A New Paradigm for Resilient Internet Infrastructure: Resilience in the Crosshairs of Climate Change

by David Theodore

Welcome to the Digital Age, where our livelihoods, healthcare and national security are tethered to the internet. We have apps to find parking, land a job and give ourselves an EKG, yet in extreme weather events, it's gone. All of it—internet, phones, texting—even 911. In storm ravaged communities, folks needing help are reduced to Magic Markers and cardboard.

The problem is magnified for business and government where the growing dependence on data and the rise of extreme weather pose dire consequences for public health, regional economies, even national security. Total internet outages, once statistically insignificant, now last days and weeks. We've seen it in Miami, New York and Houston, and less dramatically, in more and longer internet outages across every region. Power outages alone, have tripled in the past decade and mostly on account of weather.

The cost of business disruption is colossal, and the threat grows exponentially with the rise of cloud computing. Today, our most mission critical data lays in the tracks of climate change. If your ear is close enough you can hear the whistle blowing.

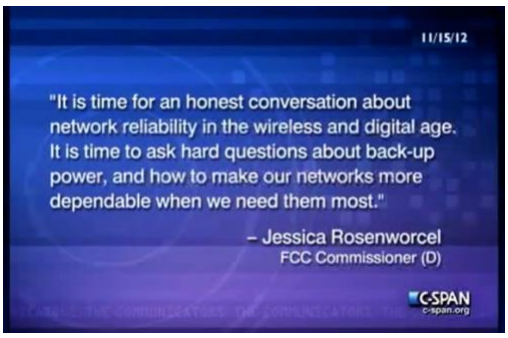
The threat is *here*, and it's not just sea level rise.

Latest research on climate and the internet focuses on sea level rise, projected across decades. Yet, a more urgent threat is already here: extreme weather. Record breaking floods, precipitation and heat are the new norm, and all indications are that climate is in a worsening trend. If we don't adapt the internet to this reality, we'll be sunk long before sea levels get us.

The question is what to do, because left unchecked, losses will devastate every sector from health care to finance, hospitality, energy, water, transportation, even national security[4].

FCC Commissioner, Jessica Rosenworcel, speaks to a persistent problem:

Then: 2012



Now: 2020

What's the actual problem?

The internet is a mystery to us. We don't know where it is or how we get to it. It's hard to address vulnerabilities we can't visualize, so let's talk about how we access the internet.

The internet comes from internet data centers, thousands of them in the U.S. and worldwide. They're home to carriers, like Verizon and AT&T, as well as cloud providers like Amazon, Microsoft, Google and myriad others.

Internet data centers are hardened for a multitude of threats, for which they're certified and rated along a tier structure. Except for those built in floodplains or hazard zones, most can ride out even the worst storms. Yet a hardened data center isn't much help if you can't reach it, and so now we come to the crux of the problem.

While it seems that we live in a wireless world, our journey to the internet is entirely dependent on physical cable (fiber optics). Smart phones and Wi-Fi operate only on the periphery of the internet, transmitting short distances before their data is offloaded to fiber. That could happen as close as your router, at your street corner or the nearest cell tower, and the reason for it, is that only fiber can support the volume of traffic in and out of data centers.

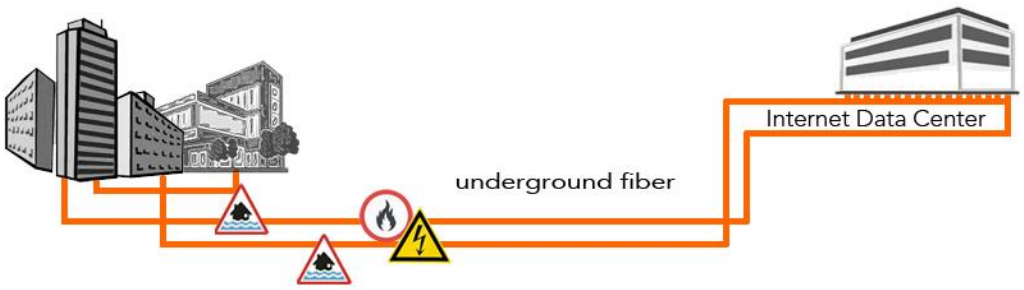
We need fiber for capacity, but it fails in extreme weather.

Fiber is strung on telephone poles ("40-foot high wooden sticks") and snakes through endless miles of underground, the whole of which is vulnerable to backhoes, vandalism and random casualties. Carriers know this, and so they build redundancies with diverse routes, manholes and building entrances, but for widescale events, like flooding, fiber is a single point of failure.

Related: Blame Your Lousy Internet on Poles by Prof. Susan Crawford in Wired.

According to Paul Barford, professor of computer science at UW-Madison: "Much of the system was put into place in the '90s without much consideration of climate change. On top of that, much of the internet's physical infrastructure is aging. A lot of it was designed to last only a few decades and is now nearing the end of its lifespan."

Internet access in 2020



Power outages are no less concerning.

It's not only fiber that's vulnerable to climate, but also the electrical grid it relies on. According to Bloom Energy, there are more than 5.5 million miles of transmission lines in the U.S.—many atop 100-year old towers—and the primary causes of blackouts are high winds and storms.

Want a shocking statistic? Power outages cost $11 TRILLION in damages between 2005 and 2020. Alone it's a colossal stat, but it's even more daunting when you consider that the preceding 25-years saw *only* $600 billion in damages.

Related: "Roughly 4,000 miles of fiber-optic cables in US coastal cities could go underwater."

Meanwhile, in a crisis, carriers are more inundated than we are.

Internet resilience seems like a thing for big carriers with billions in infrastructure, so we don't think about it. And when we lose internet, we respond the same as to a power failure. We wait.

Yet carriers are scarcely equipped for the onslaught of climate disruption and needing them to save us is the worst place to be. In disasters they're inundated: dispatching contractors, bailing out cable vaults, going tree to tree, pole to pole, into manholes and deploying emergency rigs quaintly referred to as "COWs" and "COLTS" (cell on wheels and cell on light trucks).

It doesn't matter who you are or how vital your data, you're in the queue. As one responder put it after Hurricane Harvey, "We have the capability to bring back the network as quickly and safely as possible." Translation: You're out of luck, and it could be hours, days or weeks.

Meanwhile, states like California hold regular hearings with utility and telecom giants, but solutions are elusive. The fact is, monolithic providers have impossibly large footprints for fighting climate and despite the public ire, it's impractical to place all the burden on them.

Internet resilience takes a different approach.

Talk about internet resilience is always about protecting fiber. It recalls Maslow's Law: "If all you have is a hammer, everything looks like a nail."

Forget fiber.

For that matter, forget satellite and cellular as well. Satellite has its own weather challenges. As for cellular, towers are prone to wind damage, and most have only 8-hours of power backup. Many cell sites have none at all, such as off church steeples and city buildings.

> "A total internet failure is one thing that could stop any business in its tracks, yet few are preparing for this possibility, consultancy KPMG has warned."

The Solution

Let's say you're desperate to catch a flight. The airport is open and your flight is on time, but a storm scattered debris everywhere and all roads between you and the airport are impassible. You could throw up your hands, or if you had a helicopter with fuel, you could make the airport with time to spare.

Hence our solution for internet resilience. An all-aerial service for vital data, independent of public power and infrastructure, which overcomes hurricanes, flooding, heatwaves, blizzards, sea level rise; even terrorism.

Here's how it works.

The core of resilient internet is "millimeter wave" wireless[5]. Carriers have used it for years. We use it to connect client networks, rooftop to rooftop, to a secure internet data center out of harm's way. By that, we generally mean that it's not in hazard zone or a flood plain, as many are[6].

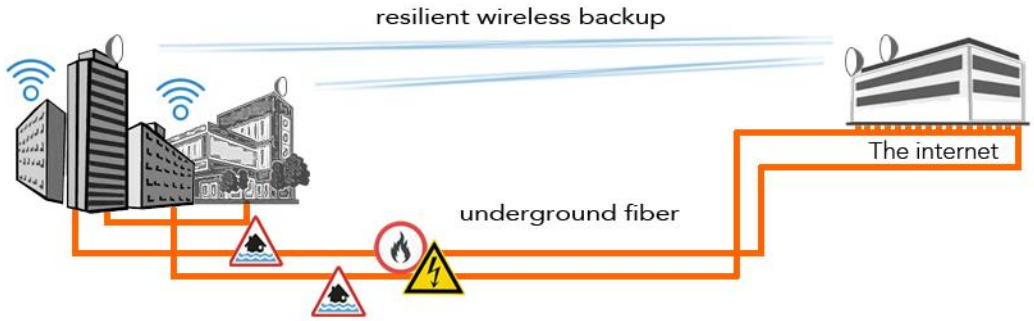
Millimeter wave is the closest wireless gets to fiber performance. It supports massive bandwidth—tens of gigabits per second—is encrypted and HIPAA approved. The downside is that it's limited to about 2-miles (typical), so for longer distances we also use microwave radio.

In the 1990s, microwave expedited internet access ahead of fiber deployment.

I adapted microwave for the early internet (1987), creating the first wireless broadband solution (a.k.a. fixed wireless), which met the full network data rate of 10 megabits per second. Fiber emerged in the mid-90's, and where availability could be months or years, microwave helped advance network deployment. Ultimately, fiber won the bandwidth war and subsequently, microwave served only fringe applications at data centers, if at all.

Today, climate resilience is a different application, well suited for wireless, because it's less about bandwidth and more about a critical lifeline.

In new Best Practices, millimeter wave acts as data lifeboats in extreme weather.



We leverage microwave and millimeter wave for their respective strengths. For instance, microwave wins for distance, but millimeter wave is best for urban environments, where it delivers the highest bandwidth, while also scaling the easiest, because it has the smallest RF (signal) footprint.

Related: "Boston is ranked eighth worldwide for expected economic losses due to coastal flooding."

So long as your building stands, you're getting internet.

As you might expect, stability of the wireless installation is paramount. For that matter, antennas are just 1-2 feet in diameter and with transmitters, weigh only about 20-pounds. The system is bolted to rooftops, through structural concrete, brick or angle iron. Attachment hardware—heavy-duty galvanized steel—outweighs the dishes they support. So long as the roof is standing, the client's getting internet.

Rooftops are best, but radio towers may be needed beyond city limits. Each such selection, however, must be scrupulously evaluated, and/or upgraded for accessibility, generator capacity and wind loading. Resilience could therefore be as solid as from rooftops, however I would rate tower installations as less than ideal.

Service in "the i of the storm."

What's the service like? You're looking at high-speed internet—building-wide—with options for outdoor Wi-Fi, for instance to cover a campus or plaza. Powering phones is the easy part.

Some will point out that, depending on threshold factors like distance, wireless performance may diminish in the heaviest storms. So then, while it's conceivable that a 5-gigabit connection could be throttled down by 50% in the eye of the storm, the impact is fleeting. Once the worst passes, service returns automatically to peak performance, and meanwhile terrestrial cable could be unavailable for days.

Resilient internet meets energy resilience.

Of course, resilient internet needs independent power, and not just for the wireless link, but for all else that wants access to it: in-building Wi-Fi, PCs, network and handheld devices, sensors, etc. For some, that will mean upgrading generator capacity.

Fortunately, we're dovetailing a booming industry of battery technology, generators and microgrids. Advances there can power internet access for days and weeks, depending on fuel service contracts and "islanding" capabilities for microgrids.

WHAT'S A MICROGRID? "A microgrid is a decentralized power system that can disconnect from the main grid and operate independently of it, reducing the frequency and severity of power outages and strengthening energy resilience for businesses and residents." Definition from Chris Ball.

As microgrids generate power apart from the grid, we generate internet apart from terrestrial infrastructure. The combination of sustainable power with uninterrupted internet is synergy at its best. Microgrids are the future and resilient internet will fuel their adoption like nothing else.

Related: Power Outages, Extreme Weather, & Microgrids Explained, by Chris Ball

Resilient internet keeps the "smart" in smart grids (and smart cities).

You've probably heard of "smart grids" and "smart cities," yet what makes them smart is data they pull from the internet. Generally speaking, no internet means no metrics, stats or data-driven anything, and that poses a bleak scenario.

According to Jonathan Strickland, "Smart grids could theoretically respond to customer needs more efficiently," … "But if the Internet were to collapse, a smart grid would be crippled. Massive power outages could become a problem across any country using such a system."

Likewise, without internet, smart cities lose data-driven decision making for traffic, public safety, citizen engagement and other services. Therefore, internet resilience must be a key consideration for smart city infrastructure.

Resilient internet enhances cyber security.

Intuitively, it would seem that data traveling over the air would be more vulnerable to interception than data contained in a wire, but not all wireless is the same. For instance, unlike omnidirectional antennas in cell phones, millimeter wave transmits in a tight, point-to-point beam, about 1-degree wide and high overhead. Excess signal that might be intercepted is so wispy it's absorbed by oxygen. To hack a transmission of this nature is like shooting a bullet with a bullet, and then encryption makes the impossible that much harder.

Resilience that scales like Legos.

As a rule, the greatest wireless bandwidth comes from point-to-point radios ("broadband wireless"), and those need line of sight between antennas. Some see that as a limitation, however creative path engineering goes a long way.

For instance, before fiber optics, AT&T's "Long Lines" microwave network spanned coast to coast with hundreds of interconnected radios. In my own experience, I once secured a continuous 700-mile wireless route between the Chicago MERC and the NYSE for high-frequency trading. It was one of the fastest data connections on earth, as described in the book, "Flash Boys."

What's key to wireless expansion is that every link in the chain is solid, installed to best practices and engineered for worst case weather. Reliability is then maximized by electronic redundancies and diverse path routing.

And for the best part, resilient internet is instant ROI.

Resilient internet isn't idle bandwidth, nor must it increase anyone's telecom budget. It pays for itself with regular use, just like fiber. It's billed monthly and if need be, the cost may be offset by scaling back some on fiber leases. Our proposition is simply about risk balancing, where losing the internet—and all that goes with it—is not an option.

Final thoughts.

Climate readiness is a growing mandate for business and policy leaders, impacting major investments and bond ratings, yet hardly anyone seems concerned about data vulnerability.

I attended dozens of climate forums and never once heard a speaker on the topic. I've read scores of vulnerability assessments for critical infrastructure and hardly find the word "internet." It doesn't make a single appearance in a 56-page, blue-ribbon Bloomberg report, "The Economic Risks of Climate Change in the U.S.," nor in countless similar publications.

The lack of awareness is stunning when you consider that data is the world's most valuable resource. Yet on the upside, the internet isn't so complicated, and neither is the vulnerability problem. The best practices I've detailed, work. We're not inventing new technology, but repurposing it according to new specifications, certified for extreme weather.

Climate resilient internet returns to a more symbiotic relationship between wireless and fiber, now with wireless acting as lifeboats for the internet. In this new paradigm, the synergy of resilient power and resilient internet represents the greatest climate adaptation opportunity on earth.

ABOUT THE AUTHOR

David Theodore pioneered wireless broadband for the emerging internet in 1987. Today, it goes by the clunky term—"fixed wireless access"—the basis for home and enterprise internet delivered by wireless ISPs and major carriers, worldwide.

David's startup, Microwave Bypass, innovated tele-radiology and distance learning, built Boston's early regional internet, connected world leaders in education, healthcare and technology, collaborated with Cisco and licensed technologies to Motorola. In its day, LAN Times named it one of the 1990's Top LAN Contenders and the Aberdeen Group put its market share at 75%.

Subsequently, David designed one of the first high frequency trading networks, connecting the CME and NYSE, and thereafter, researched the emerging WISP and 5G industries, advising providers, vendors and investors.

Today, as a climate activist and co-founder of Climate Resilient Internet, David is advancing new best practices to adapt the internet to climate change. Find him on LinkedIn and Twitter.

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