AMS 559: Project Proposal
Energy Efficient Smart Routers

Project Group 3
Rishabh Jain (111472079)
Aman Raj (112071600)
Vinod Kumar Loganathan (111491311)

Problem Description:

As per statistics, there are currently 280 million public wifi hotspots[1] all over the world and this count is projected to rise to almost 550 million in the next 3 years. Taking each router's power to be 6W, this means more than 275 billion kWh of energy, which is huge. Singapore recently piloted solar powered outdoor public hotspots[2]. By dynamically controlling the power of these routers, we can save energy and simultaneously extending the reach of the router. This can be coupled with anonymous browsing. Increasing number of websites offer "personalized" web pages which are customized as per the user's interests. There is a lack of privacy on the world wide web, so a system to ensure private communication will be helpful.

Importance of solving the problem:

1. By creating energy efficient smart router system, we can install hotspots even at remote locations without wasting too much electricity.
2. Instead of having multiple routers which are all connected to power all the time, this smart router will have the flexibility of being turned off when not in use and will help save a lot of energy
3. Instead of having multiple routers, having one master and few RPs to work as extender will be an energy efficient system.
4. The user will have more signal coverage at the expense of much lesser energy consumption
5. Flexibility in changing secondary router locations and hence the signal reach
6. Will provide more security to the user by mitigating the chances of packet sniffing

Potential Challenges:

1. Finding the exact physical location of the user, so that he/she can be connected to the nearest RP
2. Choosing which router to connect to, based on user location, router location, and signal strength.
3. Connecting the user to other RP if the user is moving from one router's range to another
4. Switching off the idle secondary routers. The main router will always be on, and the secondary router(RP) will be on only if any user is connected to it. Otherwise, to save energy, it should be switched off and this control will be given to the main router.

5. Switching on a secondary router(RP) if someone needs to connect to it for a better signal.
6. Coming up with a way to test our smart router and provide some statistics about how much energy this smart router can save if deployed in a real environment
7. Providing TOR support on the router while minimizing any delay caused by it.

Approach:

Device Requirements:

1. Raspberry Pi (RP) x 2 (Including power backup, wires, etc)
2. Raspberry Pi Wifi extender
3. Ethernet cables
4. SD card
5. Laptop (For Routing functionality)

On a high level, we propose a master-slave topology for the router and its access points, where the master controller will have complete access of the access points power consumption and networking functionality. With this we can efficiently control the throughput of power designated to each of these access points.

* The Laptop will act as the master Router or the controller.
* The Raspberry Pi will be used to simulate the actual Access Point's (slave) functionality. The physical USB connection will simulate the power access to the devices.

- Each of the RP will be connected to the router physically via ethernet - This is to simulate the multiple hotspot scenario
- The Laptop(Router) will be configured to have routing functionality -> to transmit packets from one network (RP network) to another (Internet) - The client-server mechanism to manage multiple hotspots and their energy consumption.
- Routing software will also be installed and configured on each of the RPs
  Note: The Wifi signals are extended as part of this approach giving a wider range of coverage to the users - In the actual real-world setup, we have at least 50-100 access points in a building or location to provide consistent internet access. If we are able to control the power consumption of each of these hotspots in real-time, it will have a huge impact on the energy throughput.

  We now have the following topology

```
                                   INTERNET
                                       |
                                       |
                                       |
RP1 ---------- network1 ---------- ROUTER ---------- network2 ---------- RP2
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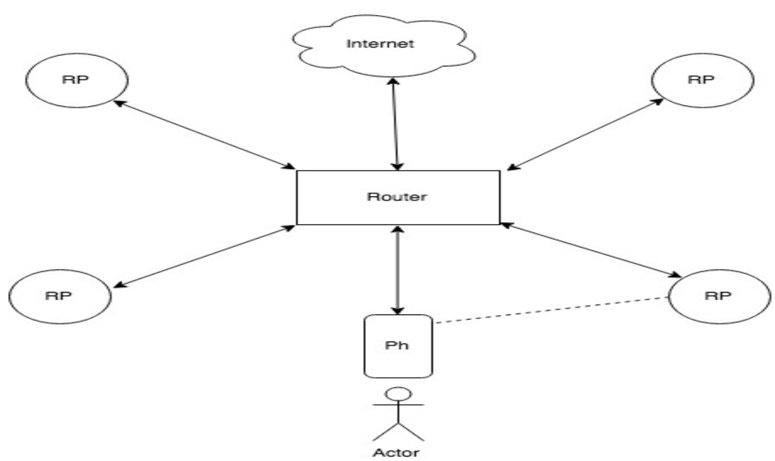
- During this time, the router finds the closest RP to the user (using the signal strength as the distance parameter). - This is the most challenging part of the problem. The algorithm needs to determine the location without help of GPS or any other location based protocols. Our initial idea is to use the signal strengths and pings to the user from the master controller to get a estimate of the user location. With this information, we can further filter out the access points and find the closest one for providing consistent internet connection.
- Now, the packets will flow via the RP and to the router and finally reaches the internet.Since the packets go via the RP, it will be encrypted and secure, that guarantees anonymous functionality. Note: The routing tables will be updated during this phase to re-transmit the packets.
  (TOR - The Onion Router is a software that provides anonymous data transfer over the internet. We install this on each of RPs to provide anonymous browsing functionality.
  A captive portal (a portal that uses user login credentials to sign up/login) will pop-up when the user tries to connect to the network.net access. The user has an option to choose "anonymous browsing" functionality. If the user opts for it, the Wifi network connection is going to be re-routed to the RP.) - This is an additional functionality.



Roadmap and Expected Results:

Week 1-2 : Gather Requirements
Week 3-4: Setup and Configuring the topology
Week 5-6: Algorithms for finding closest RP and changing routing tables
Week 7-8: Integration and Prototyping
Week 9-10: Testing and Bug Fixes

A fully functioning master-slave topology with which we can report the average power saved per hour per device. This result will be reported on a sampled data as we are going to simulate the topology as opposed to experimenting with actual access points.

References:

[1]https://www.statista.com/statistics/677108/global-public-wi-fi-hotspots/
[2]https://www.zdnet.com/article/singapore-pilots-solar-powered-outdoor-wi-fi-hotspots/
[3]https://upcommons.upc.edu/bitstream/handle/2099.1/25583/104901.pdf?sequence=1&isAllowed=y