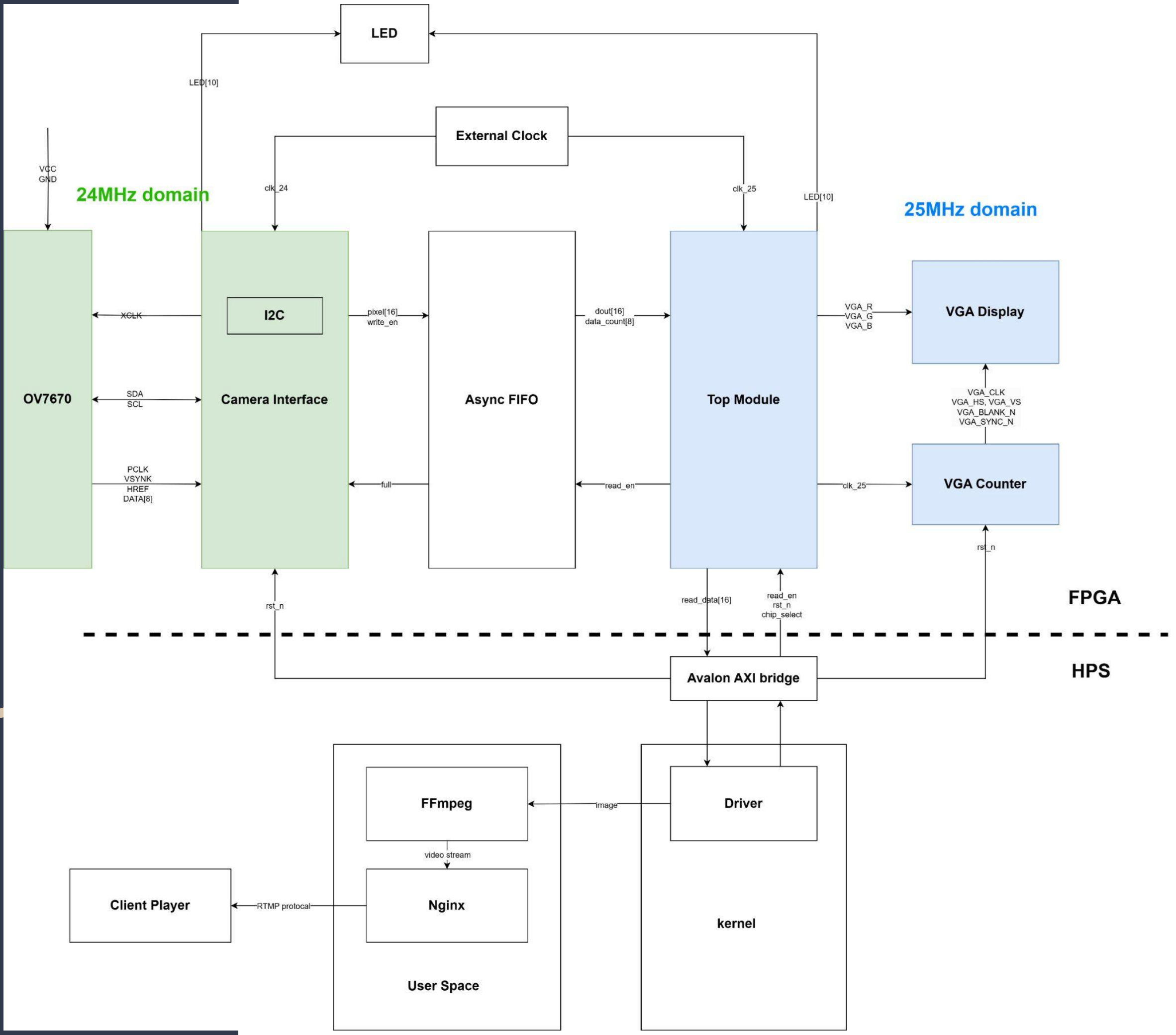
Web Camera

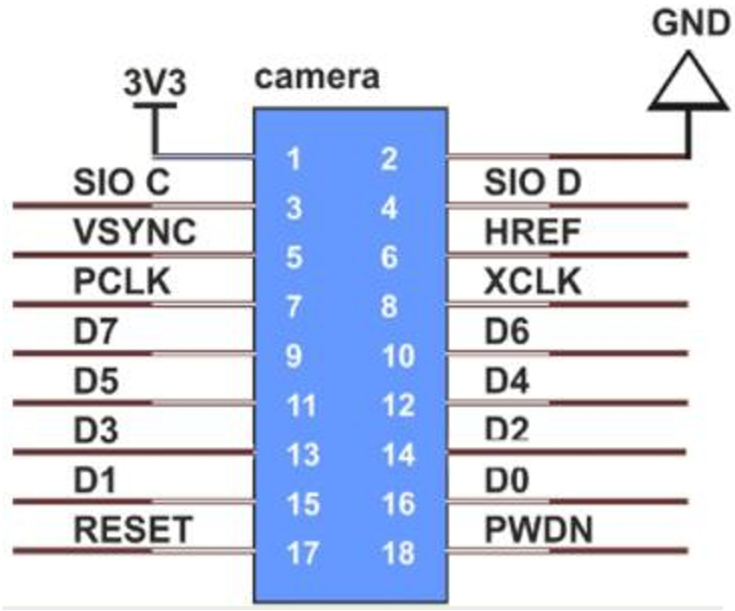
Final Presentation

Block Diagram



Connecting OV7670 Camera

- Communicate via SCCB protocol (subset of I2C)
- Send initialization signals to make it output RGB565 signal
- Read 2 consecutive cycles to data to get 16-bit pixel



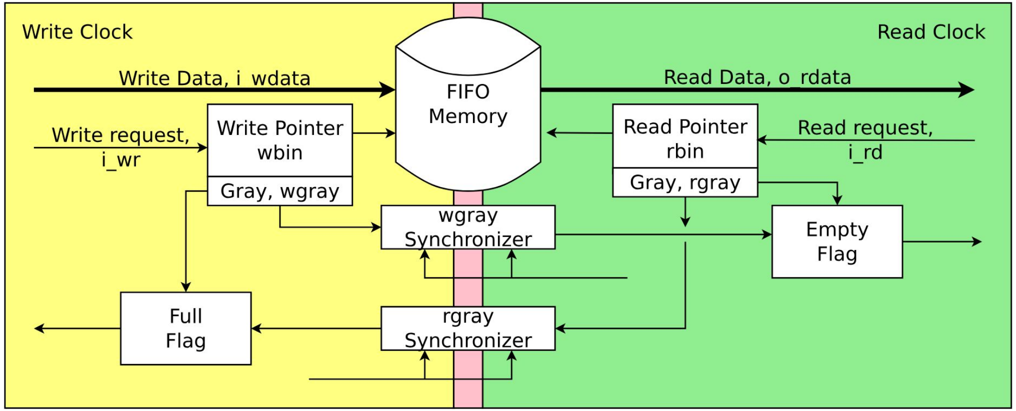
Connecting 2 frequency domains

- FIFO needs two flags: **full** and **empty**
- Comb. logic uses write pointer and read pointer to judge the two flags
- This logic is not stable when write pointer and read pointers are clocked by two different clocks (in this case 24MHz and 25MHz)

```
assign empty = (w_ptr == r_ptr);
assign full  = (w_ptr[ADDR_WIDTH] != r_ptr[ADDR_WIDTH])&&(w_ptr[ADDR_WIDTH-1:0]
== r_ptr[ADDR_WIDTH-1:0])
```

Connecting 2 frequency domains

- Idea 1: use gray counter so it will be more stable
- Idea 2: introduce middle signals, clocked be the other clock

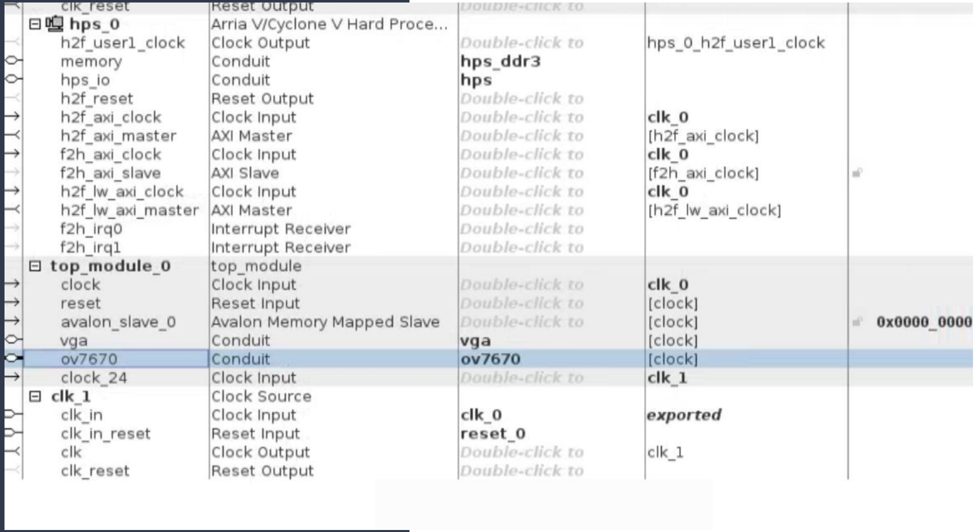


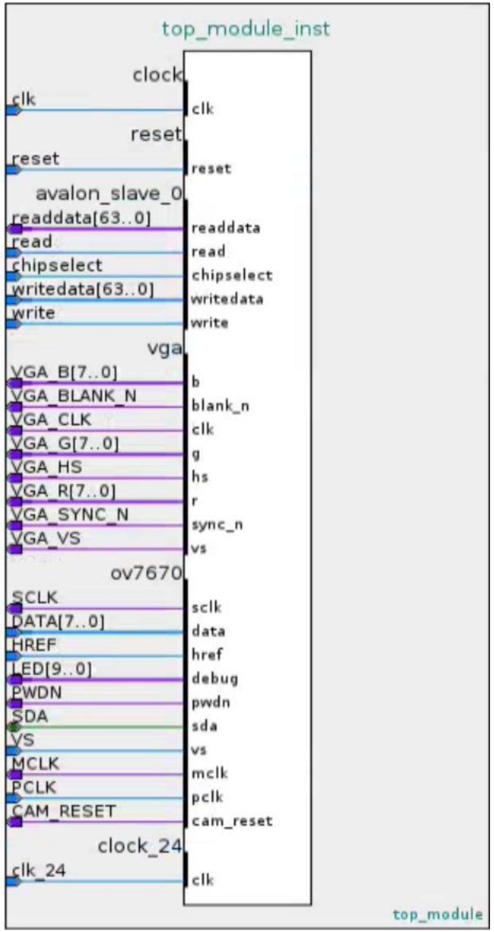
Output to VGA (for testing)

- Inherit from lab3
- Bouncing ball still functioning (a bouncing ball stacking over the video)
- Use cascading to get RGB888 signal from RGB565 signal

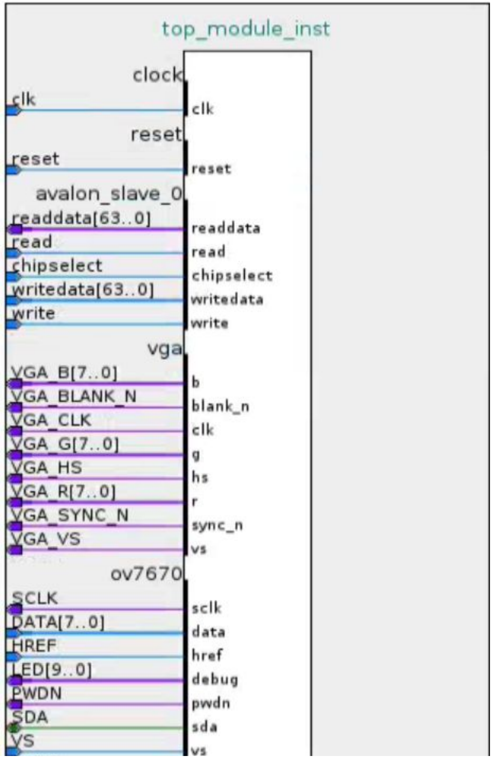
```
r_8 = {r_5, r_5[2:0]};
g_8 = {g_6, g_6[1:0]};
b_8 = {b_5, b_5[2:0]};
```

Signal Interface and Component Connection



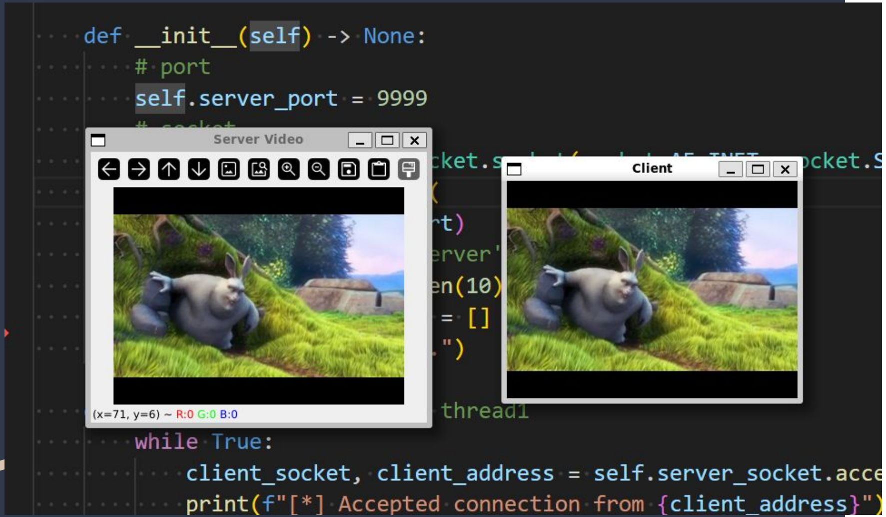


Signal Interface and Component Connection




```
output logic [63:0] readdata,  // {12'd0, column_num, row_num, endOfField, 15'd0, dout}
input logic read,
input logic [63:0] writedata,  // {32'd0, x, y}
input logic write,
```

Sending frames over the network



- Server
  - Running on DE1-SoC board (testing on Ubuntu 20.04)
  - Establish TCP connection with clients
  - Use cv2 to encode the image to JPEG and serialize
  - Send to client at 30fps (320x240 test video)
- Sender
  - Read pixel data using ioctl calls to the camera driver
  - Send frames to server
- Client
  - Running on WSL Ubuntu 20.04
  - Receive frames, decode and display with cv2

Video Driver

For the camera reading, it utilize ioread32 to fetch data from the camera

```
return ioread32((dev.virtbase));
```

In the sender:

Frame Reading: Utilizes a while loop to continuously read pixel data using ioctl calls to the camera driver, pixel by pixel, illustrating how raw image data is processed

Frame Sending: After capturing a frame, it immediately sends this data to a server using the established TCP connection, showcasing a real-time data streaming application.

```
    // Extract fields from the info
    hcount = (info >> 29) & 0x3FF;      // Extract bits 29-38 (10 bits for hcount)
    vcount = (info >> 19) & 0x3FF;      // Extract bits 19-28 (10 bits for vcount)
    pixel = info & 0xFF;                // Extract bits 0-7 for the pixel value (dout)

    // Calculate the address
    address = vcount * 640 + hcount;

    if (address < READ_PIXELS) {
        buf[address] = pixel;
    }

    // Check for end of field
    if (info & (1 << 18)) {
        break; // Exit the loop when end of field is encountered
    }
}
```

Demo