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Applying the Engineering Design Process

1. Identify the problem clearly

   The main problem is the ever increasing cost in electricity bills on a monthly basis caused by students using appliances inefficiently by leaving them turned on unattended for long periods of time, leading to increased overall power consumption and cost both to the students' pockets and the boarding house's landlord.

   - Why is electricity being wasted?
     - Parts of why electricity is being wasted come from various causes, more specifically bad habits made by students who go on about their academic days, such as forgetting to turn off lights, fans, and other appliances. Another comes from electronics and devices left plugged in all day and night unattended, which can also cause a host of problems such as fried components and bloating rechargeable batteries. Moreover, there are appliances used not in an efficient and economical manner, like lights and fans or air conditioning units running in unused spaces.
   - Who is affected?
     - Those who are primarily affected by this problem are students and the landlord. For the landlord, this comes in higher numbers in terms of cost in electricity bills, which could shift the focus of improving the boarding house's infrastructure quality towards attaining the required needs, lessening the quality of the boarding house in the long term. For the students, this comes in higher costs of basic living inside the boarding houses, which could also shift their focus on attaining their needs over their much prioritized academic tasks.
2. Research

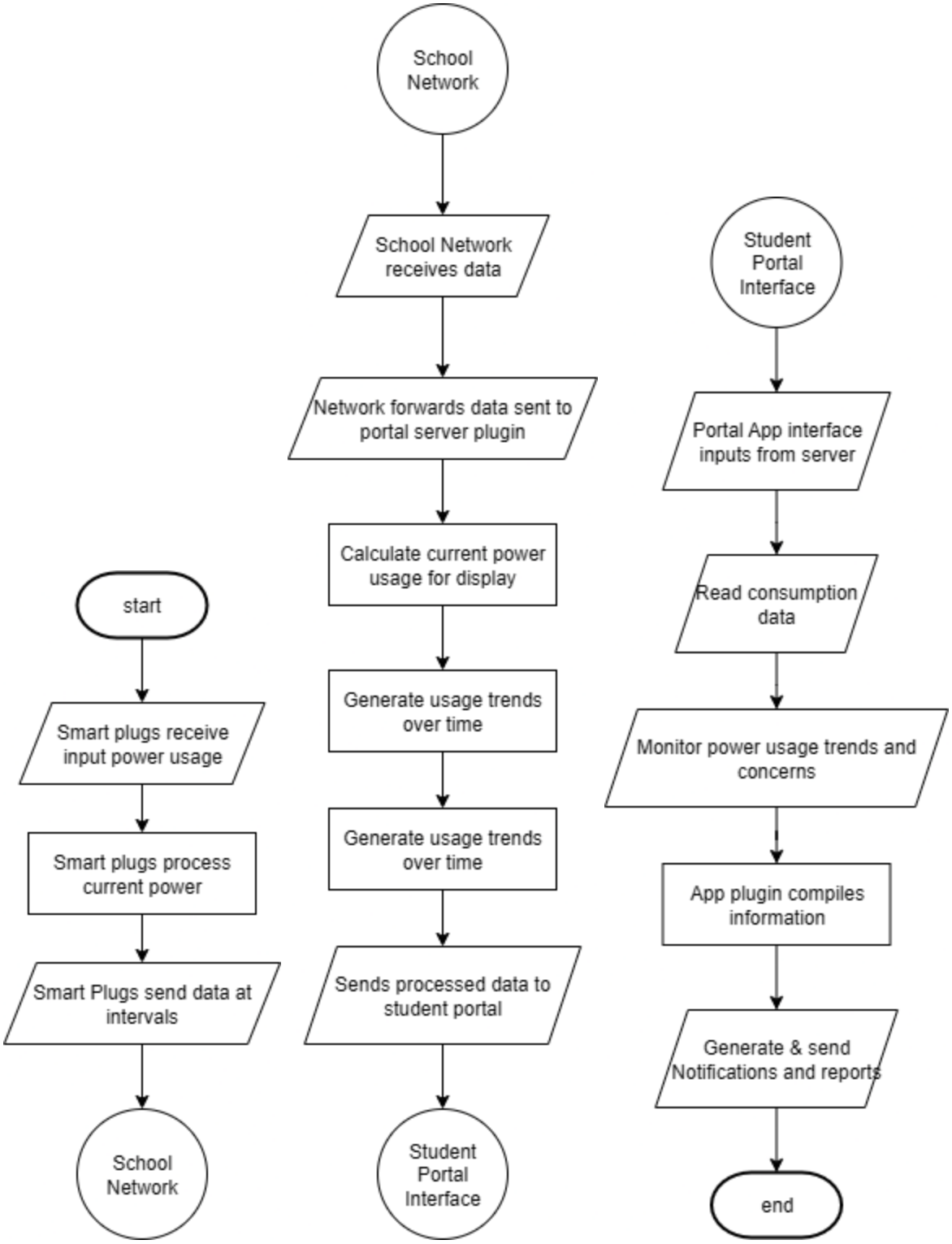
   To identify and solve this problem, information gathering about this issue is an important step in this process.

   - Common causes
     - According to an article from Arcadia, appliances and electronics "turned-off", which is actually just in stand-by mode, still take about 5-10% of overall residential power consumption. In terms of the most demanding use of electricity, HVAC (High Voltage Air Conditioning) units take up the most power usage in one location, consuming 28-63 kWh per day (GreenLogic, 2022). In context of this problem, appliances like this left unattended contribute to higher electricity consumption and costs.
   - Existing solutions
     - The existing solutions are as follows: Energy efficient appliances complying with ENERGY STAR guidelines. Usage of smart plugs which reduced electricity consumption by 5% in over a year (Oh, 2020). Advanced power strips preventing standby power usage (TEP, 2024).
3. Specify Requirements

Based on the problems given above, this project or prototype must follow and meet the following requirements.

- It must be affordable for students with limited budget and allowances.
- It must have ease of access with minimal need of instructions and technical knowledge.
- It must effectively fulfill its purpose for reducing unnecessary energy consumption and overall waste.

4. Brainstorm Possible Solutions
    - The first choice is a motion-detection solution for activation of lights and fans. This automatically activates or increases settings when a person is present in the room.
    - The next choice is a circuit timing solution for switching off power of rooms at certain hours of a day. Since students usually go out of the boarding house at a set schedule, a switch-off schedule based on their class schedule may be suitable for disabling excess consumers of electricity.
    - The third choice is a cloud-based smart plug solution that uploads power statistics to a service monitoring power usage for a real-time power consumption trend reading for the student anywhere and anytime.
5. Choose the best solution and justify why.
    - A cloud-based smart plug solution is the best solution for the following reasons: It suits the requirements of affordability, ease of access, and effectiveness. The cloud-based implementation can involve an additional plugin or service to a school's student and parent portal for monitoring. This solution expands the already smart capabilities of smart plugs with an app-accessible monitoring page containing the data from current power usage, usage trends, and outages. Through this cloud-based solution, it allows for a more transparent view on the electrical consumption, as both the landlord and student can read through the data and inform each other of concerns.
6. Create a prototype or model
    - Flowchart:


start
Smart plugs receive input power usage
Smart plugs process current power
Smart Plugs send data at intervals
School Network
School Network
School Network receives data
Network forwards data sent to portal server plugin
Calculate current power usage for display
Generate usage trends over time
Generate usage trends over time
Sends processed data to student portal
Student Portal Interface
Student Portal Interface
Portal App interface inputs from server
Read consumption data
Monitor power usage trends and concerns
App plugin compiles information
Generate & send Notifications and reports
end

References:

Oh, J. (2020). *IoT-Based Smart Plug for Residential Energy Conservation: An Empirical Study Based on 15 Months' Monitoring*. *Energies, 13*(15), 4035. https://doi.org/10.3390/en13154035

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