

## THE MATRIX OF OUR TROUBLES

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Toronto Globe and Mail  
August 16, 2003

Tens of thousands of people were walking towards us.

On Thursday evening at 6 pm, we were standing on Yonge Street, Toronto's central artery, looking south towards the city center. As far as we could see, the sidewalks were filled with people walking north. The power had failed, the subway trains had shuddered to a halt, and people were walking out of the city to try to get home.

We talked to a few of them. Some were frustrated and annoyed, but none seemed angry. Some seemed to find the whole thing a novelty—an intriguing interruption of the routine of a hot summer afternoon. Others pitched in to help by directing traffic or by guiding pedestrians across chaotic streets.

But everyone seemed puzzled and at least a bit disconcerted. What had happened? Was it terrorism? How long will it last? And how am I going to get home?

The blackout on Thursday was a sharp reminder of how electricity has insinuated its way into every corner of our lives. When the power goes down, air conditioners and elevators won't work—but that's obvious. On Thursday, we were reminded that traffic signals, portable phones, automatic tellers, debit card machines, electronic hotel-room doors, electric garage doors, and almost all our clocks won't work either. And the most disconcerting disruption was the loss of the constant flow of information we've become hooked on. Television, email, and—worst of all—the Web all failed. We couldn't tell what was happening. It was like darkness fell in mid-afternoon. People phoned BC or California to find out what was going on in the East—our acquaintances there at least had TV. Other people clustered around cars that boomed out all-news radio.

After more than twenty-four hours of power failure and extensive, rotating blackouts from Ontario and Michigan to New Jersey, investigators still don't know the cause. Some speculate that the problem originated in northern Ohio and then cascaded across the electrical grid. But the origin of the problem isn't what's most disturbing. What is truly worrisome is that such

massive blackouts were anticipated over twenty years ago.

After the 1965 blackout, which left 30 million powerless from Ontario to New Jersey, researchers acknowledged the risk of extensive electrical grid failures. In 1982, two of America's most thoughtful energy experts, Amory and Hunter Lovins, warned that the structure of the North American electrical network made the system fundamentally vulnerable. The fragility or the "brittleness" of the grid—a combination of its complexity, interconnectedness, and uncertainty—made it increasingly vulnerable to "sudden, massive failures with catastrophic consequences".

The Lovins' extensive research—reviewed by military, government, academic and industrial experts—and their call for better ways of producing and using energy, remain powerfully relevant today. When we recently asked Amory Lovins if things had improved in the last two decades, he said, "I'm surprised the lights are still on".

The risk of massive network collapse is not just a problem for power generation. Our agricultural, financial, and computer networks, to name just three, are also vulnerable. This vulnerability has many sources, but these networks' structure and their tight coupling seem to be particularly critical. These aren't problems with technology in general—rather, they're problems with the particular kinds of technologies we've chosen and how we've decided to use them.

Researchers studying network structure, for example, have shown that many of our common networks, such as electrical grids, are "scale-free." This type of network contains "hubs," which are nodes with a disproportionately high number of connections to other nodes in the network. In agricultural networks, for instance, big food processing factories are hubs; in North American financial networks, Wall Street and Bay Street are hubs; and so is [www.google.com](http://www.google.com) on the Web. Hubs create network stability and economic efficiency through organized distribution of energy, commodities, or information.

But what yesterday's power failure illustrated so aptly was the critical vulnerability of scale-free networks: failures of their hubs and key links can cascade out of control. Two years ago we saw the tragic evidence of what happens when a financial hub is intentionally,

and successfully, targeted. A hub's connections—whether money, electrical wires, or fibre-optic cable—contain an inherent power to propagate sudden change. And as our society becomes even more interconnected it becomes increasingly important for us to understand scale-free networks and how to respond to their behavior.

Our modern networks can also be tightly coupled, which means that the links among the nodes are short, making it more likely that problems with one node will spread to others. When drivers tailgate at high speed on a freeway, they create a tightly coupled system; a mistake by one driver can cause a chain-reaction of cars piling into each other.

We can take steps to reduce these vulnerabilities, by loosening the couplings in our economic and technological networks, by building into these networks buffering capacity of various kinds and, perhaps most importantly, by distributing the production of key goods and services. In the energy sector, this might mean greater use of decentralized, local energy production and alternative energy sources (like small-scale solar power) that make individual users more independent of the electricity grid. Clearly this policy would reduce economic efficiency, but the extra security of more stable and resilient production networks could far outweigh this cost.

One could draw a parallel between the sight of thousands walking north on Yonge Street and the mass exodus of people on foot from lower Manhattan two years ago. But yesterday's electrical failure did not claim thousands of lives, nor will it trigger a cascade of events leading to war. Nevertheless, what we saw in Toronto was poignant for what it represented: a people too interlocked with their technical choices, too resolute on efficiency gains, and too dependent on progress. Last Thursday's blackout should be a powerful catalyst for change.

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