FPGA side scrolling videogame

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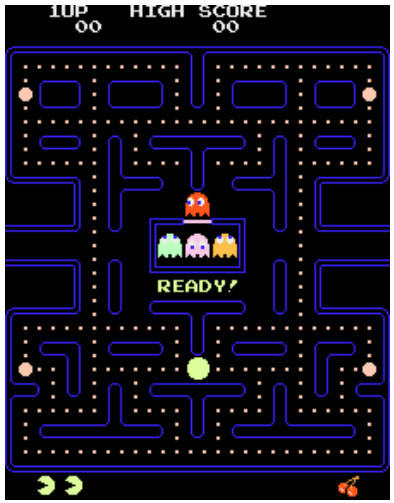
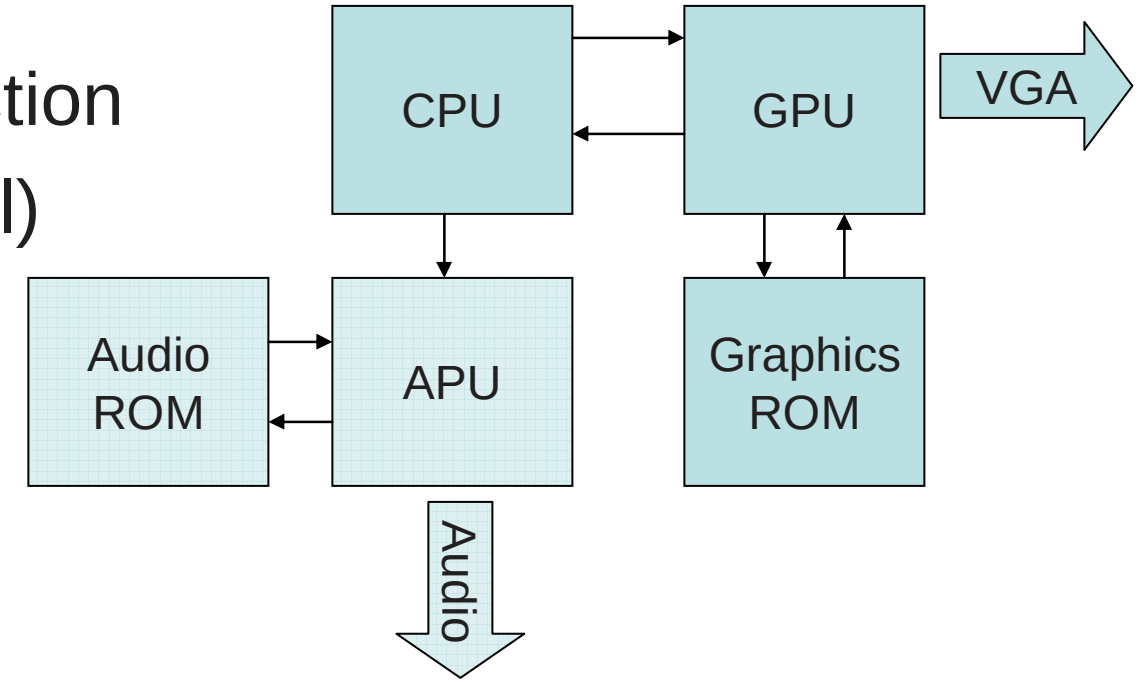
Gameplay concept

- 2D environment
- Side-view camera angle
- Hardware support to multiple possible genres
  - **Platformer**
  - Shoot ‘em up
  - Pacman



Implementation concept

- Most computation effectuated by software (Assembly game code)
- Hardware support for slow operations
  - Sprites
  - Collision detection
  - Audio (optional)



Implementation overview

- Microprocessor: “beta”
- Graphics processing unit
  - Sprite management
  - VGA signal generation
  - Collision detection
- Audio processing unit (optional)
  - Background music (wavetable synth)
  - Event-triggered sound effects (ROM)

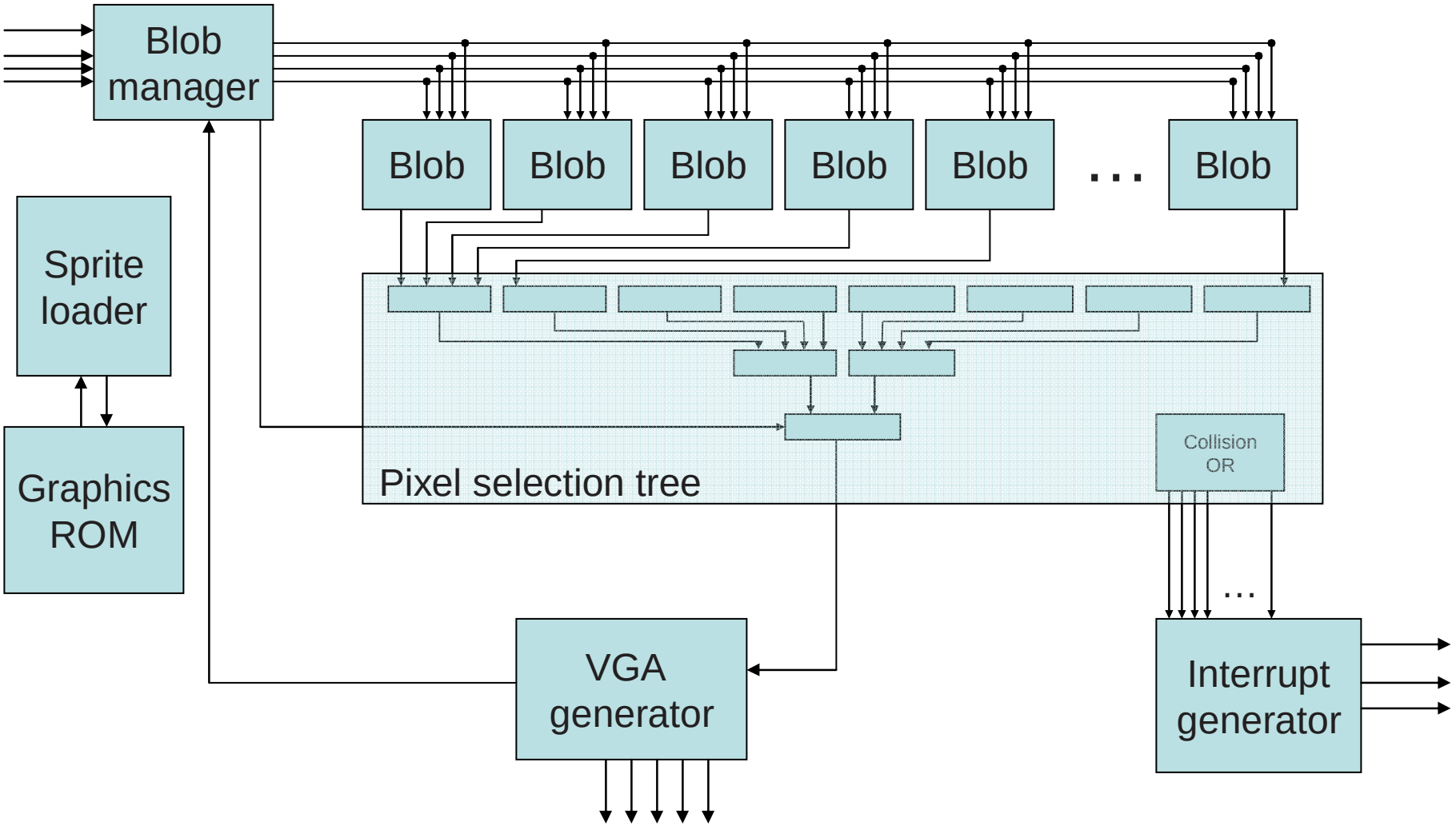
Microprocessor

- Modified beta: opcode used for communicating with other hardware modules
  - Stall the processor for a cycle (behave like a NOP)
  - Send a control signal to other hardware, which has read-access to part of the regfile

Graphics processing unit

- Capabilities:
  - Display up to 32 sprites on the screen
  - Receives high-level commands from CPU about sprite management (create sprite, change sprite type, destroy sprite, pan screen, etc.)
  - Reports sprite overlap as interrupts

Graphics processing unit



Graphics processing unit

- Core of hardware design process
- Main modules:
  - Blob manager: reads commands from CPU, sends commands down a control bus to the blobs
  - Blob (x32): responsible for displaying and animating one instance of a sprite, or a collision block
  - Sprite loader: accesses the ROM, one sprite at a time
  - Pixel selection tree: selects which pixel output from a blob should be displayed, detects collisions
  - Interrupt generator: sends an interrupt request to the CPU if the collision status of a blob was changed
  - VGA generator: sends coordinates of a pixel to the blob manager, receives it from the pixel selection tree, and produces the VGA signal

Blob manager

- Controls all blobs
- Responsible for interpreting instructions from CPU registers
- Translates screen coordinates received from VGA generator into absolute coordinates for blobs

Blob manager

- Inputs: clock, CPU, VGA
  - From CPU
    - Hardware output control signal
    - Registers 0 through 3
  - From VGA generator
    - Pixel coordinates
- Output: blob control bus, pixel selector
  - To all blobs
    - Control signals
  - To pixel selector
    - Background color

Blob

- Little FSM
  - S_NONE: blob does not represent an entity
  - S_SPRITE: blob represents an instance of a sprite
  - S_PLATFORM: blob represents an invisible rectangle, that might be collided with
  - S_TILED_SPRITE: blob represents a rectangle filled with copies of a same sprite

Blob

- Internal state
  - The sprite itself
  - X1, Y1 coordinates
  - X2, Y2 coordinates (if platform or tiled sprite)
  - Sprite type
  - Animation step
  - Animated sprite
  - Collidable sprite (clip bit)
  - Enemy sprite (enemy bit)
  - Sprite layer

Blob

- Input:
  - blob manager control bus
  - sprite loader
- Output
  - To pixel selection tree
    - Pixel
    - Blob ID
    - Collision control info (layer, clip bit, enemy bit)
  - To sprite loader
    - Sprite request

Sprite loader

- Accesses the ROM
- Receives requests from all blobs (serial scanning)
- Copies requested sprite into target blob’s memory

Pixel selection tree

- Input: all blobs' output, background pixel color
- Output:
  - To VGA generator:
    - pixel
  - To Interrupt generator:
    - 32x collision info (32x 2 bits)
      - Sprite collides with non-enemy sprite
      - Sprite collides with enemy sprite

Audio processing unit (optional)