Keeping the Internet On in the Midst of Climate Change

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[DISCLAIMER: I am employed by the Internet Society but am communicating here in a personal capacity.]

How do we adapt the Internet’s infrastructure to keep it on in the midst of climate change?

Cable Landing Stations

- Sea level rise
- Larger storms
- Greater erosion

Lights Out: Climate Change Risk to Internet Infrastructure

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ABSTRACT

In this paper we consider the risks to Internet infrastructure in the US due to sea level rise. Our study is based on sea level incursion projections from the National Oceanic and Atmospheric Administration (NOAA) [12] and Internet infrastructure deployment data from Internet Atlas [24]. We align the data formats and assess risks in terms of the amount and type of infrastructure that will be under water in different time intervals over the next 100 years. We find that 4,067 miles of fiber conduit will be under water and 1,101 nodes (*e.g.*, points of presence and colocation centers) will be surrounded by water in the next 15 years. We further quantify the risks of sea level rise by defining a metric that considers the combination of geographic scope and Internet infrastructure density. We use this metric to examine different regions and find that the New York, Miami, and Seattle metropolitan areas are at highest risk. We also quantify the risks to individual service provider infrastructures and find that CenturyLink, Inteliquent, and AT&T are at highest risk. While it is difficult to project the impact of countermeasures such as sea walls, our results suggest the urgency of developing mitigation strategies and alternative infrastructure deployments.

CCS CONCEPTS

• **Networks** → *Physical links*; *Network measurement*;

KEYWORDS

Physical Internet infrastructure, climate change, sea level rise, critical infrastructure, risks

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1 INTRODUCTION

Climate change is perhaps the most significant problem facing humanity. The dramatic rise in greenhouse gas concentrations in the atmosphere over the past 100 years is causing changes in weather patterns including increased likelihood of severe storms as well as rapid rise in sea levels due to melting polar ice caps and thermal expansion of seawater [27]. These phenomena have important implications for the planet and the effects are already being felt in many areas [36].

To understand and prepare for the impacts of climate change, a number of models have been developed to project average sea level rise. The models are based on a variety of empirical parameters including sea level rise over the past 100 years and the geographic features of coastal areas. The models predict significant incursions on coastal areas that imply displacement of large human populations. In response, some of the threatened areas are already preparing mitigation plans [37], but holding back the oceans is a formidable undertaking to say the least.

With significant sea level rise predicted, it is important to assess the threat to communication infrastructure. An indication of the potential impacts are the storm surges of major hurricanes such as Katrina and Sandy that devastated communication systems [21, 30]. While the standard buried fiber conduits are designed to be water and weather *resistant*, most of the deployed conduits are not designed to be under water permanently.

In this paper, we make a preliminary analysis of the risks of climate change on Internet infrastructure. The goal of our work is to understand risks and potential impacts over timescales of decades, which is consistent with other work on climate change [11]. Our specific interest in this paper is assessing how the rise in sea levels threatens buried fiber conduits and termination points (*e.g.*, colocation facilities, point of presences (POPs), etc.) in coastal areas in the US. Our analysis is *conservative* since it does not consider the threat of severe storms that would cause temporary sea level incursions beyond the predicted average. Our analysis also does not consider any efforts to harden or fortify communication infrastructure since we argue that this will only be feasible in relatively small geographic areas.

Our study is based on analysis of two data sets. The first is the communication fiber conduit and termination point data in Internet Atlas [24]. The Atlas repository includes

Destruction of Infrastructure

- Jamaica – Hurricane Beryl
- Wildfires
- Flooding
- (many other disasters)

Hurricane Beryl impacts Internet connectivity in Jamaica, Mexico, and Houston

Hurricane Beryl impacts Internet connectivity in Jamaica, Mexico, and Houston

July 09, 2024 By: Sebastian Moss Comment

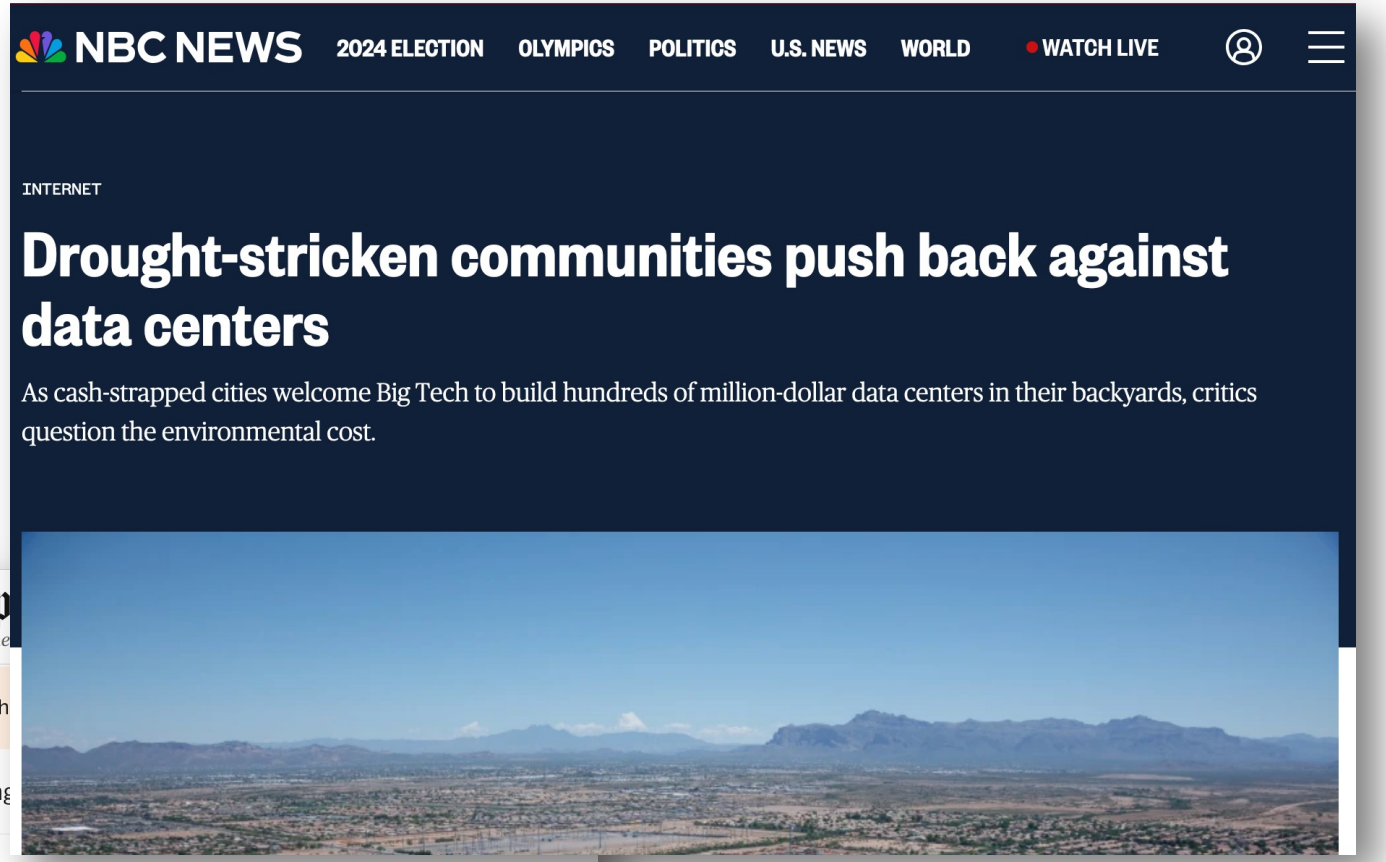
Extreme Heat

- Sunday, July 21, was warmest day ever… until Monday, July 22
- Cooling
  - People – residential and businesses
  - Data centers / infrastructure
- Severe electrical demands

"The Earth has just experienced its warmest day in recent history, according to the Copernicus Climate Change Service (C3S) data. On 22 July 2024*, the daily global average temperature reached a new record high in the ERA5 dataset**, at 17.15°C. This exceeds the previous records of 17.09°C, set just one day before on 21 July 2024, and 17.08°C, set a year earlier on 6 July 2023."

Drought / water

- Cooling of data centers



Resilience

Can we adapt the Internet to be more climate-resilient?

See also: https://pulse.internetsociety.org/resilience

Thoughts

- So much comes down to energy / electricity and deployment
- Many efforts underway to improve Internet resilience
  - Community-centered connectivity / community networks
  - Internet exchange points (IXPs) can build local resilience
  - Space-based Internet (particularly LEOs) has a role (but also questions: http://www.internetsociety.org/leos/)
  - Caching / CDNs
  - ”Local-first” applications (operate locally, sync to others)
  - Energy efficiency (ex GREEN BoF)
- Also need to think of *human* resilience – local technical communities that can operate / maintain / repair infrastructure

Discussion Questions

- Given that so much is deployment / operations focused, or energy focused, **is there a role for IETF / IRTF / IAB**?

- Protocol work? Resilience / failover?
- New research area?
- Liaison with other groups? (ex ITU-T SG5, Q12)