Preface

To explain our motivation for writing this booklet, we give you Dan's story:

> It started innocently enough. I ran a Web server, and it was in my third floor office. The office got hot, the machine got hot, so one day I decided to install a new chassis cooling fan, which meant I needed to reboot my server. The whole process took about 30 minutes. At the end of it, the machine would not reboot. It turned out that the disk had been running far in excess of the rated temperatures and the drive electronics had developed problems. Annoyingly, they worked fine for the months of overtemperature conditions (with brief reboots for operating systems upgrades), but when the machine was shut down for 30 minutes, the electronics cooled off more, shrank, and . . . cracked. No disk meant no Web server—and no income!
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> Everyone asked, "Didn't you have backups?" Well, of course I did—daily, weekly, and monthly! Except a few months before, I had changed something "unimportant" in my backup scripts[1] and never really tested them again (I just assumed that they'd work). And it turned out that I had a collection of nearly empty backup tapes. Fortunately, the disk platters were undamaged, and for a mere $6,000 to the Drive Savers disk recovery service I was able to recover all the data. I was back up and running in a little over week. So much for five sigma reliability.
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> So I bought a window air conditioner for the summer months, and whenever it got hot, I'd turn it on. Since I was down $12,000 in lost income and disk recovery costs, I was motivated. But I also traveled a lot for work, and I didn't want to leave the A/C on for weeks at a time if I didn't need to.
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> I needed a way to remotely monitor the temperature of my office and, more importantly, the temperature of my servers. Thus was the innocent beginning for what has become a minor obsession.
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> I found an inexpensive $25 kit that would allow me (through my computer's serial line) to measure temperature in up to four locations. No special software was required—you could just connect to the serial line and look at the current temperatures, so I could see the server temperature anytime I was connected to the network. But as long as I was looking at temperatures, why not log a history of data? So I wrote logging software that would record the temperatures, and then I added extra cabling and sensors. Now I was keeping track not only of the server temperature but also of the ambient room temperature, the outside temperature, and the temperature in the basement.

1. I had broken the order and types of the backups. Instead of writing three disks to the non-rewinding tape and writing the last one to the rewinding tape device, I wrote two disks to tape and then rewound, writing the third and fourth disk to the rewinding tape, overwriting the first three backups with the last backup. And that disk was last because it wasn't very important!

As long as I was at it, I wrote graphing software that would allow me to look at the day's temperature, the week's, or the month's. Then I added moving graphs, so that I could look at specific days in the past. I could tell you when the furnace came on and how long it ran. I could show you how the temperature dropped when it rained on a summer day. I could even show you the blips in the basement temperature that corresponded to the cycling of the dehumidifier. Most importantly, I could ask my housemate to turn on the A/C if the office got too hot. I was hooked.

I built a second system out of an old Novell "pizza box" system (the computer, with disk, was about one foot square and only three inches high) and installed that at a friend's summer camp at Lake George, NY. I built submersible sensors into the test tubes I got when I donated blood, and I sealed them with marine goop. The sensors measured water temperature at the surface and about 15 feet deep, as well as the inside and outside temperatures.

The problem was, my little monitoring kit would only support four temperature sensors and my software would only support a single data collection unit. So I was maxed out both at my house and at the camp. But where there is a will, there is a way. I researched other systems and discovered that there was a wide variety of data collection systems, and a whole family of sensors (including temperature, humidity, wind, rain, barometric pressure, light, and switch sensors).

I wrote one manufacturer that I had this neat monitoring package and would like to expand it. If they'd send me a sample of their hardware, I'd support it and let them have my software. To my amazement, they said yes.

But when they actually *sent* me $200 worth of hardware, I got to work. Because the new device was Ethernet-based (and not serial), I had to completely revise my software design. While I was at it, I revamped the graphing software to be more usable and added support for additional types of sensors. I started looking at more data—and the more you look at, the more you learn, and the more you realize you need to look at even more data.

I wrote to another company. They sent me another $200 sample system. I added support for wetness sensors, rain gauges, anemometers, and wind direction. I revamped the graphing software to handle radial graphs in addition to linear ones. I got braver and wrote to a third and fourth company, and they sent me $300 and $450 samples. I added support for switch sensors, barometric pressure sensors. This was getting scary! People started writing to *me*, asking if I'd add support for their hardware.

I got listed on HackADay.[2] I learned about more data collectors, and now I support a large number of them.

But addictions are hard to satisfy. I now look at my hot water usage with temperature sensors on the pipes. I acquired a power monitoring system (another donation in exchange for software support) and can tell you how much power each circuit in my house is drawing. I have planned a click sensor on my gas meter to measure gas con-

2. http://www.hackaday.com/.

sumption. I have door sensors on the garage and look at temperature and humidity throughout my house.

"Why?" you may ask. Well, other than a hobby gone wild, other than "because I can," there is a very good reason: money!

I bought my turn-of-the-century house in 1980. Since then, I have added insulation everywhere I could. It cost a little and has saved a lot. My furnace was 60 years old, so when I replaced it, I installed a 98.5% efficient furnace. It cost more, but paid for itself in five years. As a luxury, I replaced the window A/C with whole-house air, but I only use that when it is beastly hot. But now that I am monitoring things, I can save even more money.

Running whole-house A/C is expensive, but I discovered that by raising the temperature on the thermostat by one degree, I was able to reduce A/C use by 75% (I can show you the graphs where I compare plenum temperatures to the outside air temperature and humidity). The basement humidifier is essential, but it just has a dial on the front labeled "low" to "high." By monitoring the basement humidity, I determined where I could reasonably set the dial to prevent mold and mildew, yet keep the operating costs down. I've moved my office from the third to the second floor, but the third floor sensors tell me when I have forgotten to close a window on a cold day. And the electrical and gas monitoring help me optimize my energy consumption while still staying comfortable.

But I'm not done yet—a true compulsive never is! I'm going to combine the temperature sensors with dampers in my ductwork, so I can better regulate the temperature in the whole house (right now I manually tweak things, but a scientific, computerized approach will be much better). Is the garden getting dry? They make soil sensors! How much lightning was there during that storm last night? They make lightning sensors! Hey, Alvin and Parker (my cats), are you hungry or thirsty? Why not monitor the water and food levels in the cats' bowls?

That is where this booklet comes from: our personal "obsession" with seeing how things work—because if you watch your systems, you can watch the effect your changes make, and then you can make things work better. And if you watch what effect external changes have on your operating environment, you can prevent problems. We do it "because we can," of course, but more because it makes a difference in terms of efficiency, cost savings, and disaster prevention.

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