2022 6.033 Design Project:

Centertown, MA, Cooperative Electric Utility

Version 1.2

See also DP FAQ v1 and DP Errata v2

Due Dates and Deliverables

There are five deliverables for this design project:

1) **DP Prep (DPP):** In order to help you prepare with your team design effort, this assignment will require some guided analysis of the DP specification below. This assignment will be written by each student individually and is due February 25, 2022, 5pm, EST
2) **DP Preliminary Report (DPPR)**: This preliminary report will lay out your key design decisions, including both a functional system design and a sketch of any data structures, storage management, and/or network protocols required to achieve your design. It will not include any significant evaluation. It will be approximately 2,500 words and is due March 18, 2022, 5:00pm, EDT.
3) **DP Presentation**: This presentation will address the feedback received on the DPPR, and any corrections or updates to the design project specification. It will also outline evaluation criteria and use cases you will use later for evaluating your design. The presentation will occur during the week of April 11 - 19, 2022.
4) **DP Report (DPR)**: This will be your full report. It will include your final design, all diagrams appropriate for that, your evaluation of your design and a review of how effectively your design addresses the specified use cases. It will be approximately 6,000 words and is due May 2, 2022, 11:59pm, EDT.
5) **Peer Review**: In Tutorial your team will have done an early "review," providing informal feedback to another team on their design. For this peer review, you will individually review a few specific sections of that (same) other team's final report and will address some specific questions about that report. It will be approximately 250 words and is due May 6, 2022, 5:00pm, EDT.

Your assignment for each of the five parts above will be distributed in separate "assignment" documents.

The prep, preliminary report, final report, and peer review should be submitted through Canvas. As with real-life system designs, the 6.033 design project is under-specified, and it is your job to complete the specification in a sensible way given the stated requirements of the project. As with designs in practice, the specifications often need some adjustment as the design is fleshed out. Moreover, requirements will likely be added or modified as time goes on. We recommend that you start early so that you can evolve your design over time. A good design is likely to take more than just a few days to develop. A good design will avoid unnecessary complexity and be as modular as possible, enabling it to evolve with changing requirements.

Large systems are never built by a single person. Accordingly, you will be working in teams of three for this project. Part of the project is learning how to work productively on a long-term team effort. **All three people on a team must be in the same tutorial.**

Although this is a team project, some of the deliverables have individual components. See the individual assignment links for more information.

Late submission grading policy: If you submit any deliverable late, we will penalize you one letter grade per 48 hours, starting from the time of the deadline. For example, if you submit the report anywhere from 1 minute to 48 hours late and your report would have otherwise received a grade of A, you will receive a B; if you submitted it 48 hours and 5 minutes late, you will receive a C.

You must complete the three team design project components, parts 2, 3, and 4 above to pass 6.033. For the other two (individual) components of the design project, the contribution to your overall grade will be whatever grade you receive on that component. Thus, if you choose not to do one or the other of them, you will receive an F for that component only as a contribution to your overall grade.

1 Introduction

You are part of an engineering design team whose task is to design a digital management and control system for the town electric utility for the fictional town of Centertown, MA. The town operates a *municipal light company* – the Centertown Municipal Light Company, or CMLC – which is a non-profit electric utility for the town. Using municipal utilities is an established practice in Massachusetts, and unlike the commercial utilities, they serve only their local communities and are legally non-profits with no shareholders. CMLC, like many municipal light companies, is focused on controlling the cost of electricity to their residents and reducing their impact on the environment.

CMLC runs the electric plant and all the town wiring and poles, but the plant does not generate electricity. The electric plant has storage capacity to provide 12 hours of average electric consumption for the town. It is connected to the statewide electric grid and buys electricity as needed.[1] The cost of this purchased energy is 50% higher during peak hours (3pm to 9pm) and otherwise lower.

Homeowners in Centertown are increasingly installing solar energy systems. Many of the town offices and facilities would like to as well; in particular, the local hospital, police station, fire station, and a set of subsidized housing (low-income, elderly, etc.) apartment buildings. The town has a two-fold objective:

1. Make it possible for any individual solar energy system that has excess power to share that excess with others.
2. Enable the creation of *microgrids* to share resources and remain functional if there is a power outage in the larger system. (See Section 2.2.2 for a discussion of microgrids.) The physical layout of the microgrids will be done by the town, so they install all the wiring, smart meters, etc. and determine which facilities and buildings are part of which microgrid, but your system will provide the management control they need to make this a reality.

Your task is to design a system that will allow Centertown to meet these two objectives, while also providing stable power to all customers, enabling billing for all customers, as well as accounting for town services. Centertown should also be able to use your system to provide long-term projections of the electrical needs and capabilities of the town.

Finally, MIT researchers want to use the data that your system collects to model and predict demands over both the short and longer term, with an eye towards possible improvements for the system. Your job is *not* to handle that modeling and prediction, but to enable the system to deliver the data needed.

As you design your system, remember that this is not an electrical engineering system design problem. There are aspects of the electrical part of this system that we have simplified so that you can focus on the computer systems needed to control it.

[1] As an aside, the power in Massachusetts comes primarily from local power plants and hydroelectric plants in Quebec, Canada.

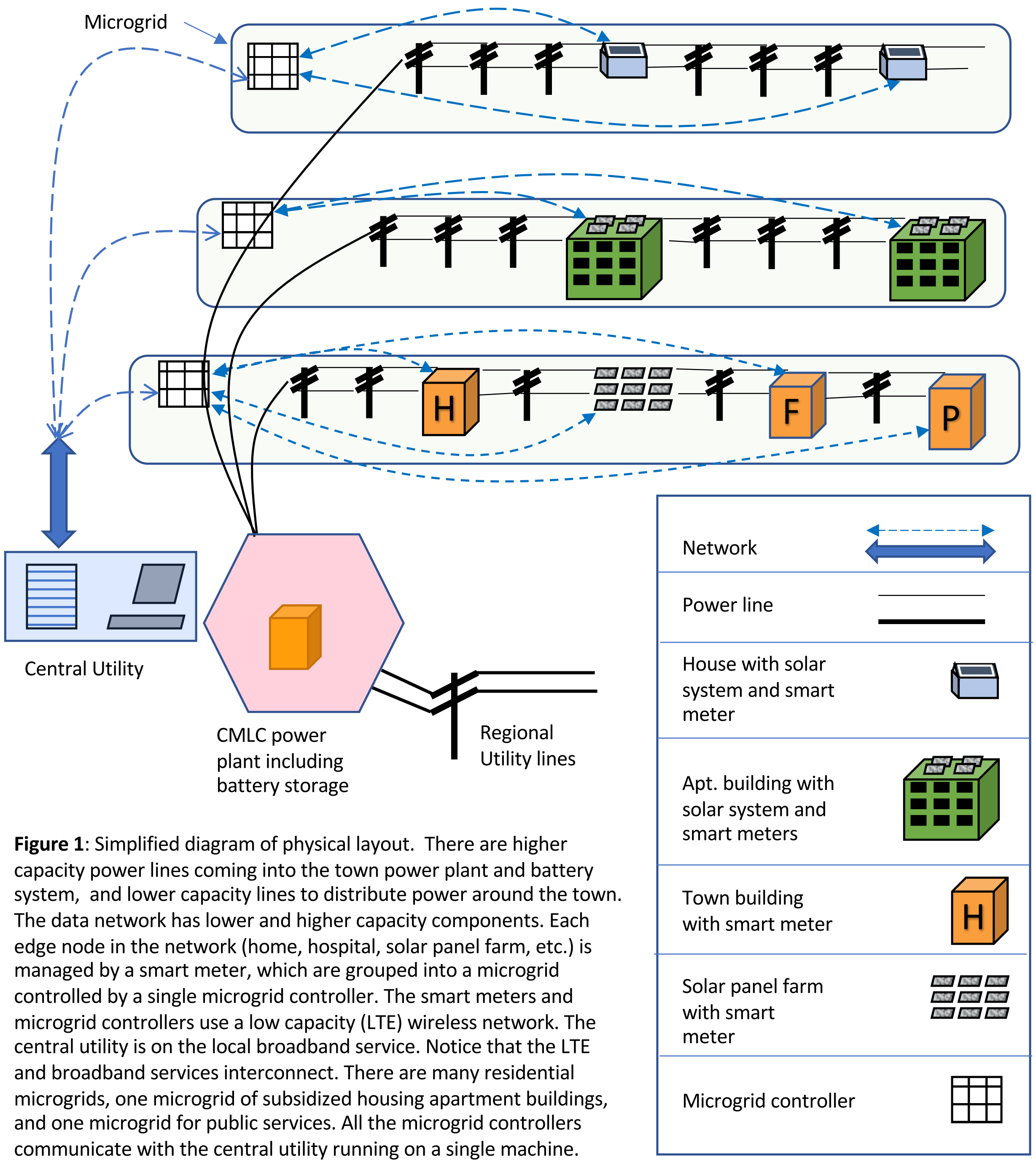

Figure 1: Simplified diagram of physical layout. There are higher capacity power lines coming into the town power plant and battery system, and lower capacity lines to distribute power around the town. The data network has lower and higher capacity components. Each edge node in the network (home, hospital, solar panel farm, etc.) is managed by a smart meter, which are grouped into a microgrid controlled by a single microgrid controller. The smart meters and microgrid controllers use a low capacity (LTE) wireless network. The central utility is on the local broadband service. Notice that the LTE and broadband services interconnect. There are many residential microgrids, one microgrid of subsidized housing apartment buildings, and one microgrid for public services. All the microgrid controllers communicate with the central utility running on a single machine.

2 The underlying systems

In this section we discuss the two systems present in Figure 1. The system that you are designing will utilize these systems; you are not designing these underlying systems.

2.1 The Electric system

There are 8,000 separate houses in Centertown, each of which has the following properties:

- A 200 amp service[2]
- A solar energy system that includes enough panels to fully charge its batteries in eight hours of sunlight. This system has enough battery storage to hold 24 hours of average usage. Notice that authorities report that even under overcast conditions, solar panel systems can charge with a loss of no more than 10 – 15% of their capabilities under full sunlight.
- Two smart meters (see below)

In addition, there are three subsidized housing apartment buildings, with 100 apartments each, with the following properties:

- Each apartment has a 100 amp service
- A solar panel on its roof that has enough battery storage to hold 24 hours of average use for the building.
- Each apartment and the solar panel farm on each building has one smart meter.

Finally, the town has allocated some open space to a solar farm that generates power for the hospital, police station, and fire station. Each of these three properties, as well as the solar farm, has a smart meter. Since these are critical services, in the worst case of power outages the hospital, police and fire will have the highest priority for additional power should they need it, and the subsidized apartment buildings will be next in line for additional power. See below for more discussion of this.

The buildings in Centertown are divided into microgrids. Each house is grouped into a microgrid of ten houses. The three subsidized housing apartment buildings three buildings form a microgrid, and the hospital, police station, fire station, and solar farm form a microgrid.

Because smart metering is a changing market, Centertown was able to buy slightly older smart meters for less than half the price of the more modern ones, but these present a small challenge: they measure the amount of electricity that passes through them, but not its direction.[3] CMLC needs to be able to provide credit for contributed electricity at one rate and charge for electricity at a different rate. So, they need to be able to understand how much electricity is flowing in each direction.

To do that, they've put two meters in each location that is both providing and consuming electricity (such as the houses): one for outgoing electricity and one for incoming electricity. This gives the town the most flexibility in setting the rates for both provision and usage of electricity differently for high and low demand times of day and the adapt them as the situation changes.

It is also important to discuss the batteries in the system. The central utility and each location of solar panels has a system of batteries. (Note that each individual apartment within an apartment building does not have its own batteries.) The batteries at each solar panel installation provide backup sustainable power when the sun is not shining. In addition, they provide an option for sharing of stored power within their own local microgrid. Since collecting solar energy is passive, it costs the collector nothing other than backup capacity to share. Each residence can set their threshold for the minimum amount of electricity below which they will not share. These can be set individually at 25%, 50% or 75%. Each apartment building will set its minimum at 50% and the solar panel farm form for the hospital, police and fire will be set at 75%. Within a microgrid that contains more than one set of batteries, if any

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[2] An *amp* or *ampere* is a unit of how much electricity is delivered per second. 100 or 200 amps is typical of homes today in the US.

[3] This is a true challenge of such devices! Not something we made up.

of them is below its minimum and others are not, the microgrid controller will instruct the others above their minimum to share, so that all are brought to their minimum. The reasoning for this is that within each microgrid, neighbors will be helping their neighbors. There is no accounting that appears on monthly bills for this, although the central utility and researchers will want to know about it. If all the batteries within a particular microgrid are at or below their minima, any home that is running out of stored power will be purchasing it from the town.

In addition, there are batteries at the central utility. It has a capacity of 12 hours of average use across the whole town. These batteries store power, either from the microgrids or the New England regional utility, and provide power to users that may need it. When all the batteries in a microgrid are above their minima, any site's batteries that are full can supply any excess back to the town. The reverse direction smart meters will keep track of this. For providing power to the central utility, they will receive a credit on their electric bill and the town will store that power in its batteries to provide to others. In an apartment building, if power is shared with the central utility, the credits will be prorated equally among the apartments in that building. If the town batteries fall below a minimum set by the town, they will buy extra power from the New England regional grid.

The reason they have organized this all this way is to minimize cost to the town residents. By sharing "for free" within a microgrid, a group of collaborating neighbors help each other generally at no cost to themselves. For any excess power they return to the town, the town credits them with that power and they receive a comparable reduction in their power bill. Since every bill has a base level for the connection to the house, if the house provides more power back to the town than it uses, its base level bill will be reduced. A bill will never go below zero in any month. Finally, from the perspective of the central utility, it is working to keep prices for the residents as low as possible. The least expensive power it receives is that from the residents. The second level of pricing is to purchase power from the New England regional utility at low-rate times. The most expensive is to purchase power during peak hours, so it must predict its overall costs to set monthly rates ahead of time and to plan how best to manage its resources. Your control system will enable this functionality but will not be doing the actual rate setting.

2.2 The basics of the management system

At a minimum the town needs to know exactly which location is consuming or providing electricity and the time of day, to allow for the low- and high-demand times of day. To do this they propose a tiered system including smart meters, microgrid controllers, and a central utility.

2.2.1 Smart meters

Each smart meter contains two tables – the history log and the event log – that collect many records with a single structure discussed below. In addition, each smart meter can be configured manually (at initialization time) to initiate transmission of its records itself one a minute or not. This is chosen by the homeowner with a manual switch. If record transmission is not originated by the smart meter, the microgrid controller will need to request such records on some schedule that you will need to determine. The acknowledgement of the **`initialize`** will include a report of which choice has been made by the homeowner. The central utility and microgrid controllers also understand these same data structures. The protocol available to you is a simplified version of the ANSI C12 protocol. It has eight basic commands:

- **`Initialize`:** boot or reboot
- **`Stop`:** shutdown

- **`Get:`** retrieve specified data from the receiver of the command, this may be to request all data or a subset of the data
- **`Put:`** deliver specified data to the receiver of the command.
- **`Isolate:`** operate disconnected from the rest of the system
- **`Aggregate:`** this takes arguments including a flag for lossless vs. lossy aggregation and an optional duration of aggregation.
- **`Deaggregate:`** this returns the smart meter to no aggregation of transmitted data.
- **`Share_power_on:`** turn on power sharing within the microgrid. This command must be sent to each individually to each smart meter that needs to be notified of it.
- **`Share_power_off:`** turn off power sharing within the microgrid. This command must be sent to each individually to each smart meter that needs to be notified of it.
- **`Reduce_power_on:`** reduce power demand
- **`Reduce_power_off:`** stop reducing power demand
- **`Acknowledge:`** acknowledge each specific operation. In the case of get and put, acknowledge how much data of which type was exchanged. In the case of **`initialize`** report whether the smart meter will push data out or not and the threshold of the batteries, if the meter is attached to a solar panel system.

The town has assigned each element of the management system a unique, static IP address, and keeps records in the central facility of the location and function of each element, the directionality of each smart meter, and meter ID for each meter.

The types of repeatedly collected data that are particularly important for this system are:

- **Power generation** per 15 sec. period.
- **Power stored** at regular intervals, collected every 15 secs.
- **Power through the meter** (remember each meter measures in one direction) per 15 sec. period
- **State:** running disconnected from the power net, running on the power net, shutdown, initialized, aggregating data or not. This data is recorded at each state change.

The first three types of information are all collected in the history log, while the last is in the event log. A history log record has the following format (total number of bytes 36 bytes each):

Field name	**Field size**
`record_type`	8 bits
`lossy_aggregation`	8 bits (on/off)
`record_ID`	64 bits
`meter_ID`	64 bits
`account_number`	16 bits
`start_time`	32 bits
`end_time`	32 bits
`Reading`	64 bits

An event log record has the following format (total of 24 bytes each):

Field name	Field size
`previous_state`	16 bits
`new_state`	16 bits
`record_ID`	64 bits
`meter_ID`	64 bits
`time`	32 bits

Each meter has 64GB of storage and will only delete accumulated data from its storage once it has an acknowledgement back from its microgrid controller confirming exactly what happened. In addition, each smart meter has a rechargeable battery that will allow it to keep operating for up to 48 hours.

Since the smart meters is the source of the bulk of the traffic on the network, there may be reason to aggregate data before it is sent. To do this, there are two forms of aggregation to be considered, lossless and lossy:

- The lossless algorithm takes all records in consecutive that are identical in all fields except their time and consolidates them into a single record over the longer period of time.
- The lossy algorithm available in the smart meters takes a simple average over every 10 readings. The town is aware that this leads to loss of detail and wants to minimize the use of this algorithm, understanding that sometimes it may be necessary.

A smart meter will not use either algorithm unless instructed to do so by its microgrid controller, which will use the `aggregate` command to instruct the smart meter.

In addition, if the smart meter finds that it is running out of storage it will independently apply the lossless aggregation to all its stored data. It is expected that it will never run out of storage under this condition.

Note that below we will discuss aggregation in the microgrid controllers.

Finally, as discussed above since there will be sharing of power within a microgrid, each smart meter will be responsible for notifying its battery system, if it is attached to one, to instruct it (upon receiving instructions from its microgrid controller) when to share electricity within the microgrid and when to stop.

2.2.2 Microgrid controllers

At the mid-level of the system are the microgrid controllers. See Figure 2 for a blow-up of a sample microgrid. They have a number of functions:

- A microgrid controller collects data records from its smart meters and passes that information to the central utility. It may pass a complete set or a partial set. The controller can issue commands to the smart meter – for example, `aggregate`, `deaggregate`. Moving data from a smart meter to the controller can be done with a `put` issued by the smart meter or a `get` issued by the controller. The same is true for transferring records between the microgrid controller and the central utility. It has 64GB of storage.

- A microgrid controller will receive communications from the central utility either to use for its own management of the local microgrid or to forward on to the smart meters in its microgrid. Examples of these will include: (1) Aggregate data, (2) Reduce demand on the public utility, (3) The public utility is offline, so the microgrid must operate in isolation in terms of energy sharing. Your design will need to include a specification of all such useful communications between the central utility and microgrid controller, so that the microgrid controller can do its job.

- A microgrid controller is responsible for the collaborative sharing of power within the microgrid. To do this, along with the actual delivery of electricity to meet demands, the controller should keep track of provided energy from an edge node to others, so that there is neither credit for electricity provided or charge for electricity used that remains in the microgrid. The scheme for this was discussed above in Section 2.1, but the microgrid controller must issue the instructions to the smart meters to make this happen. This capability may require collecting data from the various smart meters about their current status (how much electricity is stored in the batteries) and/or current demand. In terms of local power management, to do this, the microgrid controller has built-in smart meter functionality as well. Your design will include making this happen.

- A microgrid controller is also responsible for allowing the microgrid itself to continue operation if all power is lost with the central utility. If the central utility's data communications remain operational the microgrid controller will receive notification of this from the central utility, but it will also have a sensor (smart meter capability) to recognize if it is offline with respect to provision of power outside the microgrid itself.

- A microgrid controller may be instructed by the central utility to aggregate data. This is likely to occur when there has been a network outage and the amount of data to be sent from the microgrid controllers to the central utility is more than the central utility can receive and handle without loss or significant delays. This is discussed further below.

As discussed above in Section 2.1, each battery system will have a battery system minimum amount stored set for it. A homeowner's choice about this setting may be influenced by a combination of altruism for their neighbors and opportunities to gain more credits on their utility bills, among other things.

Each microgrid controller will have 64GB of storage on a single processor machine. As discussed in Section 2.2.4 below it will also have an LTE radio supporting 10Mbps each direction and maximum of 2GB per month. In addition, each microgrid controller will have a rechargeable battery that will allow it to run for up to 48 hours.

With respect to records stored on a microgrid controller and transmitted to the central utility, again aggregation may be necessary if either storage or network capacity is overloaded. The microgrid controller is provided with the same types of aggregation as the smart meters. Because at least some of the microgrid controllers are heavily loaded, especially the one for the subsidized apartment buildings, the town is concerned that you minimize the work on the microgrid controllers. They also realize that it is possible that some other lossy algorithm than averaging might prove more useful. This is not critical to the design, but because the microgrid controllers are programmable, they are open to a suggestion of an alternate approach here.

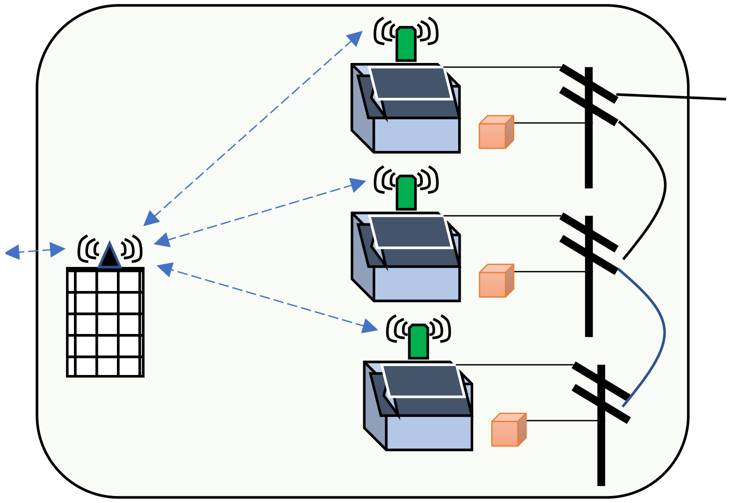

Figure 2: A microgrid. Each house has solar panels, batteries, and a smart meter. It is connected to the power lines, which form a local loop with a connection to the central power utility. A microgrid controller controls it and communicate with LTE to both the individual smart meters and the central utility

You will need to design the control structure (e.g., threads or processes) as well as storage management for the microgrid controller. You will need to think about which data that otherwise might pass through the microgrid controller will be needed to make decisions and manage the microgrid itself as well as the interface with the utility. Finally, you will need to identify the complete but minimal set of messages that the microgrid controller will need to be able to receive from the central utility to do its job.

2.2.3 The central utility

The central utility will run on a single centralized system to collect information from the microgrid controllers, which in turn collect information from the smart meters, do the billing, understand when they need purchase power on the spot market, and do any long-term planning about the whole system. As mentioned, the central utility produces the monthly bills with accounting for all the energy it has provided to each location and received from each location including time of day, to allow for differential billing rates for different times of day. On a regular basis it will also need to provide to the microgrid controller the billing rates for each time period.

The central server has an 8-core 2.6 GHz Intel processor, 256GB RAM, and 2 TB of storage. As discussed below it will be on the broadband network.

The central server will also be the locus of decisions about priority for receiving additional electricity during over-utilization or under-supplied periods. For example, due to a sustained heatwave, there may be increased demand for power within the town and decreased availability from the external sources because of demand across the region. If there is significantly high demand for power and reduced availability from the external grid, the utility will give highest priority to the microgrid for the hospital, and police and fire stations. Its second priority will be the microgrid of town housing in subsidized apartment buildings, with the lowest priority to the individual residences. Note above that within a microgrid under microgrid control power may be shared unequally based on personalized priorities.

There are two kinds of longer-term challenges to the central system. The first is that for long-term planning, the utility management team will need monthly, quarterly, annually, and 5-year rolling period information about patterns of usage. The second use of the data is the MIT researchers who want to learn and predict all sorts of micro-level and macro-level behaviors and demands on electricity. For that they need the most fine-grained data possible. Any lossy aggregation will have a negative impact on their ability to learn about the behaviors of the customers.

2.2.4 Networking

There are two types of data networks used in the system. The smart meters and microgrid controllers are only on the local cell-phone LTE phone service. To save money for its customers, the town has contracted with the cell phone company for each smart meter and microgrid controller to have the following service: 10 Mbps in each direction (download and upload) with a maximum capacity of 2GB per month. The cost is $10 per line, which is all the town feels they can add to the customers' bills.[4] Since the smart meters and microgrid controllers are only on LTE, they are limited by it both for incoming and outgoing traffic. For the hospital, police station, fire station, and solar panel farms this may not be an issue, but for the homeowner with two meters or the subsidized apartment dweller with one meter, it will be important to keep costs down. We raise this issue because there are options to pay more for increased monthly caps and higher speeds, but the town has decided not to choose those options in consideration of the residents of the town. At the same time, the town is worried about this decision. Especially for the microgrid supporting the subsidized housing, they ask your advice on the network capacity for the microgrid controller.

In addition, the central utility will have Internet connectivity through the local broadband company. This will be a fixed price and will provide 200Mbps for $100.

Notice that in this section we are considering the *data* network, but above we discussed the electrical network. The data network is used to control aspects of the electrical network, but each can fail independently. Thus, if part of the power network fails (a tree falls on a wire), the controllers involved will need to be notified by the data network if possible. If the data network fails (from personal experience Comcast fails occasionally, independently from power failures), the power grid will continue to provide power, but one or another part of the control system may be unavailable.

3 Your challenge

Your challenge is to design the aspect of the management for the whole Centertown Municipal Light Company that provides all the necessary storage, management, and communications among the smart meters, microgrid controllers, and central utility. As you are learning in 6.033, this involves a coordinated storage system among these devices, management of the computational resources, especially on the microgrid controllers and central utility, and effective utilization of the communications capabilities (i.e., networking). It also includes designing the commands exchanged

[4] The wireless company actually supports more expensive, higher capacity services (this is real), but in order to minimize costs, because they believe it is feasible, they have chosen the lowest option. This cost is passed directly through to each customer.

between the central utility and the microgrid controllers and utilizing of the pre-defined set of commands between the microgrid controllers and smart meters. The town cannot afford any more hardware or otherwise upgraded services with the one possible exception of the network service for the subsidized housing microgrid controller, so you must do this within the bounds set out in the sections above. Note that the smart meters are not a resource you can (re)design, but the microgrid controllers and central utility are programmable.

Before you start you may want to think about the following questions, to help guide your design:

1. Who is impacted by your system? In what ways are they impacted?
2. What functions should the system provide for them?
3. Besides those functions, do they have other concerns or interests that should be considered in the design?
4. Are there goals of the system that cannot be perfectly satisfied simultaneously? If so, how will you balance those goals?

As you begin to think about your design to achieve those goals, consider the resources you have available, including but not limited to storage, CPU capacity, and network bandwidth. In both the microgrid controllers and central utility, you may also be able to parallelize functionality through virtualization, at some cost. In the end, you will need to justify both the benefits and costs of the design choices you make. Examples of these costs could be in the form of dollar costs, less accuracy, less speed, or other negative impacts; you will need to consider who takes the burden of those costs.

4 Use cases

To help you both ground your design and to demonstrate its effectiveness, you must consider at least the following use cases. You are encouraged to add your own use cases as you see fit to further confirm your design choices.

4.1 Normal operation

In this use case, the system is running under normal load, with enough sunlight to keep the residential batteries at 75% on average. Because behaviors are statistical, even in the normal scheme of operations, on average in each day, one home in each residential microgrid will require enough energy to drop its stored power to 25%. In this case, all systems remain operational. In addition, the microgrids of the subsidized housing apartment buildings and municipal buildings are generating enough power for their microgrid demands. All administrative functionality should continue as normal.

4.2 Extreme power demand

The temperatures soar to at least 100° F for a week straight, with cooling only to 80° F at night. Especially in the public housing buildings, there are many residents with health problems and in need of both steady power (e.g. to operate medical equipment) and need for air-conditioning. The demand for power in those apartments doubles, whereas for the hospital, police, and fire, although they need more air conditioning, that amount of power is only an increase of 5%. For the individual residences, the demand rises by 20% during the daytime 12 hours and then drops to 5% for the nighttime hours. Throughout this heat wave it is sunny the whole time.

4.3 Storm outages

A Nor'easter rages up the East Coast with spotty effects. The problems arise in three phases. First a tree falls on the broadband company's lines into the central utility. As the storm continues, another tree falls on one of the main power lines that serves half the residential microgrids disconnecting them from the town power lines. Neither of these affects the cellular network, nor are any of the local power lines within the microgrids taken out. The outage lasts 12 hours.

4.4 Long-term changes

The town just went through a "learning" experience during the pandemic. With a few days' notice, everyone was home 24/7, going to school virtually, working from home, doing laundry and needed air conditioning and heating during the day. Suddenly, "peak" hours changed. The town now understands that not only might demand change slowly over time, but there may be times when it changes very quickly without warning. They want to understand the ways in which your design will or will not allow them to adapt to such changes, both the slow and faster changes.

5 Some additional questions from the town

The Municipal Light Company would like your recommendations and insights into the following questions as part of your design:

- What happens on less than full sunny days or shorter days? How will this impact the balancing and rebalancing of power within a microgrid?
- Who is impacted in this system? How does your design affect this?
- The town is concerned about loss of detail when aggregation of data is necessary. Under what circumstances will this be needed?
- Are there privacy issues in this system? (We won't talk about these until late in the term, so just think about them for now.)