# CSE 546 — Project Report


## Team Members:

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**General requirements:**

- Strictly follow this template in terms of both contents and formatting
- Submit it as part of your zip file on Canvas by the deadline.

### 1.Problem statement

Clearly describe the problem that you are solving and explain why it is important.

The main aim of the project is to detect objects in a video with low latency and by using the computing resources ( cloud and raspberry-pi 3) efficiently. Detecting intruders is a time critical job. For edge computing devices there is always less computing power available. So to improve latency for the given task it is important to distribute tasks properly between cloud and edge devices in our case raspberry pi.

Why are we working on this project:

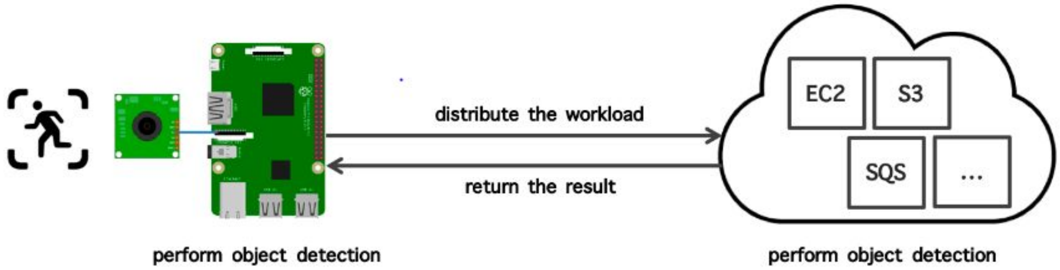
Edge computing is an emerging paradigm for enabling computation on or near the smart devices and Internet of Things (IoT) that produce the input data and provide feedback to users and the physical world.

With the growth of data by various edge devices deployed every day, the cloud is not able to meet all the computational demands, especially when the response time requirement is tight.

The continuous advancement of System-on-Chips has enabled edge devices to conduct more complicated workloads, leading to the emergence of edge computing which extends the computing from the cloud to the edge.

One main advantage of edge computing is the low response time since computation is conducted close to where the input is generated and the response needs to be produced.

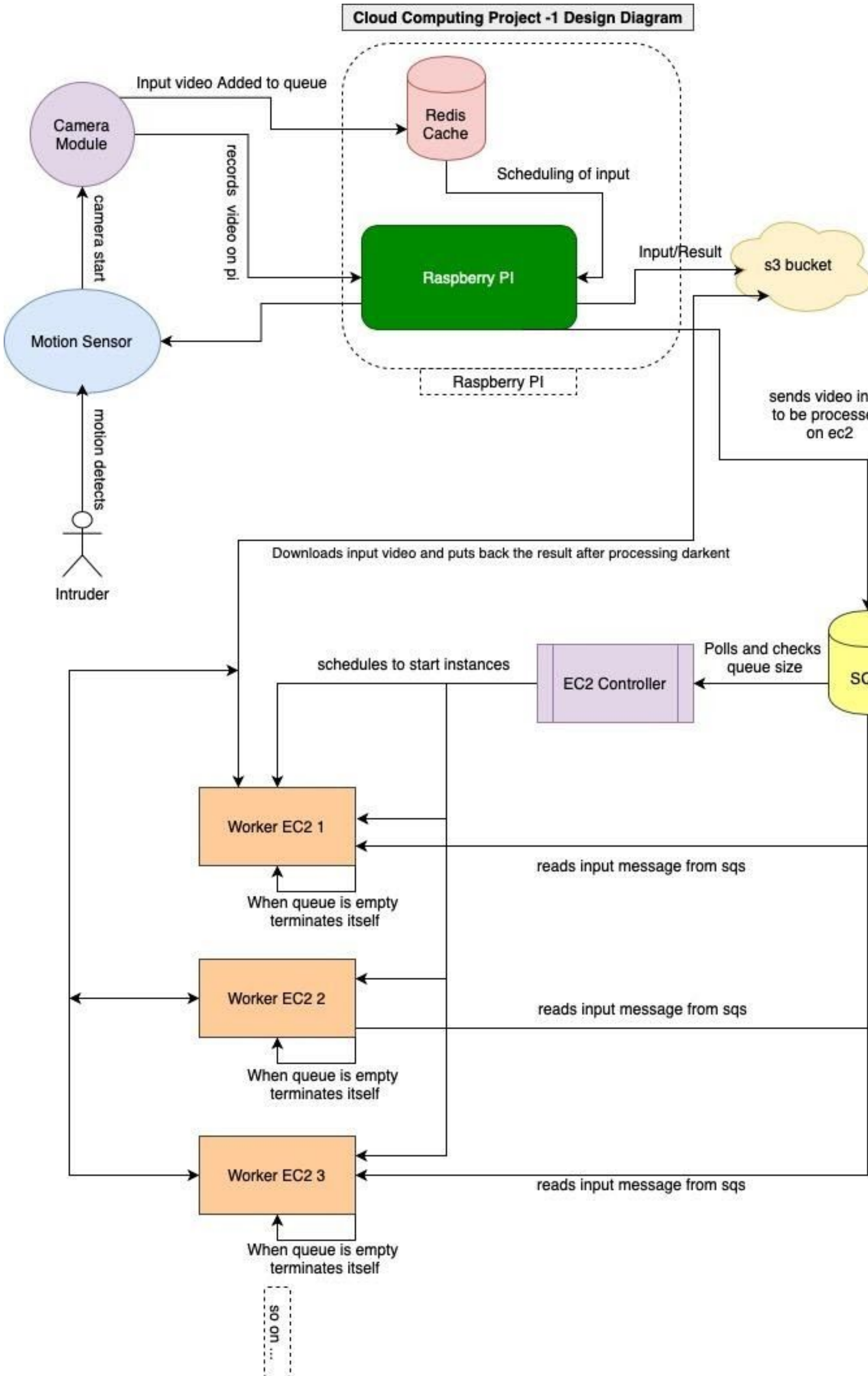
### 2.Design and implementation



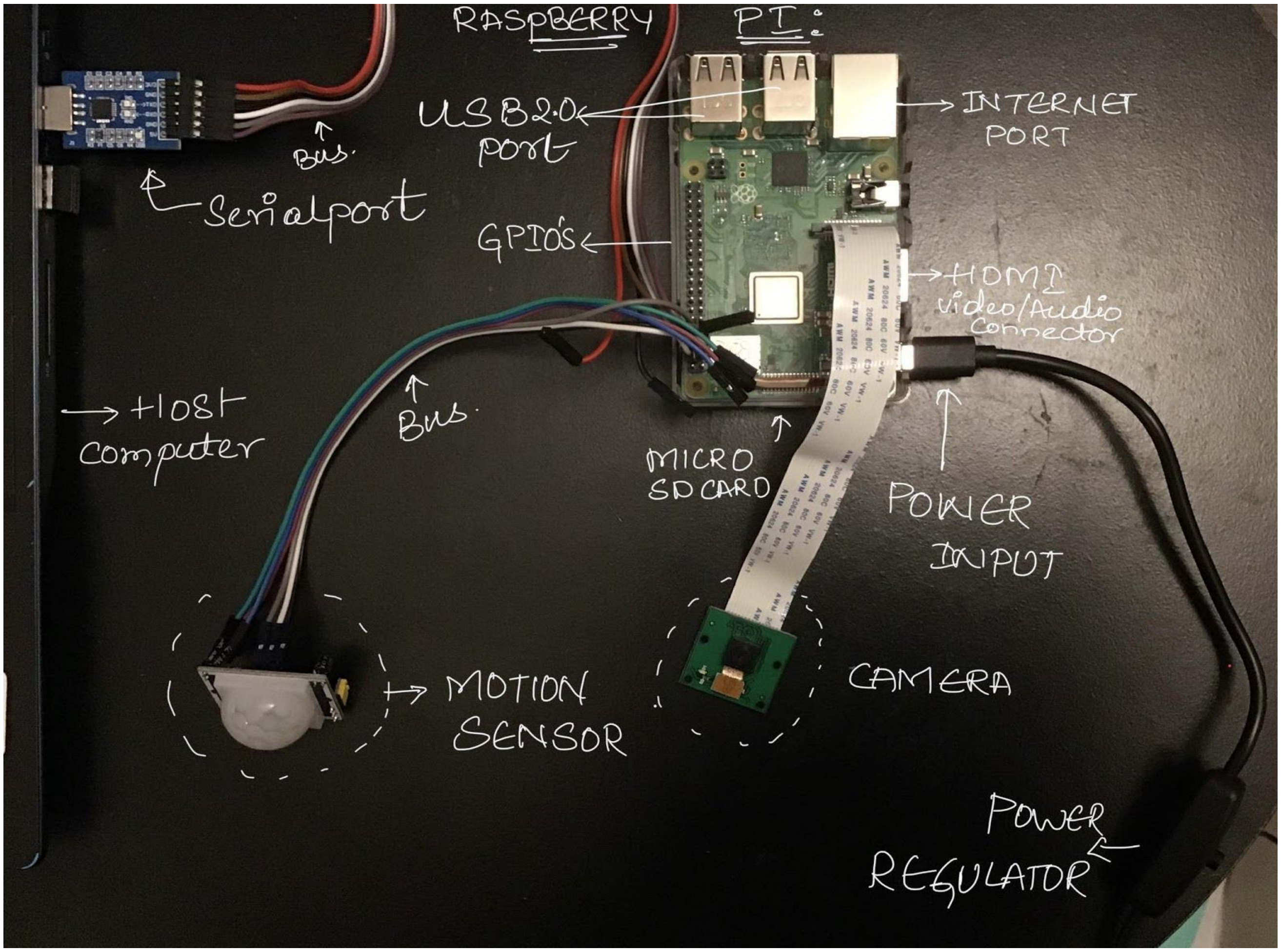

- Raspberry-pi setup
    - OS - setup:
    - Connecting to pi:
        - Serial port connection
        - Directly accessing the Pi
        - Connecting via network
    - Camera setup:
    - Setup the Camera Module
    - Record videos
    - Redis - Queue
- Raspberry-pi to Cloud
    - Redis - Queue
    - Compute input videos
    - S3 Buckets ( input & result )
    - SQS Queue
- Aws Cloud
    - Ec2 controller node
    - Ec2 worker nodes
    - S3 buckets (input & results bucket)
    - SQS queue

### 2.1 Architecture

Following is the architecture diagram for our architecture.


Cloud Computing Project -1 Design Diagram
Input video Added to queue
Camera Module
Redis Cache
records video on pi
camera start
Scheduling of input
Raspberry PI
Input/Result
s3 bucket
Motion Sensor
Raspberry PI
sends video input to be processed on ec2
motion detects
Intruder
Downloads input video and puts back the result after processing darkent
SQS
Polls and checks queue size
schedules to start instances
EC2 Controller
Worker EC2 1
reads input message from sqs
When queue is empty terminates itself
Worker EC2 2
reads input message from sqs
When queue is empty terminates itself
Worker EC2 3
reads input message from sqs
When queue is empty terminates itself
so on ...

**Raspberry Pi setup**




**Pi Controller Logic**

Based on the Redis-queue length, it calls an algorithm designed by me to decide the number of videos to be processed on PI and cloud. This algorithm is designed based on the average time taken by the video to process on the cloud. The cloud approximately takes 5 mins to generate the result by processing a 5 seconds video. Similarly, the average time taken by the Pi to process a 5 seconds video is 40 seconds. In total, we can approximately process 7 videos ( including the uploading of input ) on Pi in 5 minutes.

Now the designed algorithm splits the videos based on redis-queue length ( ql ) by sequentially allocating the first 7 videos on to Pi and the next (ql-7) on to cloud in a loop. This algorithm optimizes the total number of cloud resources being allocated and results in a decrease in latency time.

## 2.2 Autoscaling

Explain in detail how your design and implementation support automatic scale-up and -down on demand:

For Autoscaling, we used a controller server for running scheduler code and SQS queue as metric for scaling-up. Controller has a scheduler code which checks no of messages in the queue every 20 seconds to spawn new worker nodes based on the size(no of messages) of the SQS queue with a maximum limit of 20 worker nodes. Controller creates worker nodes from an AMI image created previously. Controller also considers no of worker nodes already running before creating new worker nodes(for 20 worker nodes limit). Each worker node will continuously pull messages from SQS queue & process messages one by one which includes downloading video from s3 process using darknet command & uploading results to s3 bucket. Now for scaling-down when the worker node finds an empty queue it terminates itself.

We are starting worker instances from single stored AMI so we don't need to keep instances in a stopped state so extra storage resources space for all instances. So after the worker instance is done with processing it gets terminated completely thus saving cloud resources.

## 3.Testing and evaluation

Explain in detail how you tested and evaluated your application.
Discuss in detail the testing and evaluation results:

We have tested our code using 2 ways.

**Method 1: ( Given test video )**

By giving the same type of input videos of length 10. This way we are processing the 7 videos on PI and 3 videos on cloud. Our controller running on PI uploads the videos parallelly and puts a message in SQS that these are the input to be processed on cloud. After this process of the darknet starts on PI.

All the input videos are of the same length and size. Total input videos : 10

This way we are using the 3 EC2 instances and 7 videos we will be processed on PI. To process these 10 videos our code took a total time of 348 seconds i.n 5minutes 48 seconds.

**Method 2: ( By recording videos using pi camera)**

By recording live videos of length 10 using the motion sensor. This way we are processing the 7 videos on PI and 3 videos on cloud. Our controller running on PI uploads the videos parallelly and puts a message in SQS that these are the input to be processed on cloud. After this process of the darknet starts on PI.

All the videos are recorded using a given PI camera. Total number of videos : 10.

This way we are using the 3 EC2 instances and 7 videos we will process on PI. To process these 10 videos our code took a total time of 382 seconds i.n 6minutes 22 seconds.

## 4.Code

Explain in detail the functionality of every program included in the submission zip file.
Explain in detail how to install your programs and how to run them:

**Client(raspberry pi) side:**

1) **Motion sensor:** when a motion is sensed by a sensor, a command to record video for 5 seconds starts. After recording the video, a message is sent to redis queue that there is an input video to process. Before running this, create a **cloudProject/inputFiles, cloudProject/resultFiles** folders to store the data.Place the survillence_cc.py file in the darknet folder of PI and then run the following command.
   python survillence_cc.py
2) **Redis queue:** We are maintaining this queue to see what all inputs to be processed. This queue is a key value store and it will be easy for retrieval.
   Installation of redis queue on PI: ( https://redis.io/download )
   $ wget http://download.redis.io/releases/redis-5.0.8.tar.gz
   $ tar xzf redis-5.0.8.tar.gz
   $ cd redis-5.0.8
   $ make
   $ src/redis-server ( to start the server )
3) **Pi Controller:** Now based on the input size of the queue we will decide the number of videos to process on Pi and cloud. Ideally for darkent to process a 5 seconds video takes 30 - 40 seconds to process and get the result. Similarly for darknet on aws ec2 it takes 4-5 minutes to process a single 5 seconds to process. So, if the queue size is greater than 7, then we send the remaining ( max 18 ) videos to the cloud using parallel processing.

   Copy the controller.py to darknet folder. We have to install python3 on PI to run the controller.py because we are using python boto3 to access the results.

   Please follow this link for the installation of python-3 on pi : installation
   Now install virtualenv and activate the virtualenv.
   After that install the dependencies boto3 using the command pip3 install boto3
   python controller.py

   This will run in a loop and checks if there are any messages in the queue and based on this it will decide whether to process the videos on PI or cloud.

**Server side:**

There are two main programs: 1) controller 2) worker

1) controller:

   Controller project contains logic for controller code. starup.py is the entry point for the project and running that file starts a scheduler which polls SQS queue size every 20 seconds. We can start controller using following commands:
   cd controller
   pip3 install -r requirements.txt
   python3 startup.py

2) worker:

   The worker project contains logic for worker code. Entry point for the project is starup.py and running that file starts a scheduler which reads messages from SQS queue and based on key name it'll download a video file from s3 bucket. After downloading the video it'll run darknet detection command on that video and upload results to s3 bucket. After finishing one video, the scheduler will check for a new message in the SQS queue again and if it finds the message then it'll process that or if the queue is empty then the worker node will terminate itself. We can manually start worker using following commands:

```
cd worker
pip3 install -r requirements.txt
python3 startup.py
```

For creating a worker AMI image first create an EC2 instance from darknet AMI given to us then deploy worker code to the darknet folder and put the startup script(starup.sh) given in the project to the home directory. Add script to crontab: using "crontab -e" add following line to crontab:

```
@reboot starup.sh
```

After that form AWS dashboard select that particular instance and create AMI. Use that AMI id to the controller project code in create_instace.py file.