Adaptive Smart Grids for Migratory Government Drones

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Abstract

The proliferation of cheaply produced surveillance micro UAVs fueled by low voltage power lines and a loose interpretation of the fourth amendment has devastated America's electric grid. This paper aims to develop a framework for creating a smart grid capable of gracefully handling unpredictable loads caused by migratory government drones. These micro UAVs, also known as *birds*, have created many issues for power plants and grid operators. With the unpredictability of the size and location of the load caused by government drones, the nation hasn't been in more need of an adaptive solution to save it's aging electrical infrastructure from crumbling due to overloaded transformers and overworked generators. The framework outlined in this paper will show a method which integrates a ground to air radar with a smart grid designed for outages caused by severe weather. A technique will also be described which includes using renewable energy systems and air rifles to cull the number of government drones before causing damage. Finally this technique will be applied to a mid sized American city and tested against varying masses of migratory drone swarms. While this technique allows the cities infrastructure to be much more resilient, the large swarm sizes still required heavy islanding of the smart grid.

Keywords: Power, Electrical Engineering, Micro-UAVs, Renewable Energy, Smart Grids

1. Introduction

With the introduction of the flappy bird drone design, the US intelligence department has rapidly increased it's airborne surveillance capability. Across the country, America's aging infrastructure is coming under attack from the increased load of supporting these government micro UAVs. Powered by electric wings and a battery, these drones tear through power with their inefficient flight. Not to mention the camera and live uplink, these drones in masse can overload a distribution transformer in under an hour.

In many southern California communities, these pesky voyeurs have caused rolling blackouts across the state. The increased load isn't even the most worrying issue caused by these flying electric leeches. Too many drones recharging on the same power line can create dangerous imbalances in the phase of the grid. Many substations have even resorted to installing extra batteries and capacitor banks to balance the loads of the three phase power systems.

1.1 Migratory Government Drone

Below in figure 1 is a typical government drone. Though the designs have changed through the years they are all relatively the same.

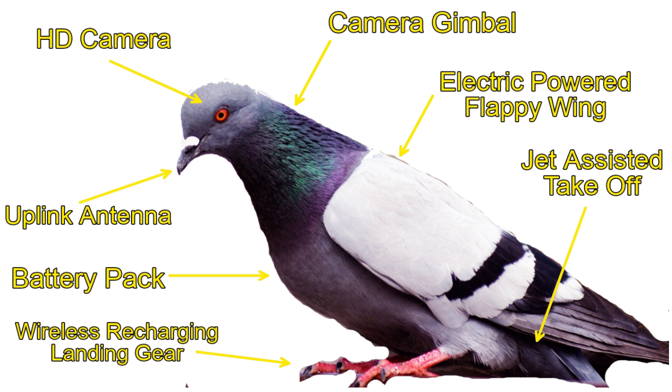

Figure 1: Typical Government Drone

Throughout the drone or *bird*'s evolution, they have consisted of a camera attached to a 360 degree gimbal and a short range uplink Antenna to the data collection center or *nest*. With the battery pack in the center above the wireless recharging landing gear, these drones can recharge on any low voltage power line. While the Electric powered flappy wing is typically enough to handle take off, many models have been outfitted with a Jet Assisted Take Off in the rear for adverse conditions which spews an energy dense white rocket fuel.

2. Architecture

In this novel smart grid system we will integrate air surveillance doppler radar systems to predict future loads. Adaptive renewable and generation methods to balance loads as well as reactive power adjustments will also be implemented. In dire circumstances, emergency power will be preserved in as many distribution nodes as possible with islanding and load shedding. Finally, renewable energy sources will be strategically placed to cull the number of operational government drones that can make it to the grid. Below, the smart grid architecture can be seen in Figure 2. There are enough shapes and lines it should be sufficient to design an entire power grid.

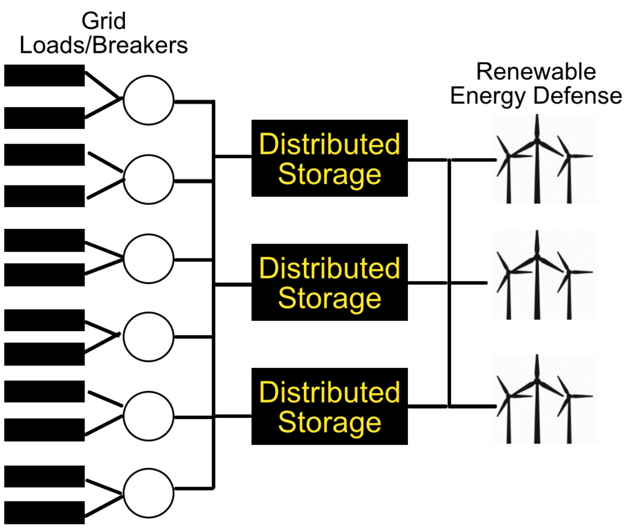

Figure 2: Smart Grid Framework

2.1 Radar

Migratory drone swarms haven't just been a nuisance to power grids. The aviation community has been struggling with these government intruders for years. Many of the problems have been documented in [1] which showed an astonishing number of accidents from drone collisions with small aircraft. Many have already begun outfitting airports with radars capable of detecting airborne objects under 50lbs such as the robin radar system.

The downside of these radar systems is that once a system has been tuned to detect something as small as a flappy bird micro UAV, it will pick up just about anything and will typically have a high false alarm rate. While it's not perfect, it is a good enough predictor of large drone swarm activity which is what is important. Missing one drone or expecting one that isn't there will not ruin the predictive power generation that much. Unfortunately, integrating these systems can become expensive. With only a 10-20km range due to the size of the drones limiting the capability of any radar, many are required to provide full coverage of a city's power grid.

2.2 Generation and Storage

Once the radars have been used to predict the additional load required by the grid, power plant output can be accordingly increased using a load estimation methodology derived in [2]. Combining the radar range equation with Ohms law, [2] shows that you can estimate the extra power required with the equations below where the delta grambles is the Lagrangian form and the Farenheit wet bulb heat index is color code enumerated. All data required for calculation should be available on a standard weather channel smart phone app.

$$Extra\ Power = Resistance_{air}\left[\int_{Range0}^{Range1}\frac{P_s\lambda^2\sigma}{P_e(4\pi)^3L_{ges}}\right]^{4/3}$$

$$Resistance_{air} = \coprod_{\zeta}^{\aleph}\iint_{\alpha}^{\tau}\sqrt[4]{\frac{\emptyset^3\nabla_{Grambles}\nexists\%{}^{\circ}\mathrm{F}_{Wet\ Bulb\ Heat\ index}}{\sqrt{\gamma}\sigma^3\vartheta\epsilon}}\,d\omega d\blacksquare$$

Any additional energy needed can be handled with any large scale energy storage system. You can store your energy using any normal method. Flywheels, pumping water uphill, compressed air in a mine, massive flow batteries. Unfortunately for our test city, we had to resort to a standard bank of car batteries connected in parallel as described in [3].

2.3 Reactivity Correction

While Capacitors and inductor banks are still used to correct a grid phase imbalance they may not be enough if a large swarm of drones is perched on one particular single phase node. Many smart grid systems will typically resort to shedding those loads or accepting terrible inefficiency and generating more power. According to a new study, there is an easier proactive approach called the *pellet gun correction* described in [4] that is shown to be extremely effective in balancing the phased load.

In the pellet gun correction scheme, monitors at each substation will detect an abnormally heavy load on any one phased node. Instead of tripping a breaker, a lineman is dispatched armed with a pellet gun. Once they have arrived at the power line loaded down with drones they can open fire on the micro UAVs until enough have vacated the distribution line. Usually two pumps on a standard pellet gun will be enough to trigger the drones predator warning system which may even alarm nearby drones to escape the danger. However, if the drones are being stubborn and two or three pumps don't trigger the predator warning system, the lineman can pump up the gun at least four to six times and take out a single drone with a direct hit.

2.4 Renewable Energy Defense Network

Some of the pesky surveillance drones can be even taken out before they arrive at your grid by strategically purchasing and installing renewable energy sources. While there are many critics of wind energy for being eye sores and not as supportive of Appalachia as coal plants, they are some of the best defenses against micro UAV swarms. According to [5], between 140,000 and 328,000 *birds* are destroyed by monopole wind turbines a year in the US due to airborne collisions. While it is difficult to assess how many drones are destroyed per windmill, due to regional differences in the data, Scott R. Loss goes on to suggest using taller windmills to increase the mortality rate.

While not as effective, Leroy J. Walson et al showed in [6] that 37,800 to 138,600 micro UAVs were destroyed by Utility Scaled Solar Energy (USSE) facilities. These USSE's also caused deaths due to airborne collisions but to a lesser extent. Most of the government drones were destroyed by Solar flux, where the reflective surface would either completely fry out the circuitry of the *bird* or incapacitate it's aerodynamic shielding feathers, wings and other critical flight systems causing it to slowly die off on the ground. The most efficient way of frying these drones is with a concentrated solar power plant which creates a deadly beam or solar light throughout the entire day frying every drone unfortunate enough to fly through. These however are more expensive to install and less easy to distribute around a city.

2.4 Islanding and Load Shedding

Unfortunately, the defensive systems may not be enough to take out enough spy drones. Whether it's an inability to cull drones from the air, not enough pellet gun armed linemen or just not enough extra generation and storage, some loads may have to be shed. In the last stage of the smart grid mitigation plan, emergency sectors are isolated out into islands if deemed important enough or the bribe check clears. Meanwhile less important distribution nodes are cut off. As shown in [7] it is possible to target heavily swarmed neighborhoods with load shedding to take out some of the drones that have a low enough charge.

3. Testing Methodology

In order to test the limits of the new *bird* drone resistant smart grid we scheduled a series of tests in Bakersfield CA with increasing sizes of drone swarms. Each period of swarming was separated by two days so that necessary repairs might be made and data could be sufficiently collected. We had to stock up on a lot of transformers.

Swarm size was roughly controlled as an independent variable by posting carefully chosen amounts of NSA *'no no'* words to attract federal attention. After a small amount of research we created our swarm attractive social media activity by using a guide outlined in [8]. Once the swarms were on their way we monitored grid activity closely at a nearby natural gas power plant and had pellet gun armed linemen at the ready. The test was then repeated with no smart grid control techniques as a control group. When complaints came in from the rolling blackouts, we blamed it on a recent heat wave.

Before and after the twitter trap was placed to attract the drones, a count of dead drones around a random sampling of neighborhoods and renewable energy sources was done to determine how many drones would be destroyed during the test. Of course we could not disassemble and reassemble our renewable energy sources so the only measurable difference between the first and second test would be from the pellet guns.

4. Results

The size of the swarm drones drawn from [8]'s listed NSA *'no no'* words appeared to do the trick. At the lower three levels we saw a steady regular increase. When we began using the *'no no'* words that were highlighted in red for the swarm levels 4 and 5, we began seeing an extinction level event as Bakersfield became swarmed with every make and model of government drone they had in stock. We even got mentioned in the Audubon society as an emerging location for *bird* watching [9]. Our radar feed became so jammed up with tracks that the private contractor that came with the radar system thought it was a bug in the software. We almost didn't test level 5 due to safety concerns for the people of Bakersfield but we continued due to our adventurous spirit and a love of scientific inquiry.

The metrics below in table 1 show drones destroyed during each test and the percentage of households who reported a power outage from the resulting rolling blackouts.

The defensive mechanism performed as expected. While the renewable sources and local cats might kill 50-100 on a normal day the death rate increased proportionally with the amounts of drones from each increasing swarm level. The addition of the pellet guns did help but could only increase the kill count by 40-120 due to the limited amount of linemen time and trouble spot detections.

Table 1: Drone Swarm Grid Resiliency and Defense

\Swarm Level	1	2	3	4	5
Drones Destroyed control	153	284	430	1040	3380
Drones Destroyed w/ mitigation	210	323	482	1114	3490
Power Outages Experienced control	1%	2%	6%	23%	38%
Power Outages Experienced w/ mitigation	0.4%	1.2%	2.6%	7%	20%

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Despite the lower kill count, the surgical strike on the overloaded power lines and the additional techniques such as additional generation and storage orchestrated by the radar feed and more targeted load shedding allowed for a far more resilient grid against the government drone swarm. The techniques were able to keep outages down to a minimum in the first three levels of drone swarms. The smart grid only began to struggle to maintain resiliency through the world ending amount of micro uavs we received in levels 4 and 5.

5. Conclusion

Despite the trouble in levels 4 and 5, it was much more resilient in every condition compared to the unprotected grid. Under extremely adverse conditions, the smart grid techniques could use some improvement but the increase in resiliency is definitive in between an unprotected dumb grid and a protected, adaptive, state of the art smart grid. With this system as the first iteration of smart grid defenses against intrusive micro uavs, it won't be long before we start seeing normal resiliency numbers and these drones are no longer a threat to the power grid.

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