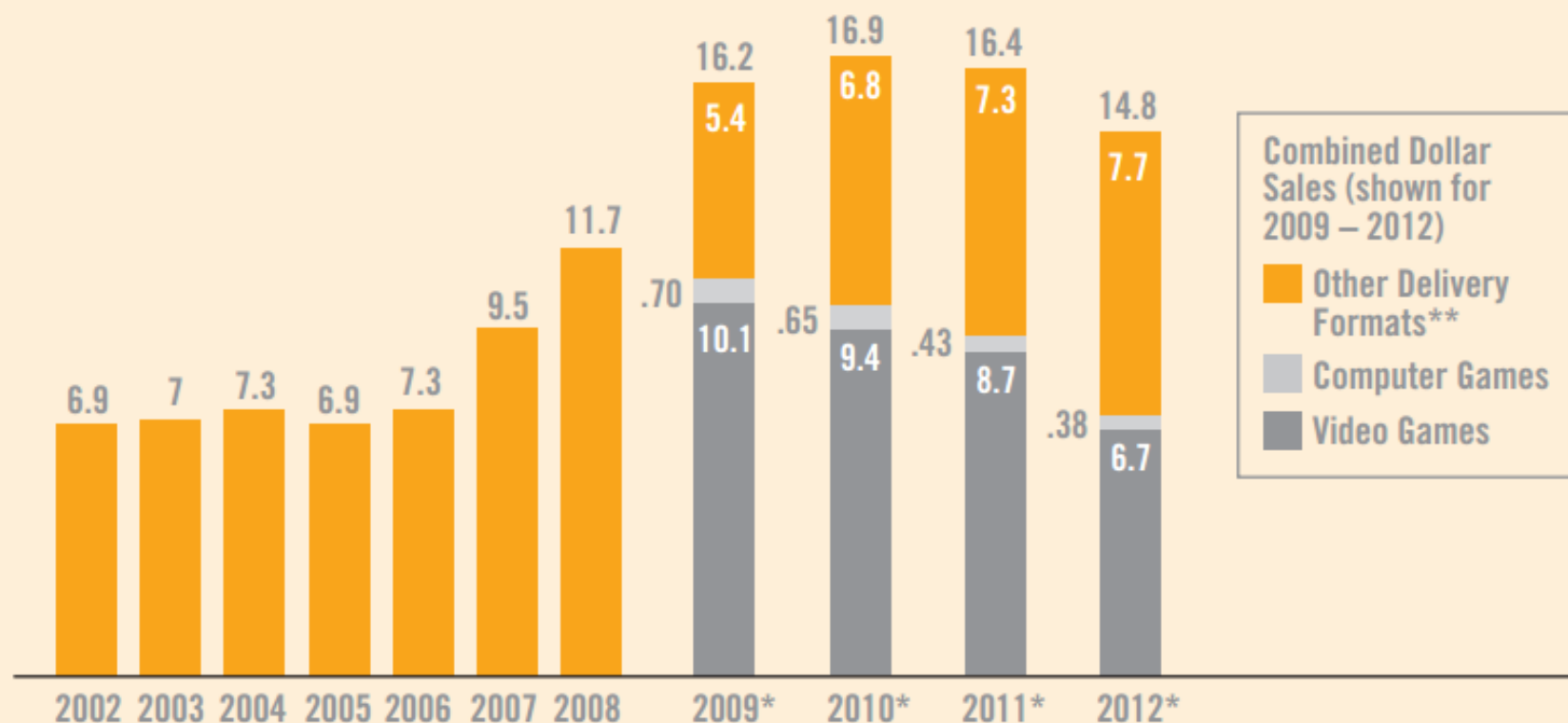
Game Production Cost in Millions

U.S. Computer and Video Game DOLLAR Sales Growth

DOLLARS IN BILLIONS*

Chart data:
- 2002: 6.9
- 2003: 7
- 2004: 7.3
- 2005: 6.9
- 2006: 7.3
- 2007: 9.5
- 2008: 11.7
- 2009*: 16.2 (Other Delivery Formats 5.4, Computer Games .70, Video Games 10.1)
- 2010*: 16.9 (Other Delivery Formats 6.8, Computer Games .65, Video Games 9.4)
- 2011*: 16.4 (Other Delivery Formats 7.3, Computer Games .43, Video Games 8.7)
- 2012*: 14.8 (Other Delivery Formats 7.7, Computer Games .38, Video Games 6.7)

Combined Dollar Sales (shown for 2009 – 2012)
- Other Delivery Formats**
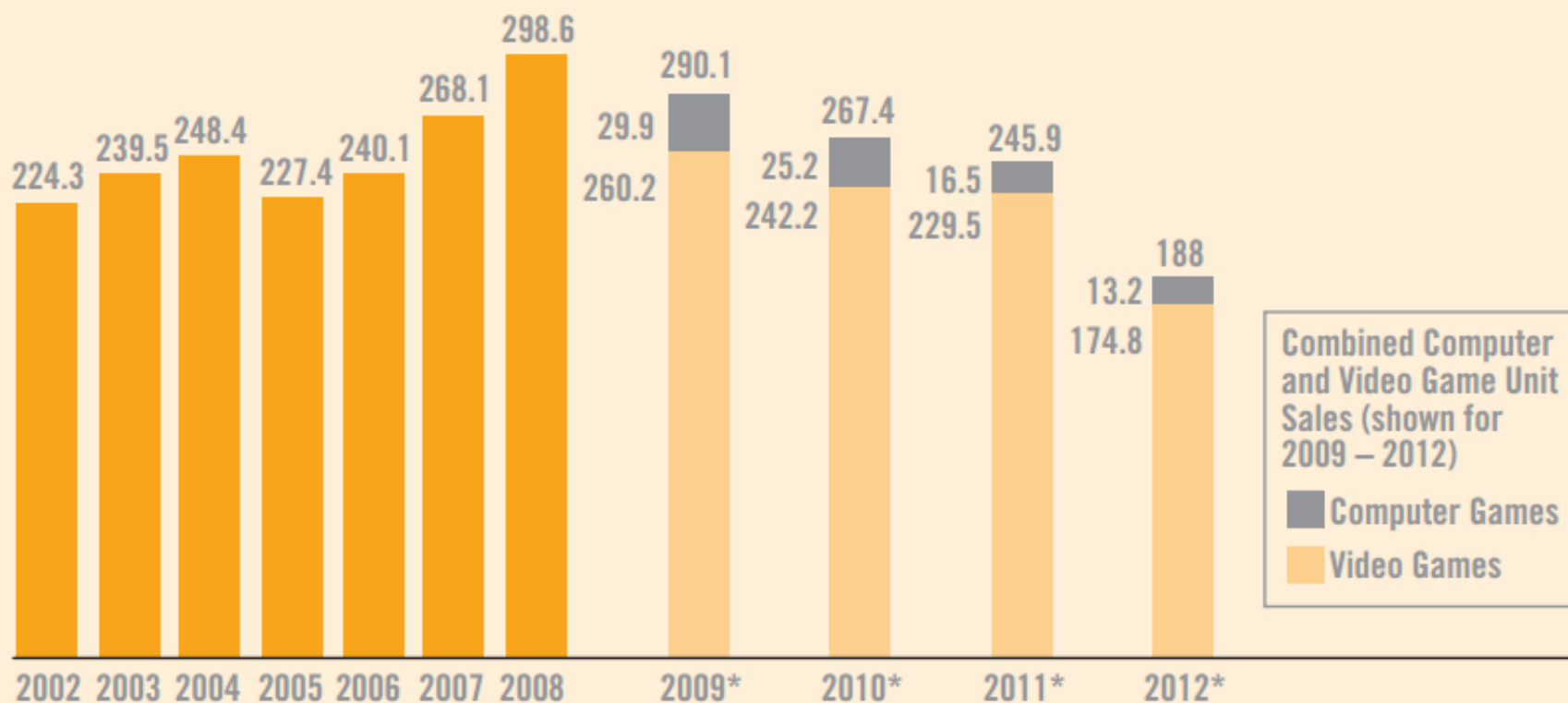- Computer Games
- Video Games

Source: The NPD Group/Retail Tracking Service; Games Market Dynamics: U.S.

  * Figures include total consumer spend

** Other delivery formats include subscriptions, digital full games, digital add-on content, mobile apps, social network gaming and other physical delivery. 2002-2008 figures are sales of new physical content at retail exclusively.

# U.S. Computer and Video Game **UNIT** Sales Growth

UNITS IN MILLIONS*

Year	Computer Games	Video Games	Total
2002			224.3
2003			239.5
2004			248.4
2005			227.4
2006			240.1
2007			268.1
2008			298.6
2009*	29.9	260.2	290.1
2010*	25.2	242.2	267.4
2011*	16.5	229.5	245.9
2012*	13.2	174.8	188

Combined Computer and Video Game Unit Sales (shown for 2009 – 2012)

■ Computer Games
■ Video Games

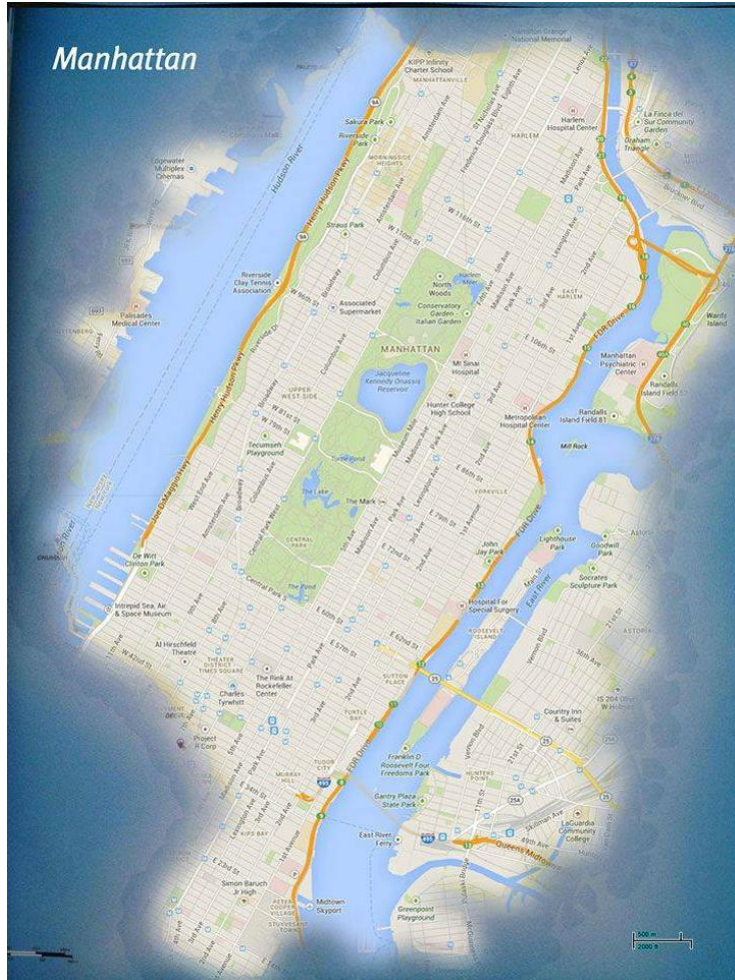Source: The NPD Group/Retail Tracking Service; Games Market Dynamics: U.S.

Figures are sales of new physical content at retail exclusively

Content
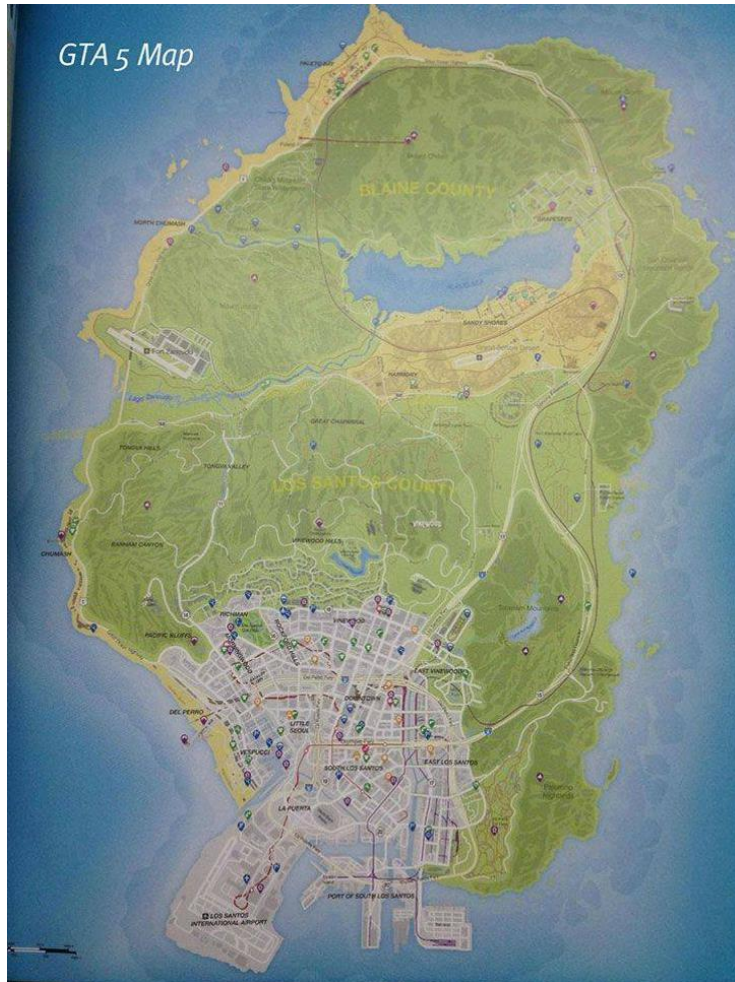
City of Los Santos,
Grand Theft Auto V, 2013

Content
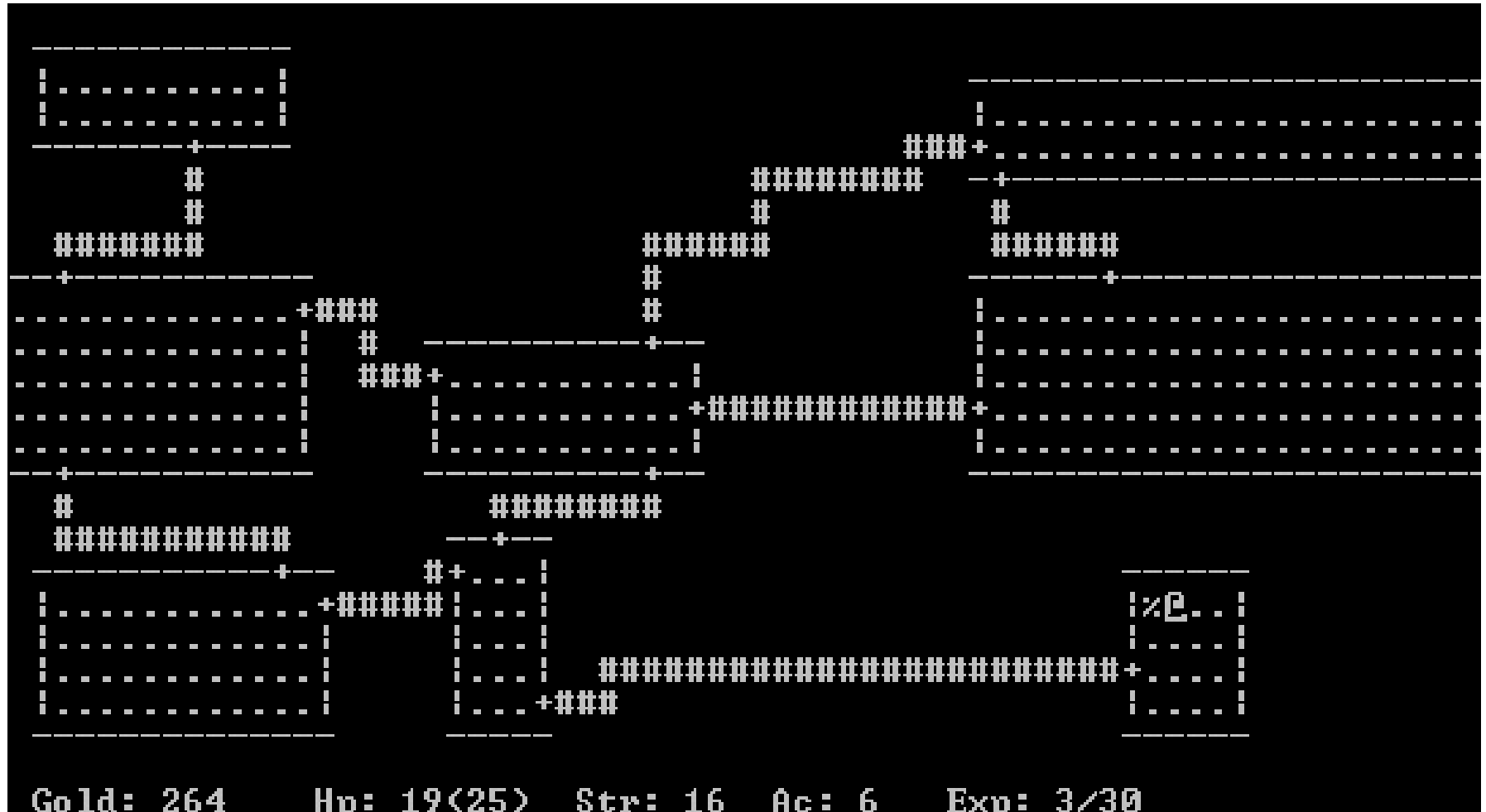

City of Los Santos,
Grand Theft Auto V, 2013

Manhattan (to Scale)

Procedural Content Generation

Procedural content generation (PCG) is the programmatic generation of game content using a random or pseudo-random process that results in an unpredictable range of possible game play spaces.
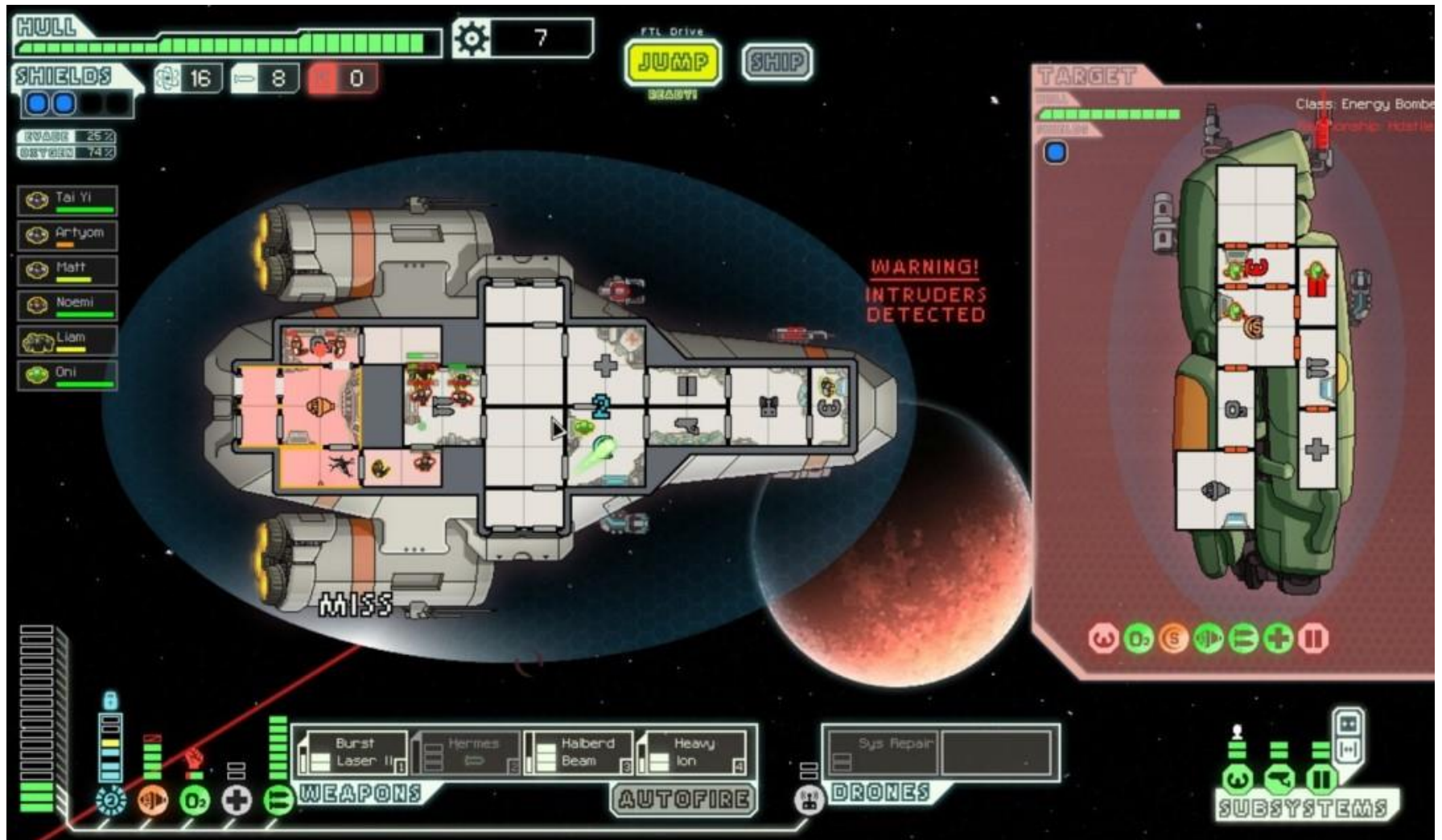
Source: PCG Wiki (pcg.wikidot.com)

Rogue, 1980


```
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```

Gold: 264   Hp: 19(25)   Str: 16   Ac: 6   Exp: 3/30

Diablo, 1997

Elite, 1984

Minecraft, 2010

FTL: Faster than Light, 2012

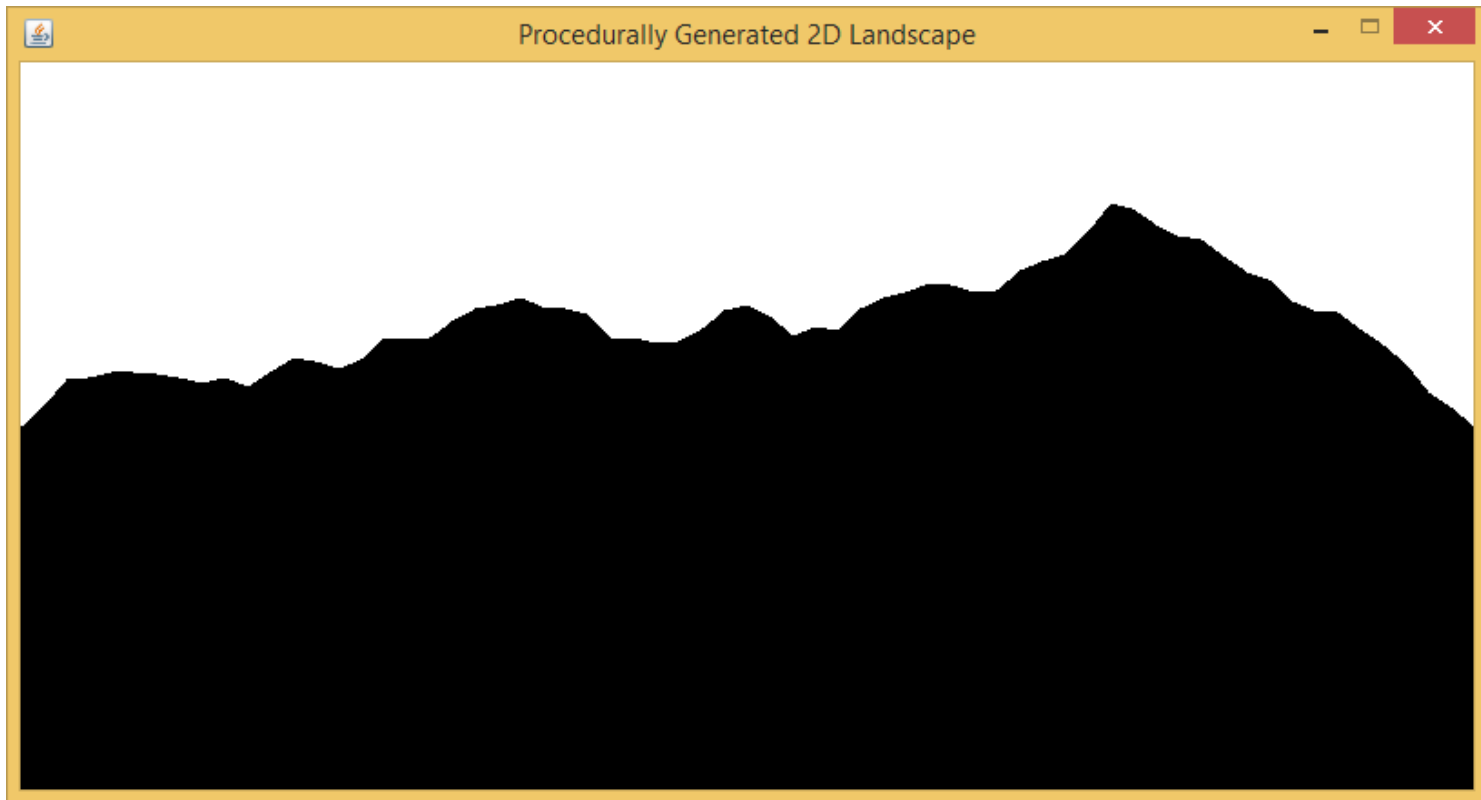# *Borderlands II*, 2012

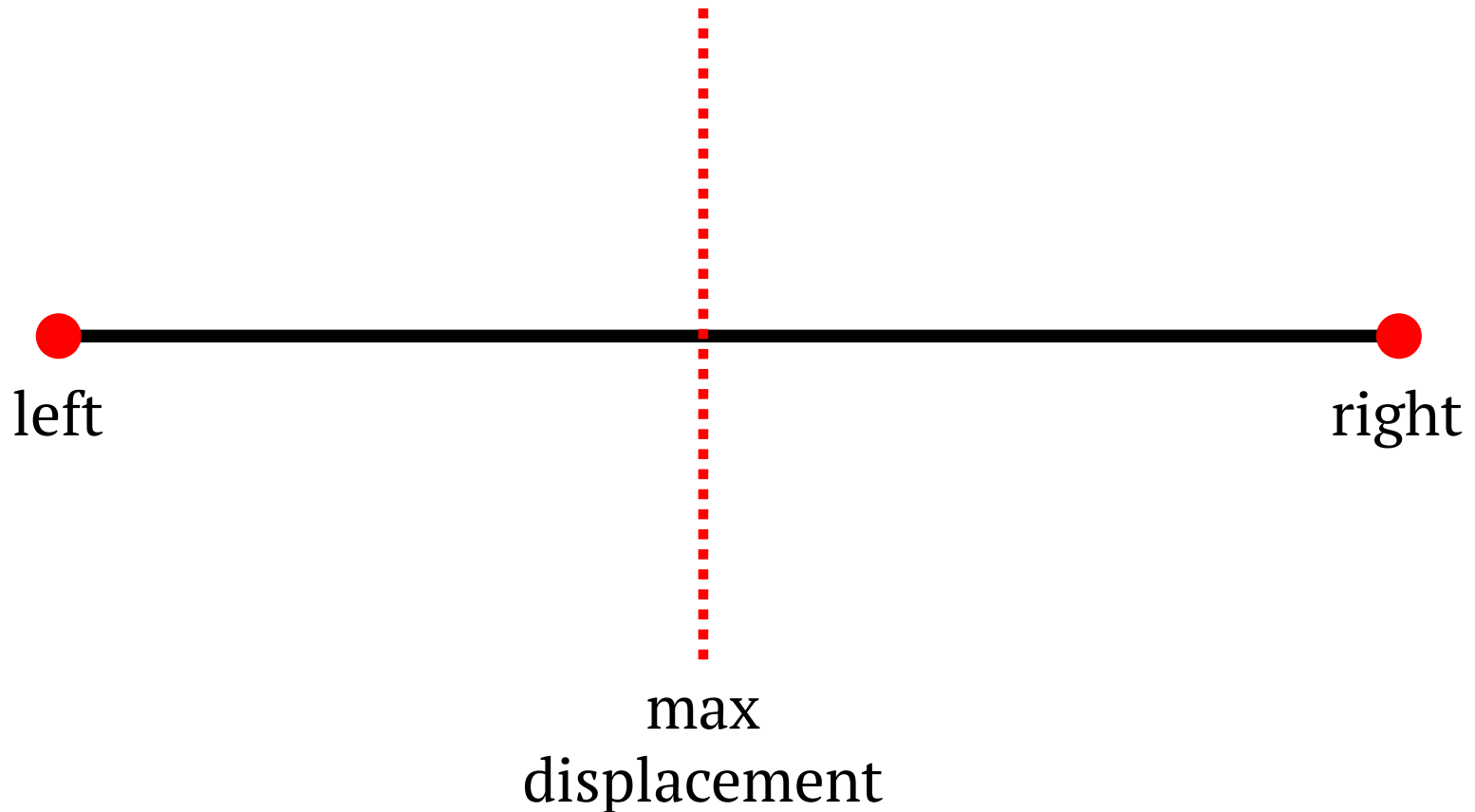*Spore*, 2008

Procedural Animation in Spore
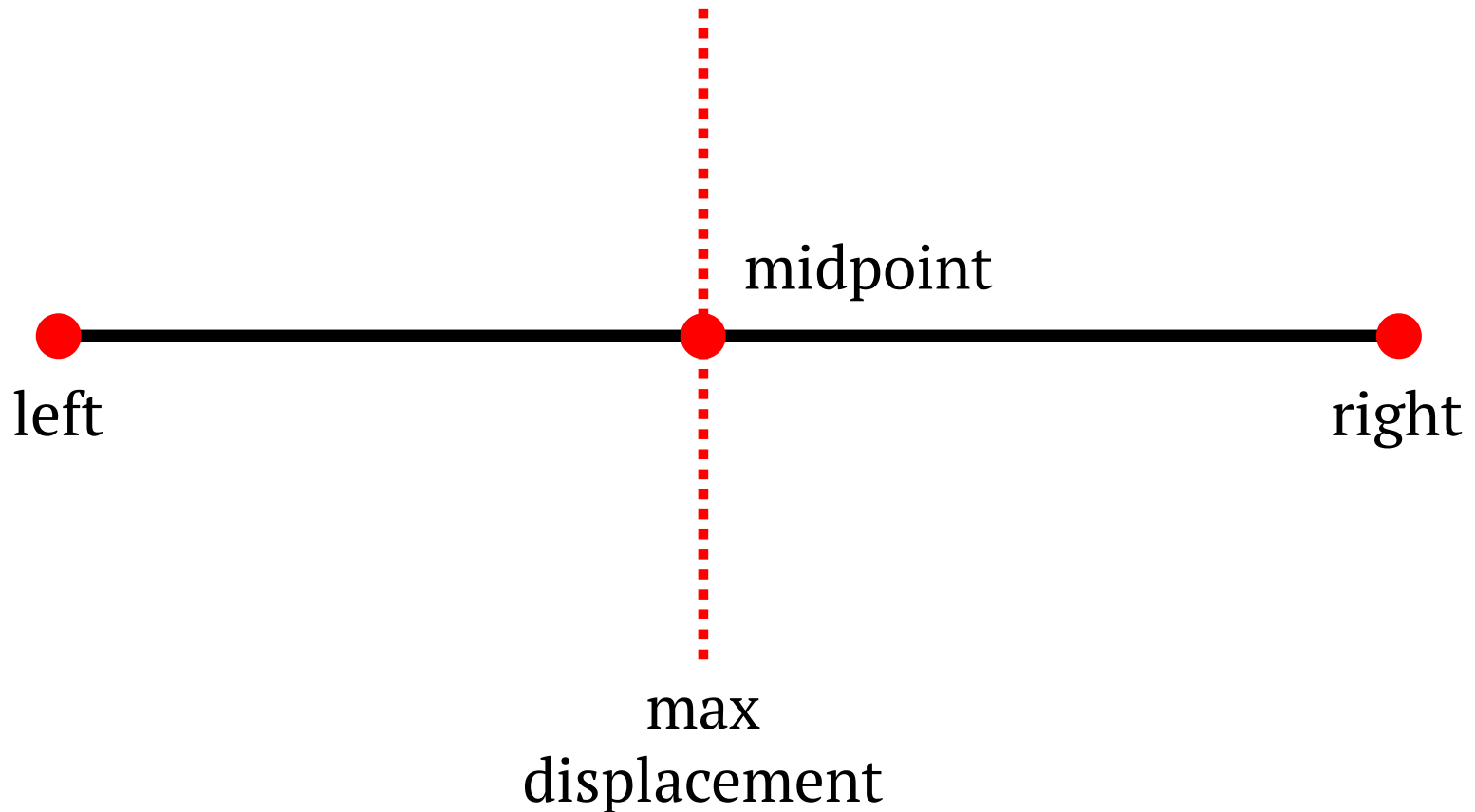
Exercise: Generate 2D Landscape

Midpoint Displacement (2D)

- Based on generating self-similar random fractals (patterns where a smaller part appears the same as the whole).

1. Begin with a line segment.

2. Raise or lower the midpoint by a random amount.

3. Repeat this process for the left and right halves of the line segment, but reduce the amount by which the midpoint can be displaced.
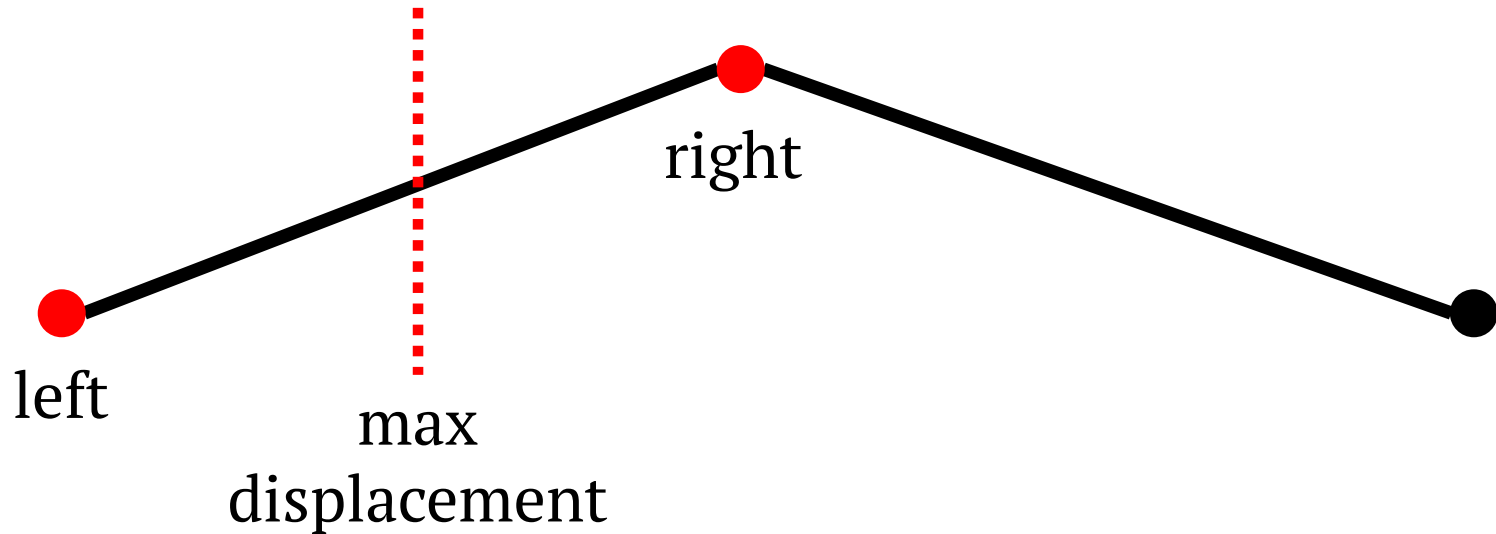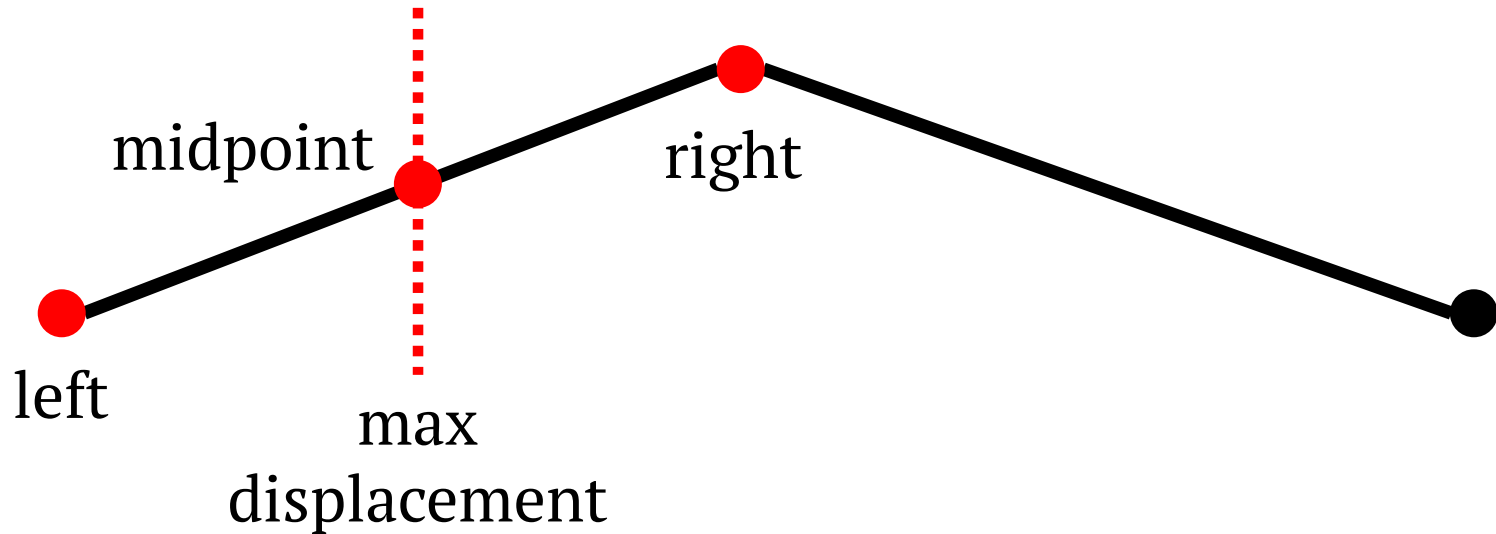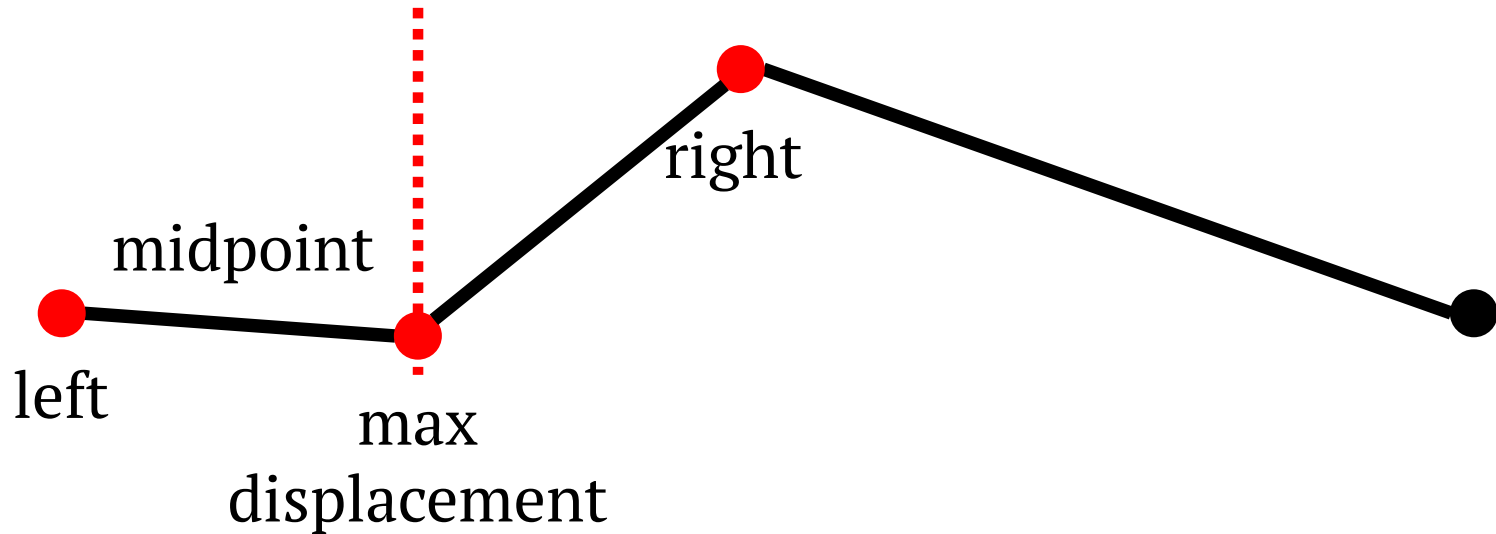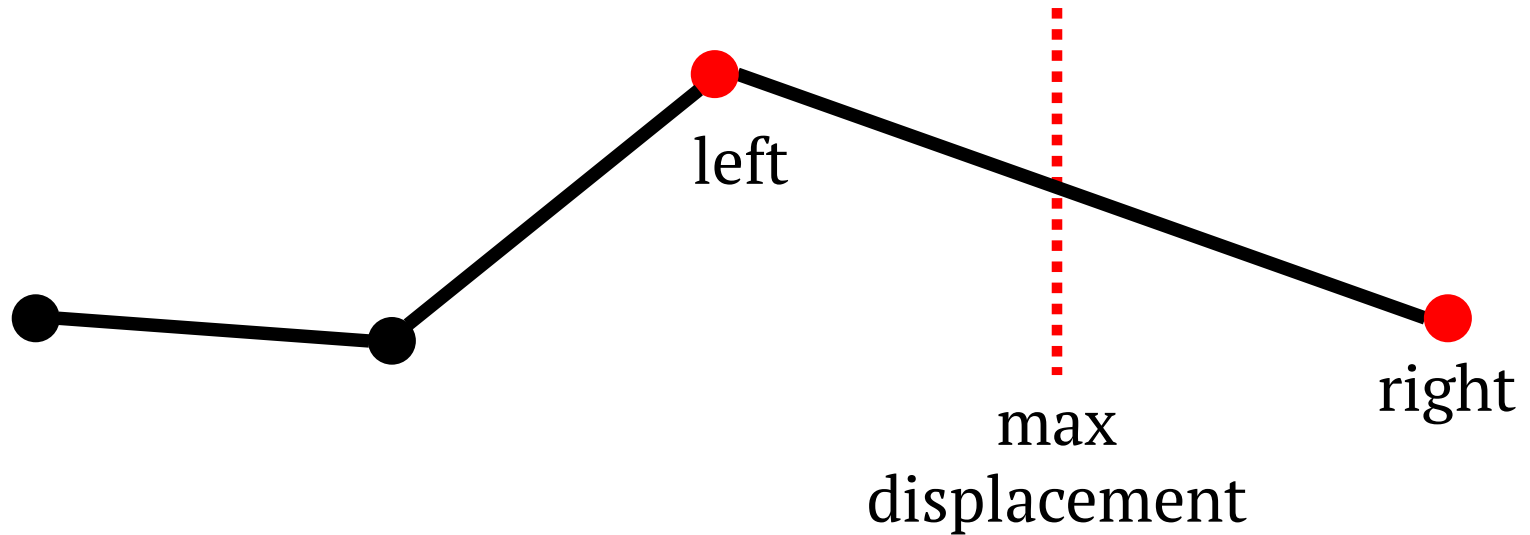
Midpoint Displacement

Midpoint Displacement

Midpoint Displacement

midpoint
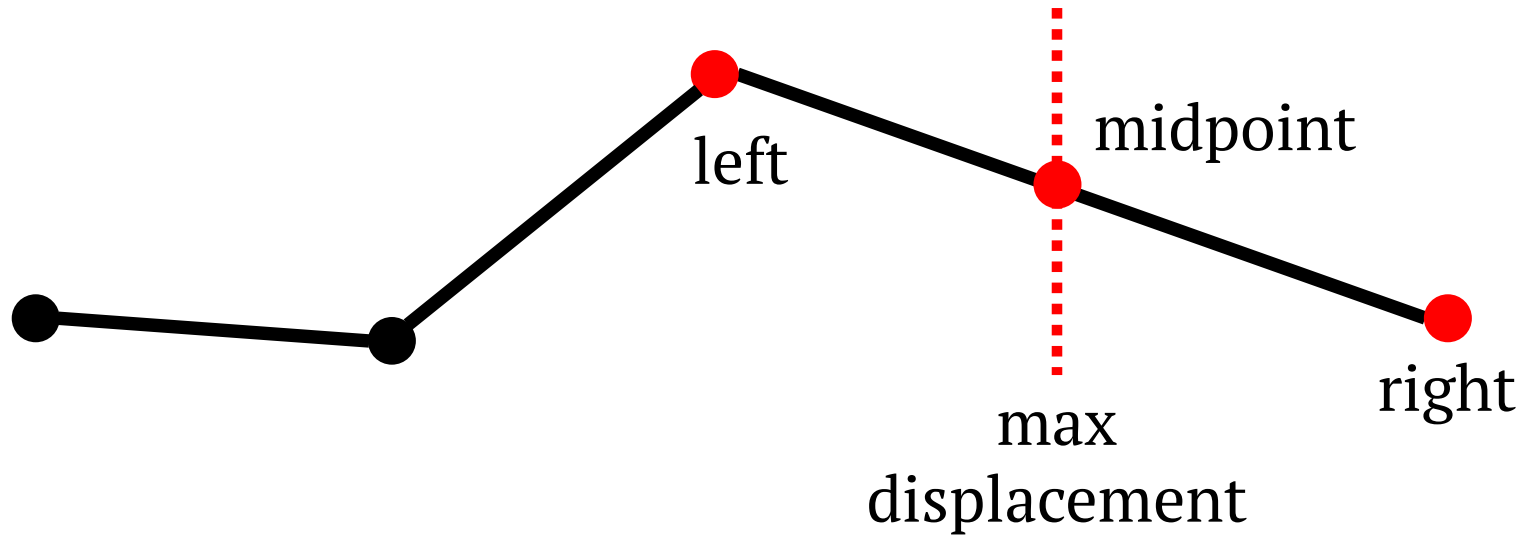
left

right

max
displacement

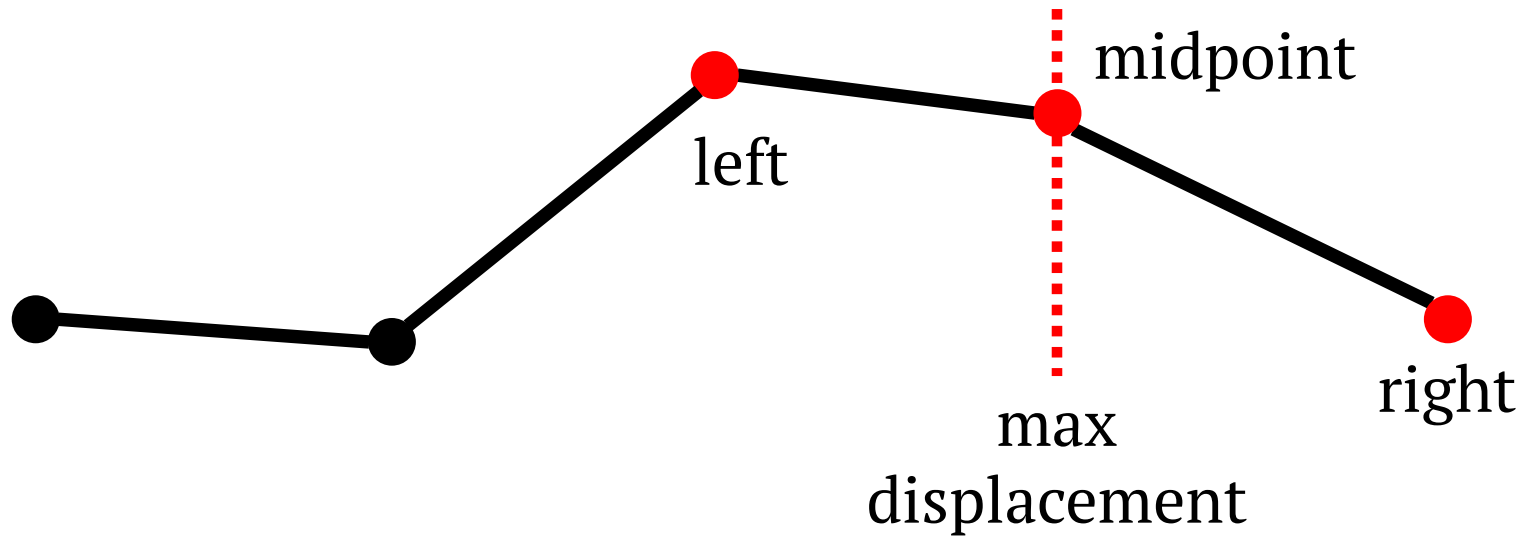# Midpoint Displacement

Midpoint Displacement

Midpoint Displacement

Midpoint Displacement
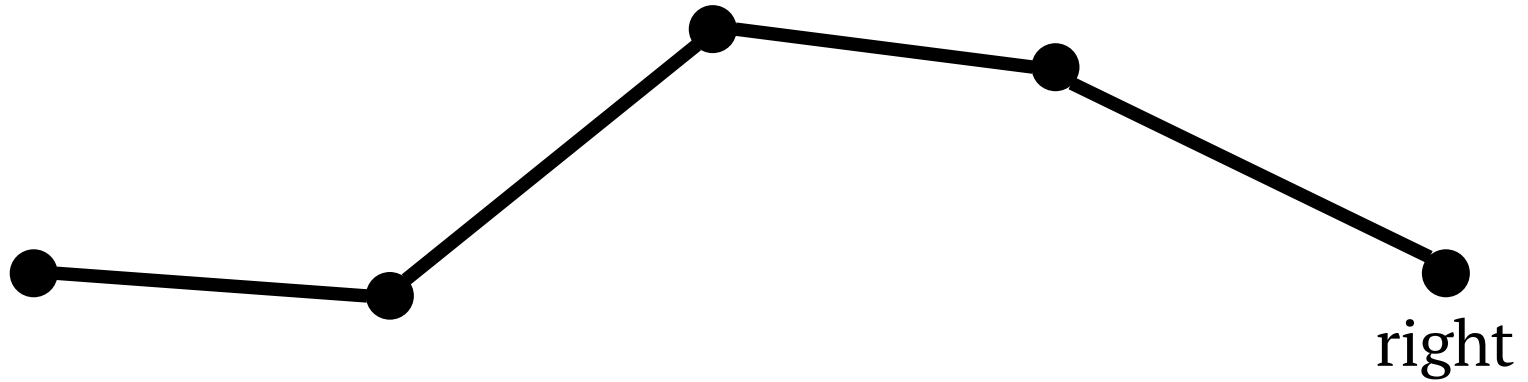

left

right

max
displacement

Midpoint Displacement

Midpoint Displacement

Midpoint Displacement

right

Midpoint Displacement (3D)

- Same basic principle, but using squares instead of lines.

- Rotate square 45° to avoid square-like artifacts (the diamond square algorithm)

diamond step

Midpoint Displacement (3D)

- Same basic principle, but using squares instead of lines.

- Rotate square 45° to avoid square-like artifacts (the diamond square algorithm)

square step

Midpoint Displacement (3D)

- Same basic principle, but using squares instead of lines.

- Rotate square 45° to avoid square-like artifacts (the diamond square algorithm)

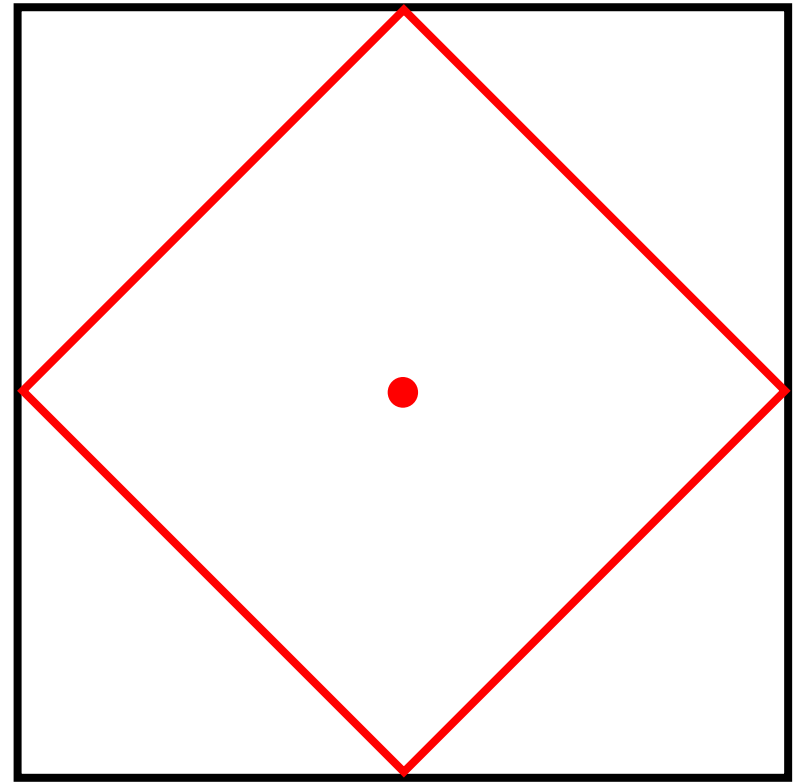diamond step

Midpoint Displacement (3D)
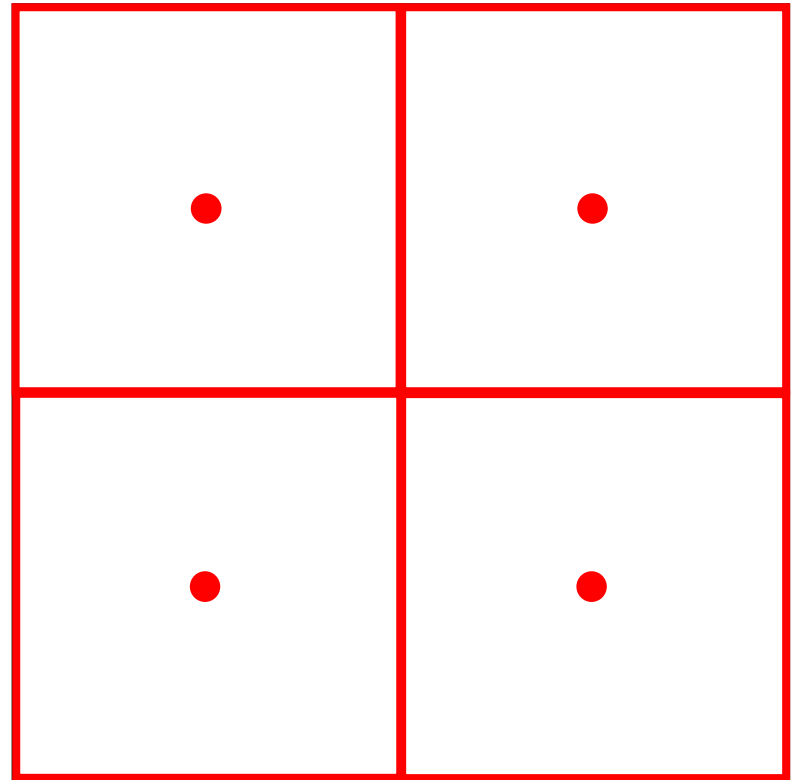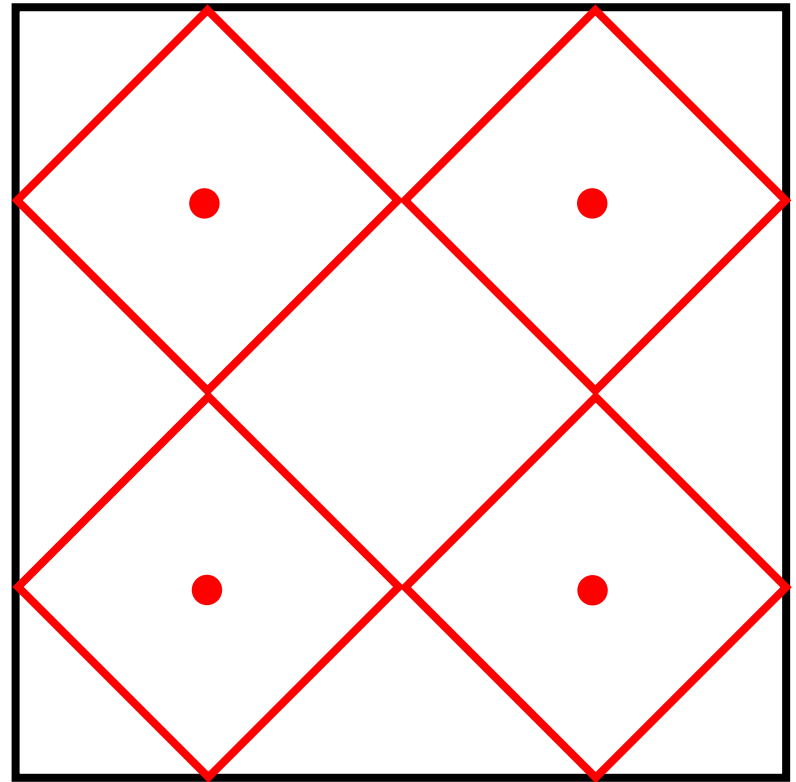
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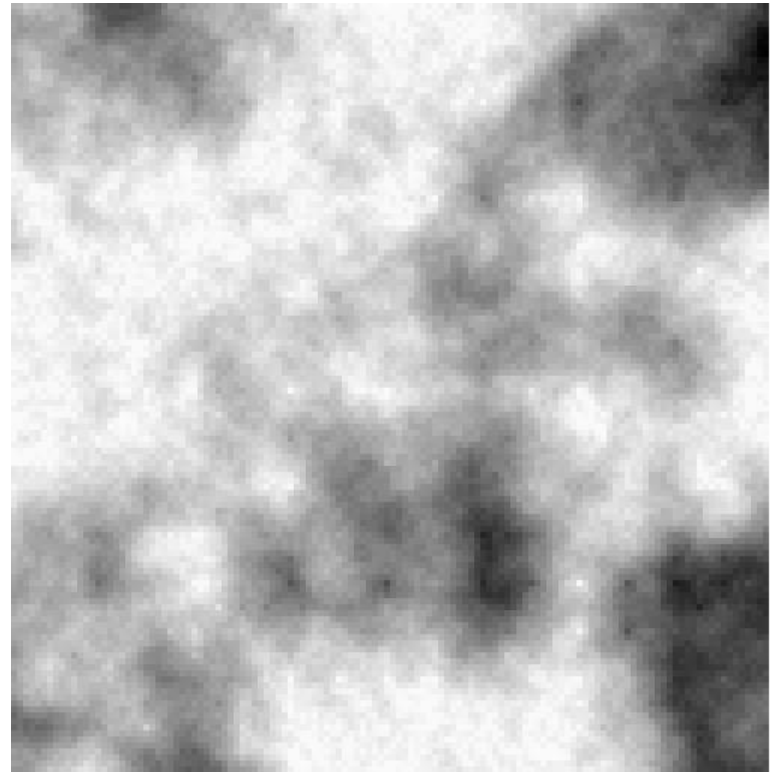
Perlin / Simplex Noise Maps

- Used in games like Minecraft
- Any position in the space can be sampled, so we don't need to generate the whole space before the game starts (terrain can be generated on the fly).

Procedural Content Generation

Procedural content generation (PCG) is the programmatic generation of game content using a random or pseudo-random process that results in an unpredictable range of possible game play spaces.

Source: PCG Wiki (pcg.wikidot.com)

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Procedural Content Generation

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Source: PCG Wiki (pcg.wikidot.com)

Farranti Mark I Computer, 1951

Cube planet gone wrong in *Spore*
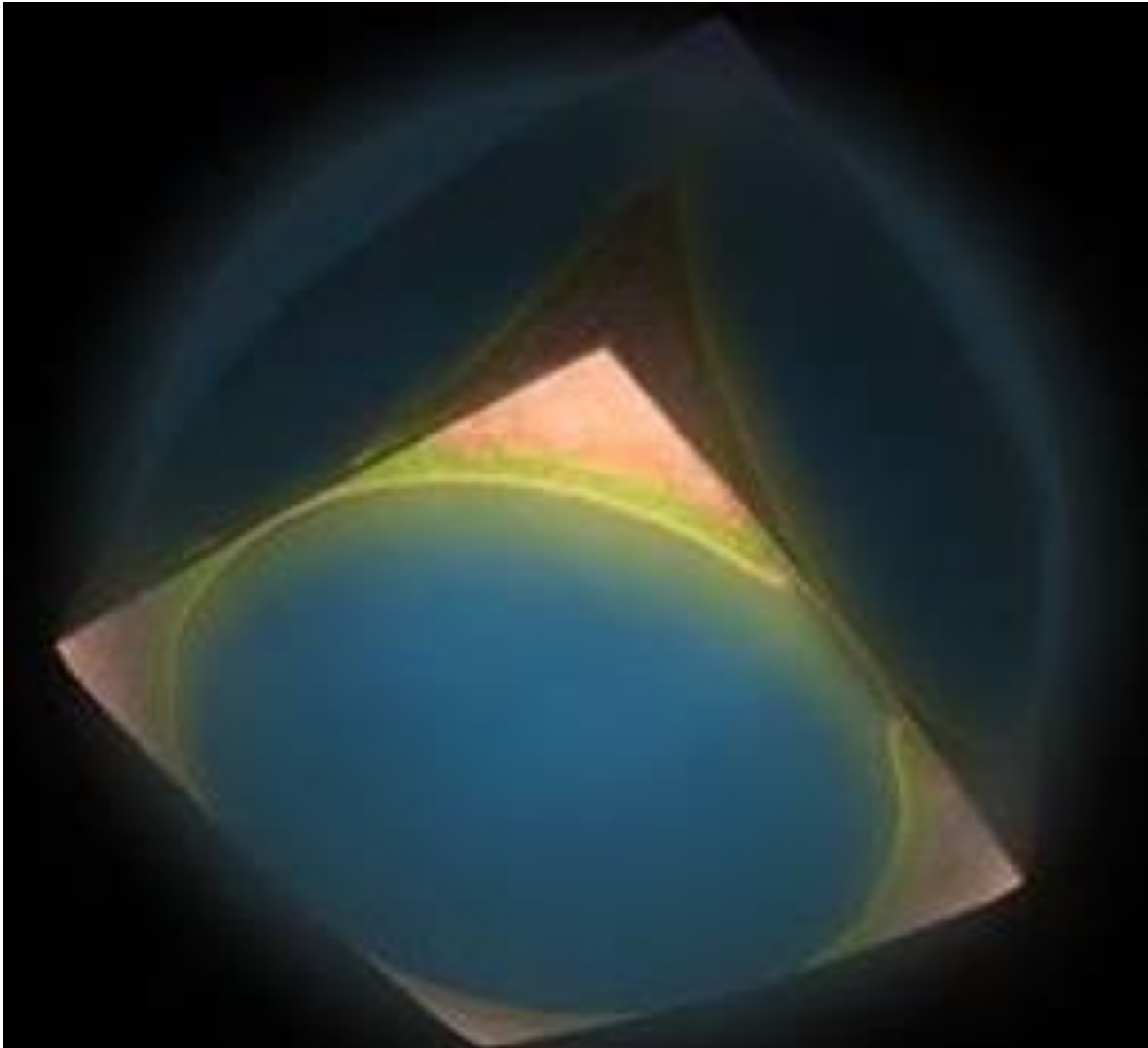
Pitfall! 1982

Left 4 Dead 2, 2009

Procedural Content Generation

- Randomness is easy!
- Unpredictable is bad!

Procedural Content Generation

Procedural content generation (PCG) is the programmatic generation of game content guided by quality metrics.
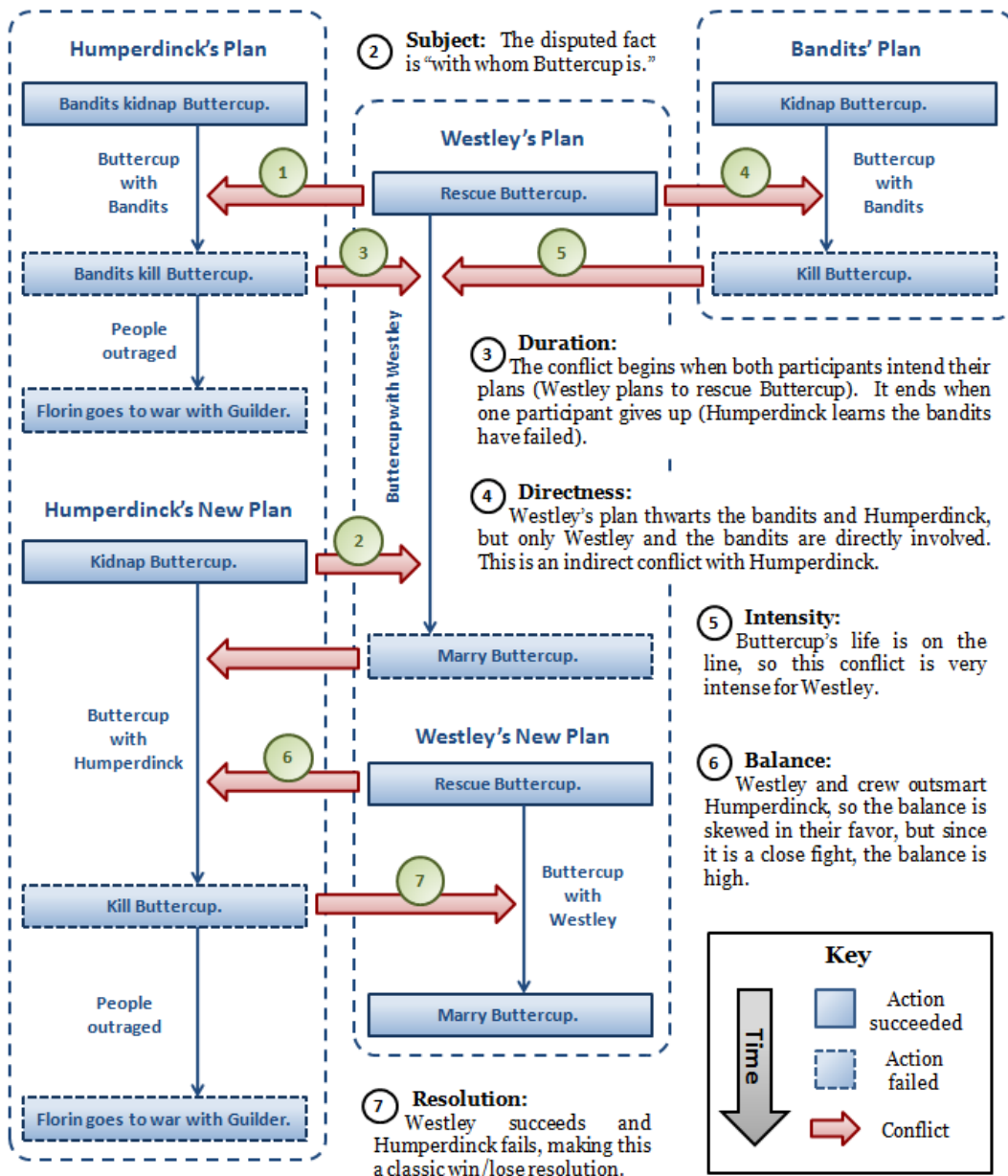
Challenge

Designing quality metrics that constrain content generation to produce a diverse play space, all of which is meaningful.

PCG for Narrative

- Narrative Madlibs
- PCG Quests in *Skyrim*
- Beat-based model in *Façade*
- Plan-based models

The Princess Bride©

① Participants: This conflict is between Humperdinck and Westley.

② Subject: The disputed fact is "with whom Buttercup is."

Humperdinck's Plan

- Bandits kidnap Buttercup.
- Buttercup with Bandits **①**
- Bandits kill Buttercup. **③**
- People outraged
- Florin goes to war with Guilder.

Westley's Plan

- Rescue Buttercup.
- **⑤**
- Marry Buttercup.

Buttercup with Westley

Bandits' Plan

- Kidnap Buttercup.
- Buttercup with Bandits **④**
- Kill Buttercup.

③ Duration: The conflict begins when both participants intend their plans (Westley plans to rescue Buttercup). It ends when one participant gives up (Humperdinck learns the bandits have failed).

④ Directness: Westley's plan thwarts the bandits and Humperdinck, but only Westley and the bandits are directly involved. This is an indirect conflict with Humperdinck.

Humperdinck's New Plan

- Kidnap Buttercup. **②**
- Buttercup with Humperdinck **⑥**
- Kill Buttercup. **⑦**
- People outraged
- Florin goes to war with Guilder.

Westley's New Plan

- Rescue Buttercup.
- Buttercup with Westley
- Marry Buttercup.

⑤ Intensity: Buttercup's life is on the line, so this conflict is very intense for Westley.

⑥ Balance: Westley and crew outsmart Humperdinck, so the balance is skewed in their favor, but since it is a close fight, the balance is high.

⑦ Resolution: Westley succeeds and Humperdinck fails, making this a classic win/lose resolution.

Key

⬇ Time	▢ Action succeeded
	⬚ Action failed
	⇨ Conflict

The Best Laid Plans, 2014

Pros of PCG

- Reduced authoring burden
- Emergent behavior
- Increased replay value
- Thwart walkthroughs

Cons of PCG

- Difficult to design quality metrics
- Difficulties in quality assurance
  - Varying quality of experiences
  - Difficult to provide support
- Thwarts walkthroughs

One alternative to PCG: Crowdsourcing