Pingin’ in the Rain

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Outline

• Introduction
• ThunderPing
• Analysis of Data
• Results
• Conclusion and Future Work

Pingin’ in the Rain
Introduction

• Weather affects network performance
  – Connectivity
  – Loss rate
  – Latency

• What are some large scale causes of network failures?
Introduction

• Weather affects network performance
  – Connectivity
  – Loss rate
  – Latency

• What are some large scale causes of network failures?
  – Power failure
  – Lightning strikes
  – Cable cuts
  – Fires
Introduction

• Small scale failures
  – Affect last-mile residential Internet
  – Thunderstorms
  – Rainstorms
  – No redundancy
  – Not studied as much
Introduction

• Collection of information
  – Type of link
  – Geography
  – ISP
  – Type of weather

• Limitations
  – Does not isolate type of failure
  – Does not distinguish user actions
  – Imprecise reports of weather and host location
ThunderPing

- ThunderPing - “measures the connectivity of residential Internet hosts before, during, and after forecast periods of severe weather”

- How it Works
  - Listens for severe weather alerts
  - Finds IP addresses
  - Pings addresses
ThunderPing

- National Weather Service (NWS)
- XML feed alerts
  - Considers watches and warnings
- FIPS code
  - Numeric code for each county
ThunderPing

- Ref: [SS2011]

Figure 1: Example XML entry for a weather alert for two counties in Wisconsin. Some XML entries omitted for brevity.
ThunderPing

- Choose 3 IP addresses
  - Match to US residential ISP
  - IPs in same block are the same ISP
- Link IP addresses to FIPS codes
  - Match latitude and longitude
  - MaxMind GeoIP
  - US Census Bureau’s county border data
- Ping IP addresses
  - 100 from each ISP and link type
Analysis of Data

- 10 PlanetLab distributed hosts (vantage points)
  - Ping every 11 minutes
  - Start 6 hours before
  - Ends 6 hours after

- Weather effects may be hidden by
  - Congestion
  - Outages
  - Network events
Analysis of Data

- Ping Response
  - Agreement of vantage points
  - Pings can be lost
  - DHCP lease can run out
- Some vantage points fail
- Ref: [SS2011]

Figure 2: Hosts may not respond to the first ping. The lower graph shows the conditional probability that a host first replies to ping $x$, given that it does not reply to any of the pings preceding $x$. The upper graph shows the fraction of hosts (in log scale) that first reply to ping $x$. The gray lines indicate the ping interval when all ten vantage points are operational.
Analysis of Data

• Determine actual weather
  – 900 weather stations at airports
  – Provide hourly weather measurements
    • Wind
    • Pressure
    • Rainfall
    • Light emitting diode weather indicator (LEDWI)
Analysis of Data

• Interpret ping data
  – What are the 3 states?
Analysis of Data

• Interpret ping data
  – What are the 3 states?
    • UP
    • DOWN
    • HOSED
  – Find transitions
  – Correlate transitions with weather conditions
  – Ref: [SS2011]

Figure 3: During heavy thunderstorms reported at KTUP airport in Tupelo, Mississippi at 3:16AM on April 27th, 2011, ten vantage points (y-axis) saw Comcast cable customer 75.66.230.135 go down for 7.6 hours. A ● represents a ping with a response, a × represents a ping that timed out. At this time, eight other Comcast customers near this airport failed.
Analysis of Data

Figure 4: We also observed hosts enter a state of partial responsiveness. In this state, the host intermittently responds to pings. CenturyLink DSL customer 209.206.208.59 goes into a partial responsiveness state for 37 minutes during heavy thunderstorms reported at KSTP in St Paul, Minnesota at 6:30 AM on May 9th, 2011.

– Ref: [SS2011]
Results

• Collected pings for 66 days
  – Only if a weather alert was issued
  – Focused on large ISPs
    • Cable – Charter, Comcast and Cox
    • DSL – Ameritech, CenturyLink, MegaPath, Speakeasy, Verizon
    • Satellite – WildBlue
    • Fiber – Verizon
  – Looked for UP to DOWN transitions

• Failure rate = number of transitions / total time in weather condition
Results

Figure 5: The rate of up to down failures relative to the total failure rate for each provider. Weather affects the failure rate for all types of links, and for all selected providers.

- Ref: [SS2011]
Results

Figure 6: The normalized rate of correlated up to down failures. Thunderstorms appear to affect the failure rate for all types of links and providers.

• Ref: [SS2011]
Results

Figure 7: CDF of the time DOWN after transitioning from UP in clear conditions. Some providers stay DOWN longer than others and it does not appear to be related to link type.

Figure 8: CDF of the time DOWN after transitioning from UP during thunderstorms. Surprisingly, the satellite provider’s failures are shorter than in clear conditions.

• Ref: [SS2011]
Conclusion and Future Work

- 65,529 IPs observed (23,957 HOSED)
- Significant correlation of weather and ping response
- Reveals typical causes of everyday unavailability
- Find sources of inaccuracy
  - Accurate positions of IPs
  - Increased precision of weather
  - Errors in the last-mile or the backend
  - Expand scope beyond the United States
References and Further Reading

Questions?

• Please email me at brckd6@mst.edu and I will be happy to answer your questions