Domain-Specific Declarative Languages

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Declarative Domain-Specific Languages

- Declarative
  - Nice algebraic properties for ease of reasoning ...
    - for the user / query writer
    - for system designer / implementer
  - (Note that the language could *look* imperative.)
- Domain-specific
  - Language should be appropriate for domain
  - Can’t have “one size fits all”

Computer Games

- Unique challenges
  - Virtual environments
  - High degree of interactivity

- $17B in sales in 2007
  - Rivals movie industry

Data-Driven Game Design

- Game design brings together many disciplines
  - Art, music, computer science, etc…
- Today's games are designed *data-driven*
  - Game content is separated from game code
- Examples:
  - Art and music are kept in separate, industry-standard file formats
  - Character data is kept in XML
  - Character behavior is specified through scripts

Advantages of Data-Driven Design

- Engine is reusable.
  - Able to recoup R&D costs over several games.
  - Possible to license engine to other companies.
- Can extend the life span of the game
  - Adjust game balance
- Players can change the character of the game
  - Modder communities develop around the game.
    - Half-life → Counter Strike
  - (Air Force uses modded StarCraft in officer training.)

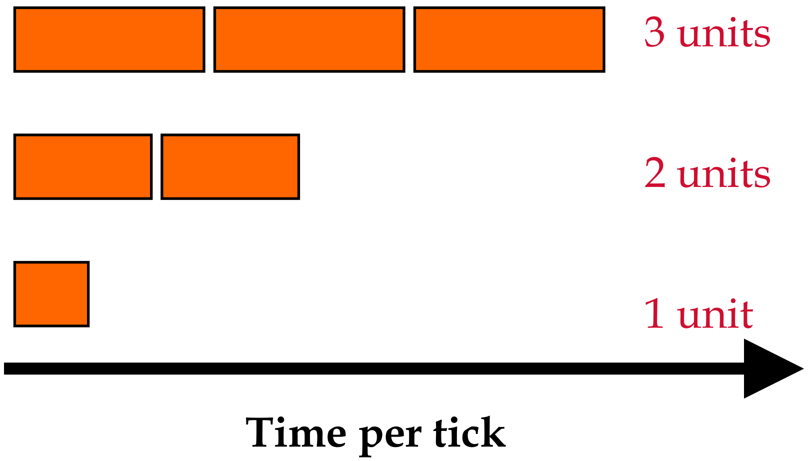
Modding: Simulation Games

- Non-Player Characters (NPCs): Characters not directly controlled by the player.
  - Controlled either by built-in or by player-designed scripts.
- "Doll House" games (e.g., *The Sims*)
  - NPCs have needs and desires.
  - Objects can satisfy needs and desires.
  - Player controls the game via object placement.
- Real-Time Strategy games
  - Troops move and fight in real time.
  - Player controls the game via a limited number of commands.
  - Player multitasks between large number of units.

Simulation Games: NPCs

- Games need complex NPC behavior.
  - Example:
    - Units are afraid of skeletons
    - Likelihood of staying inverse proportional to number of skeletons around

- Simple example: morale
  - Units afraid of skeletons
  - Morale proportional to number of skeletons seen
  - Processing cost:
    - O(n) to count skeletons
    - O(n^2) to process all units



Expressiveness vs. Performance

- Expressiveness:
  the range of behavior
  scriptable by modders
- As # of NPCs increases,
  expressiveness decreases
  - *Neverwinter Nights 2*
    - Each NPC fully scriptable
  - *WarCraft III*
    - Script armies, not NPCs
    - Little NPC coordination
  - *Midieval: Total War*
    - No individual scripting at all

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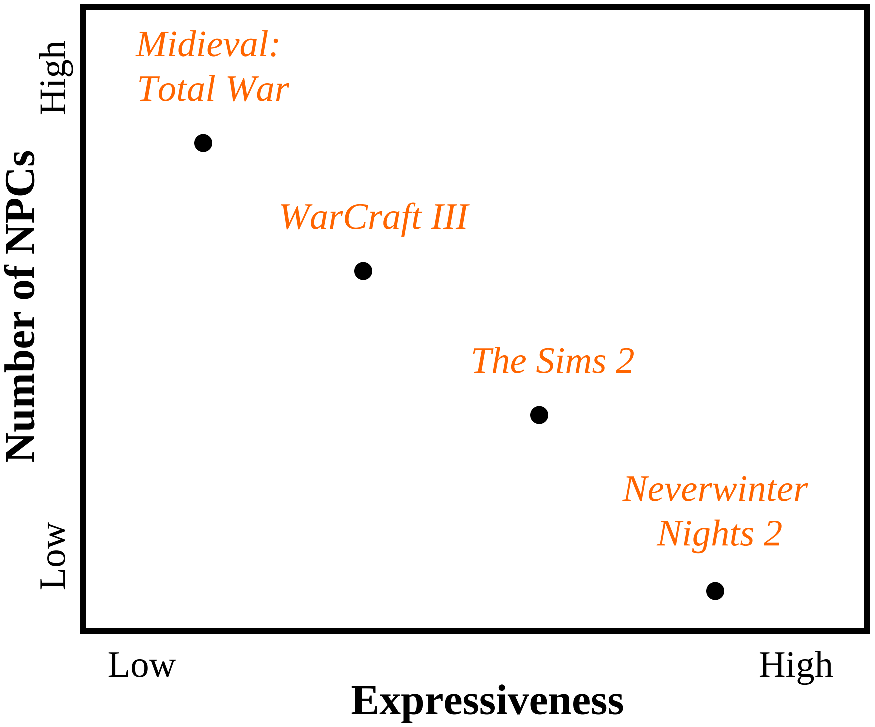

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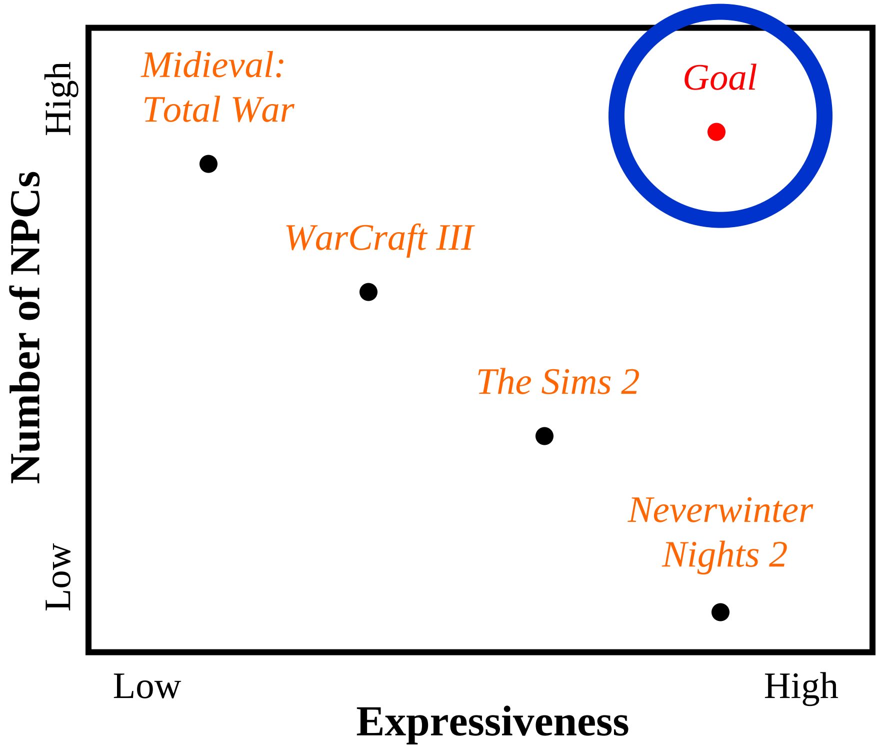

What We Have Done

- Developed domain-specific *imperative* language
    - Game designers find SQL difficult
    - Cannot program at the individual level

```
main : Unit {
    // Compute # skeletons, group center
    accum c with sum, sx with sum,
        sy with sum over u from UNIT {
     if (isEnemySkeleton(u) &&
        dist(me,u) < range) {
       c <- 1; sx <- u.x; sy <- u.y;
     }
    } in {
     //If too many skeletons
     if (c > morale) {
      let (norm=(x-sx/c)*(x-sx/c)+
              (y-sy/c)*(y-sy/c)) in {
        // Run in opposite direction
        vx <- (x-sx/c)/norm;
        vy <- (y-sy/c)/norm;
     }}
     ...
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- Developed domain-specific *imperative* language
- Compiles down to set-at-a-time Bag Algebra

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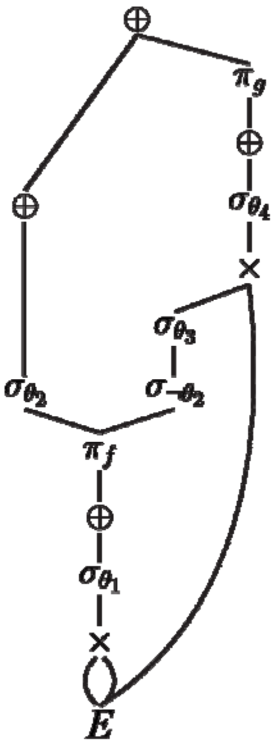

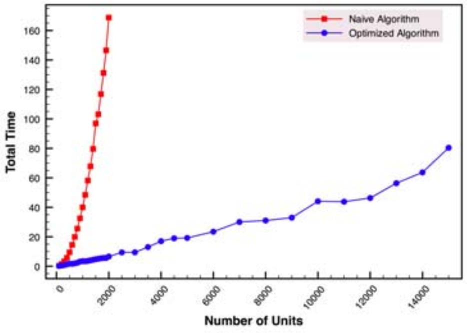

What We Have Done

- Developed domain-specific *imperative* language
- Compiles down to set-at-a-time Bag Algebra
- Built prototype of a game engine
- Integrated crowd simulations into SGL
- Developed novel transactional models for virtual worlds

- Opened up many more problems
  - Main-memory data management with decision-support-style *update* workloads
    - Query optimization, query processing, indexing
  - Steering
  - Collaborative motion planning

Recipe Applied to Other Domains

- Complex Event Processing
- Personalization of three-tier applications
  - Build full CMT in 15 minutes
  - Personalize the system to add double-blind reviewing for *your* conference in 5 minutes
- Expressive ad auctions
  - Submit bidding programs to Google according to an ROI strategy

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Summary and Discussion

- Declarative, domain-specific languages

There is much more:

- Multi-core
- Creativity
  - Attractor for the next generation of students?
  - Gate to a new way of enabling and understanding creativity?

Let’s Play!

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Thank you: National Science Foundation, Air Force Office of Scientific Research, Microsoft, Yahoo!