2048

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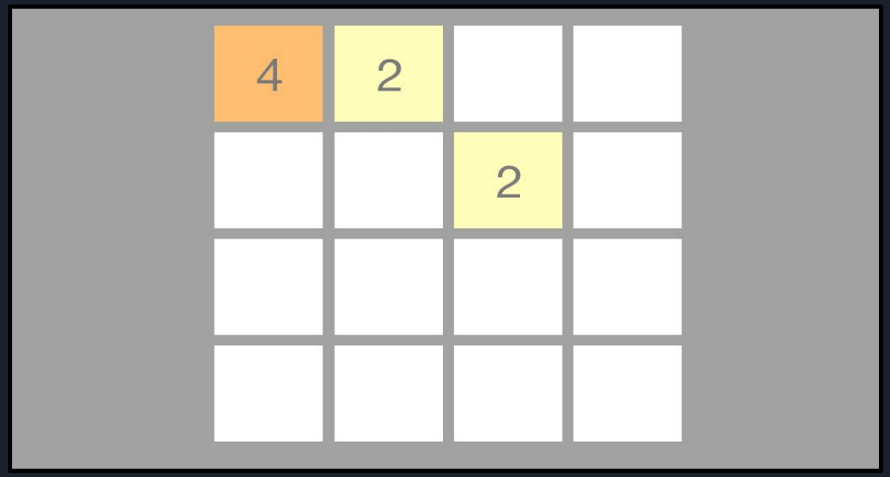
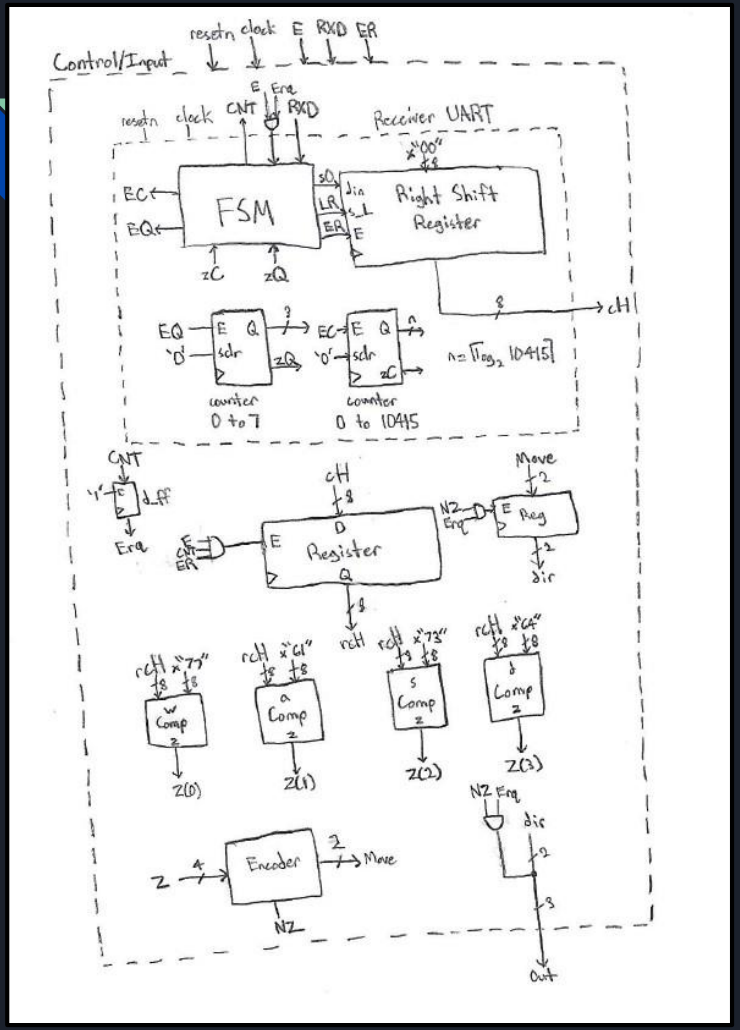
How it works

- Receiver to accept input from a computer, serially at 9600 baud, across a USB
- PuTTY is used to transfer this data
- Accepts only the characters w, a, s, and d, and only lowercase
- Output of receiver is a 3 bit encoded direction, with MSB being a pulse when a correct character is output, and the last two being the direction
- This is sent to a control circuit, and read by an FSM
- FSM generates 2 or 4 randomly and puts it on the grid
- FSM adds matching values when shifting in direction dictated by receiver, and also checks to see if any of the values equal 2048 (victory condition)
- It is possible to lose the game if all the tiles are full and cannot be added together
- Grid is constantly outputted to a file that makes it compatible for a VGA, then sent to a VGA

The Game

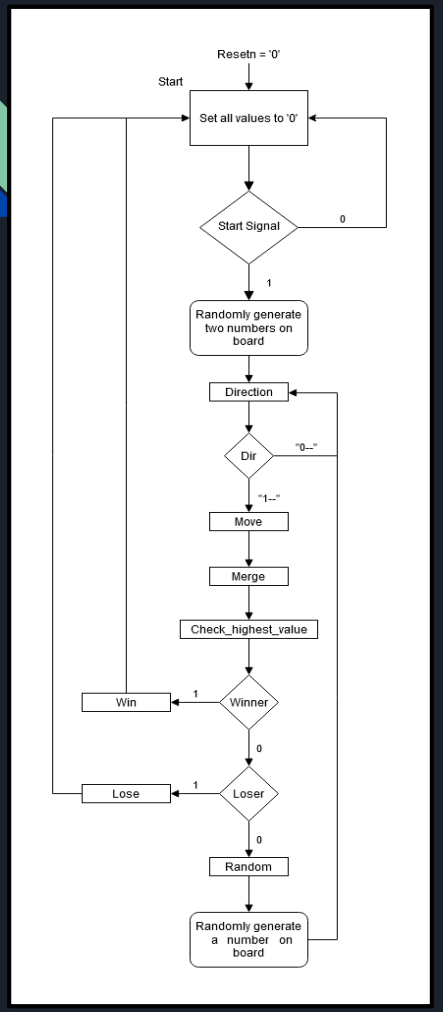


- 2048 is a game where the user slides tiles in a direction, and matching tiles add up.
- Random numbers spawn with each slide
- If the table fills, they lose, if they reach 2048, they win
- The game was created in 2014 by Gabrielle Cirulli as a web game
- Was based on “Threes”, which was a much slower paced game released the same year



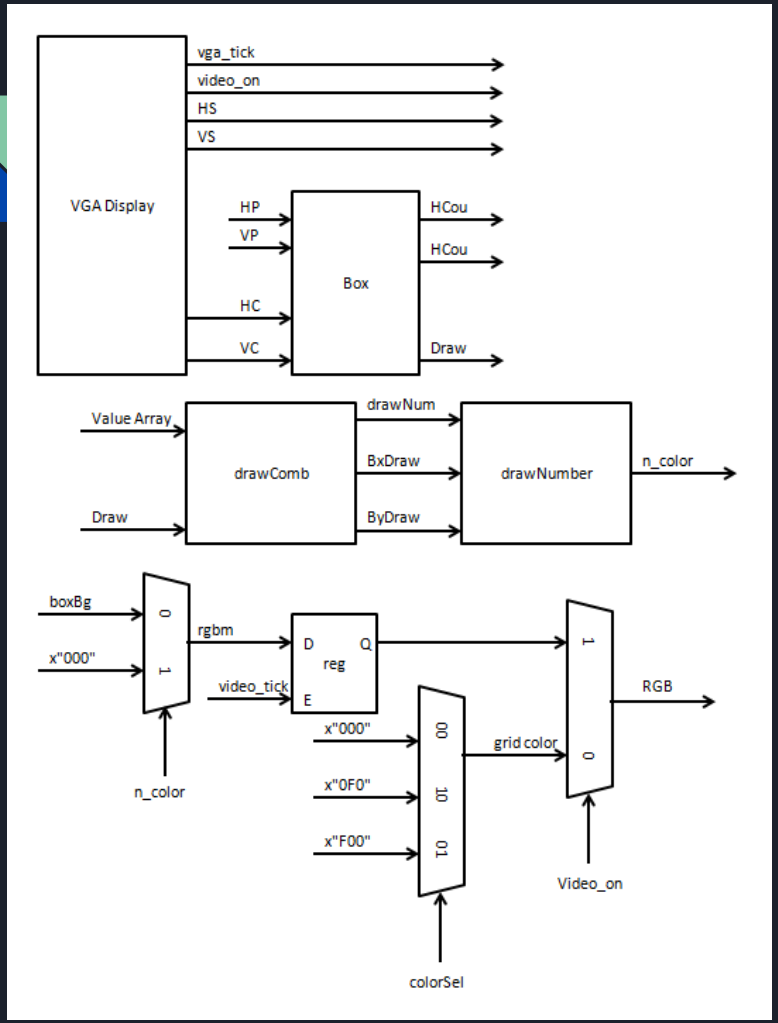
Receiver Datapath

- Composed of UART, comparators, an encoder, registers, and logic gates
- Output earlier described can be seen
- The characters w, a, s, and d that are compared to are stored similarly to an LUT



FSM

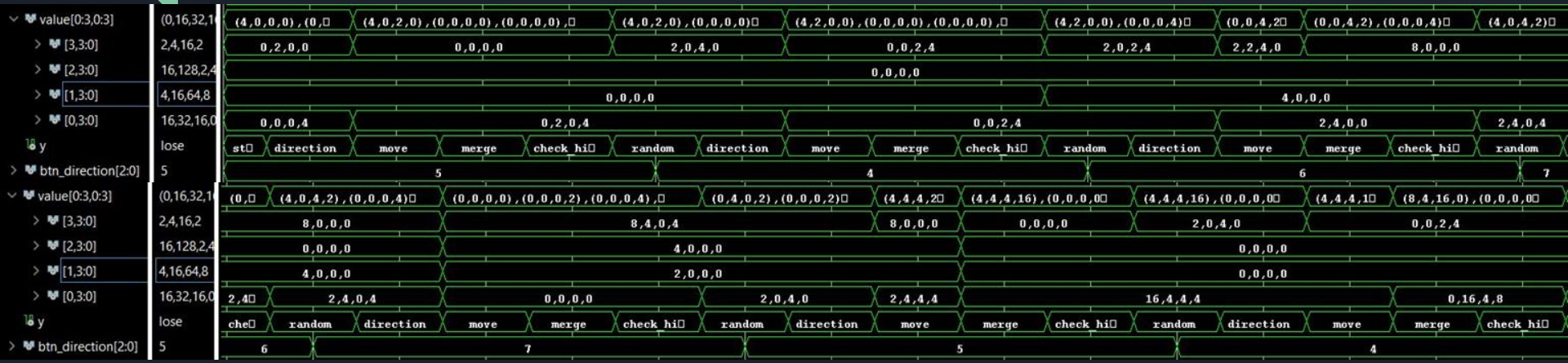
- Main controller of the game
- Determines number movement and merging
- Stores values into an array



VGA Display

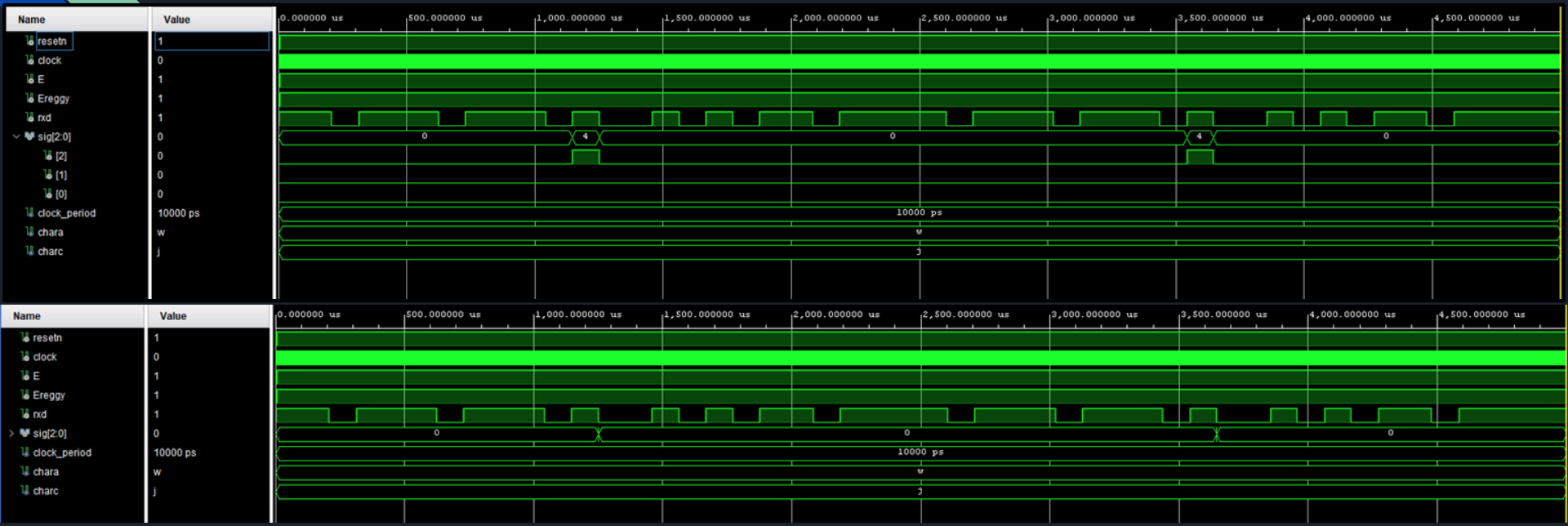
- Uses a VGA connection to output to a monitor
- Objects are drawn on the screen depending on the Horizontal and Vertical count.
- Kept in sync by HS and VS to keep images from moving.
- Screen is thought of as a graph and is told to color a certain area when a signal is high.

FSM Simulation



Btn_direction: 4 is right, 5 is down, 6 is left, 7 is right

Receiver Simulation



- Sig is the output, w and j are input by the simulation
- Emits a pulse with each input matching the internal LUT
- Ignores inputs that don’t match the internal LUT
- Problem: Matching wrong clock pulse
- Resolved by moving S5 ‘done’ output of UART to S1

References

- https://2048game.info/the-history-of-2048/

- https://www.ibtimes.com/what-2048-convoluted-origin-threes-1024-game-clone-topping-app-store-charts-1568533