AARON SCHULMAN  NEIL SPRING

PINGIN' IN THE RAIN

University of Maryland
Residential links may fail

Links are not redundant

Equipment updates are rare

Equipment operates in an uncontrolled environment

photo credit: Ode Street Tribune
Weather causes residential link failures

**Lightning** destroys equipment and causes interference

**Water** seeps into unpressurized cables and equipment

**Wind** snaps tree limbs and stresses wires

Weather will always threaten residential links
Why measure weather failures?

Weather is a routine mini-natural disaster

To inform providers of weather-related problems

We rely on links for Phone, T.V. and Internet
Measuring weather-related failures

**Identify** residential IPs that will be subject to weather

**Ping** before, during, and after a weather event

**Analyze** the pings to find weather-related failures
Measuring weather-related failures

**Identify** residential IPs that will be subject to weather

**Ping** before, during, and after a weather event

**Analyze** the pings to find weather-related failures
Finding residential IPs to ping

- 71.96.2.1  L100.DLLSTX-DSL-08.verizon-gni.net.
- 71.96.2.2  pool-71-96-2-2.dfw.dsl-w.verizon.net.
- 71.96.2.253 pool-71-96-2-253.dfw.dsl-w.verizon.net.
- 71.96.2.254 pool-71-96-2-254.dfw.dsl-w.verizon.net.
- 216.27.175.1 vrrp-1-gw.216-27-175.atl1.speakeasy.net.
- 216.27.175.2 dns.atl1.speakeasy.net.
- 216.27.175.253 5.ge-0-2-0.cr2.atl1.speakeasy.net.
- 216.27.175.254 dsl027-175-254.atl1.dsl.speakeasy.net.

Found 100 Million U.S. residential IPs
Finding residential IPs to ping

71.96.2.1               L100.DLLSTX-DSL-08.verizon-gni.net.
71.96.2.2               pool-71-96-2-2.dfw.dsl-w.verizon.net.
71.96.2.253           pool-71-96-2-253.dfw.dsl-w.verizon.net.
71.96.2.254           pool-71-96-2-254.dfw.dsl-w.verizon.net.
216.27.175.1         vrrp-1-gw.216-27-175.atl1.speakeasy.net.
216.27.175.2         dns.atl1.speakeasy.net.
216.27.175.253     5.ge-0-2-0.cr2.atl1.speakeasy.net.
216.27.175.254     dsl027-175-254.atl1.dsl.speakeasy.net.

Found 100 Million U.S. residential IPs
Finding residential IPs to ping

71.96.2.1               L100.DLLSTX-DSL-08.verizon-gni.net.
71.96.2.2               pool-71-96-2-2.dfw.dsl-w.verizon.net.
71.96.2.253           pool-71-96-2-253.dfw.dsl-w.verizon.net.
71.96.2.254           pool-71-96-2-254.dfw.dsl-w.verizon.net.
216.27.175.1         vrrp-1-gw.216-27-175.atl1.speakeasy.net.
216.27.175.2         dns.atl1.speakeasy.net.
216.27.175.253     5.ge-0-2-0.cr2.atl1.speakeasy.net.
216.27.175.254     dsl027-175-254.atl1.dsl.speakeasy.net.

Found 100 Million U.S. residential IPs
Aiming pings at weather

Monitor the alert feed from the U.S. National Weather Service

<title>Severe Weather Statement issued May 12 at 4:46PM CDT expiring May 12 at 5:15PM CDT by NWS GreenBay http://www.crh.noaa.gov/grb/</title>

<summary>...A SEVERE THUNDERSTORM WARNING REMAINS IN EFFECT FOR CENTRAL WAUPACA AND NORTHWESTERN OUTAGAMIE COUNTIES UNTIL 515 PM CDT...AT 443 PM CDT...NATIONAL WEATHER SERVICE DOPPLER RADAR INDICATED A SEVERE THUNDERSTORM CAPABLE OF PRODUCING QUARTER SIZE HAIL...AND DAMAGING WINDS IN EXCESS OF 60 MPH. THIS STORM WAS LOCATED 7 MILES NORTH OF NEW LONDON...OR 20 MILES NORTHEAST OF WAUPACA...MOVING</summary>

<cap:effective>2011-05-12T16:46:00-05:00</cap:effective>
<cap:expires>2011-05-12T17:15:00-05:00</cap:expires>
<cap:urgency>Immediate</cap:urgency>
<cap:severity>Severe</cap:severity>
<cap:certainty>Observed</cap:certainty>
<cap:geocode><valueName>FIPS6</valueName><value>055087 055135</value></cap:geocode>

Monday, November 7, 11
Aiming pings at weather

Monitor the alert feed from the U.S. National Weather Service

<title>Severe Weather Statement issued May 12 at 4:46PM CDT expiring May 12 at 5:15PM CDT by NWS GreenBay http://www.crh.noaa.gov/grb/</title>

<summary>...A SEVERE THUNDERSTORM WARNING REMAINS IN EFFECT FOR CENTRAL WAUPACA AND NORTHWESTERN OUTAGAMIE COUNTIES UNTIL 515 PM CDT...AT 443 PM CDT...NATIONAL WEATHER SERVICE DOPPLER RADAR INDICATED A SEVERE THUNDERSTORM CAPABLE OF PRODUCING QUARTER SIZE HAIL...AND DAMAGING WINDS IN EXCESS OF 60 MPH. THIS STORM WAS LOCATED 7 MILES NORTH OF NEW LONDON...OR 20 MILES NORTHEAST OF WAUPACA...MOVING</summary>

<cap:effective>2011-05-12T16:46:00-05:00</cap:effective>
<cap:expires>2011-05-12T17:15:00-05:00</cap:expires>
<cap:urgency>Immediate</cap:urgency>
<cap:severity>Severe</cap:severity>
<cap:certainty>Observed</cap:certainty>
<cap:geocode><valueName>FIPS6</valueName><value>055087 055135</value></cap:geocode>
Locating IPs covered by weather alerts

Locating 100 Million residential IPs
MaxMind database of IP to geolocation

Sampling IPs covered by a weather alert
Ping 100 IPs from each provider and link type

Finding the provider and link type of an IP
Reverse name (pool----.sangtx.dsl-w.verizon.net)
Measuring weather-related failures

**Identify** residential IPs that will be subject to weather

**Ping** before, during, and after a weather event

**Analyze** the pings to find weather-related failures
Measuring weather-related failures

**Identify** residential IPs that will be subject to weather

**Ping** before, during, and after a weather event

**Analyze** the pings to find weather-related failures
Pinging to observe failures

One vantage point is not enough
Ten PlanetLab-based vantage points

Ping infrequently
From each vantage point, ping once every 11 minutes

Omit needless pings
Only ping IPs that reply before the weather

One ping is not enough
Retry immediately when a ping indicates failure
Measuring weather-related failures

**Identify** residential IPs that will be subject to weather

**Ping** before, during, and after a weather event

**Analyze** the pings to find weather-related failures
Measuring weather-related failures

Identify residential IPs that will be subject to weather

Ping before, during, and after a weather event

Analyze the pings to find weather-related failures
U.S. airport weather stations monitor conditions
U.S. airport weather stations monitor conditions

- Visibility
- Lightning Detection
- Precipitation Identification
- Cloud coverage
- Temperature
- Precipitation accumulation

Photo credit: Austin Cross

Monday, November 7, 11
12:57 PM, 80.1, 48.0, 32, 29.95, 10.0, Variable, 3.5, -, N/A, Clear, METAR KFLG 051957Z VRB03KT 10SM CLR 27/09 A3029 RMK AO2 SLP141 T02670089,0,2011-07-05 19:57:00

1:57 PM, 81.0, 45.0, 28, 29.92, 10.0, SSW, 8.1, -, N/A, Clear, METAR KFLG 052057Z 20007KT 170V240 10SM CLR 27/07 A3026 RMK AO2 SLP131 T02720072 58013,200,2011-07-05 20:57:00

2:57 PM, 75.9, 48.0, 37, 29.92, 10.0, WNW, 6.9, -, 0.00, Scattered Clouds, METAR KFLG 052157Z 29006KT 10SM SCT090 24/09 A3025 RMK AO2 RAB46E56 SLP130 P0000 T02440089,290,2011-07-05 21:57:00

3:57 PM, 75.0, 45.0, 34, 29.93, 6.0, Variable, 3.5, -, Haze, METAR KFLG 052257Z VRB03KT 6SM HZ BKN075 24/07 A3026 RMK AO2 SLP134 T02390072,0,2011-07-05 22:57:00

4:16 PM, 64.4, 55.4, 73, 30.27, 5.0, North, 13.8, 17.3, 0.07, Rain-Thunderstorm, Thunderstorms and Rain, SPECI KFLG 052316Z 01012G15KT 5SM TSRA BKN041 BKN050 OVC075 18/13 A3027 RMK AO2 TSB10RAB2258 TS OVHD P0007,10,2011-07-05 23:16:00

4:57 PM, 64.9, 55.9, 73, 29.95, 10.0, West, 8.1, -, 0.13, Rain-Thunderstorm, Light Thunderstorms and Rain, METAR KFLG 052357Z 27007KT 10SM -TSRA FEW031 BKN095 18/13 A3024 RMK AO2 TSB10RAB2258 SLP140 TS OVHD P0013 60013 T01830133 10294 20167 58007,270,2011-07-05 23:57:00

5:13 PM, 64.4, 55.4, 73, 30.26, 1.8, WSW, 10.4, 17.3, 0.03, Rain-Thunderstorm, Heavy Thunderstorms and Rain, SPECI KFLG 060013Z 24009G15KT 210V280 1 3/4SM +TSRA SCT027 BKN085 18/13 A3026 RMK AO2 P0003,240,2011-07-06 00:13:00

Monday, November 7, 11
Reducing pings to responsiveness

Monday, November 7, 11
Reducing pings to responsiveness
Reducing pings to responsiveness
Pingin’ during hurricane Irene
Pingin’ during hurricane Irene

August 26, 2011 18:00
Pingin’ during hurricane Irene

August 26, 2011 18:00
Preliminary results

Collected data
Pinged during 66 days (Spring - Summer 2011)

Focused on large providers with known link types
3 Cable, 6 DSL, 1 Satellite and 1 Fiber

Computed failure (\(\text{UP} \rightarrow \text{DOWN}\)) rate for each provider

\[
\frac{\sum \# \text{ failures}_{IP}}{\sum \text{ time observed}_{IP}}
\]
UP ➡ DOWN failures

- Charter
- Comcast
- Cox
- Ameritech
- CenturyLink
- MegaPath
- Speakeasy
- Windstream
- Verizon DSL
- WildBlue
- Verizon FiOS

UP ➡ DOWN rate (failures / hour)

- Charter
- Comcast
- Cox
- Ameritech
- CenturyLink
- MegaPath
- Speakeasy
- Windstream
- Verizon DSL
- WildBlue
- Verizon FiOS

once every 35 days

Monday, November 7, 11
UP ➡ DOWN failures

<table>
<thead>
<tr>
<th>Provider</th>
<th>Clear</th>
<th>Cloudy</th>
<th>Fog</th>
<th>Rain</th>
<th>T-storm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charter</td>
<td>0.000</td>
<td>0.005</td>
<td>0.010</td>
<td>0.020</td>
<td>0.025</td>
</tr>
<tr>
<td>Comcast</td>
<td>0.000</td>
<td>0.005</td>
<td>0.010</td>
<td>0.020</td>
<td>0.025</td>
</tr>
<tr>
<td>Cox</td>
<td>0.000</td>
<td>0.005</td>
<td>0.010</td>
<td>0.020</td>
<td>0.025</td>
</tr>
<tr>
<td>Ameritech</td>
<td>0.000</td>
<td>0.005</td>
<td>0.010</td>
<td>0.020</td>
<td>0.025</td>
</tr>
<tr>
<td>CenturyLink</td>
<td>0.000</td>
<td>0.005</td>
<td>0.010</td>
<td>0.020</td>
<td>0.025</td>
</tr>
<tr>
<td>MegaPath</td>
<td>0.000</td>
<td>0.005</td>
<td>0.010</td>
<td>0.020</td>
<td>0.025</td>
</tr>
<tr>
<td>Speakeasy</td>
<td>0.000</td>
<td>0.005</td>
<td>0.010</td>
<td>0.020</td>
<td>0.025</td>
</tr>
<tr>
<td>Windstream</td>
<td>0.000</td>
<td>0.005</td>
<td>0.010</td>
<td>0.020</td>
<td>0.025</td>
</tr>
<tr>
<td>Verizon DSL</td>
<td>0.000</td>
<td>0.005</td>
<td>0.010</td>
<td>0.020</td>
<td>0.025</td>
</tr>
<tr>
<td>MegaPath</td>
<td>0.000</td>
<td>0.005</td>
<td>0.010</td>
<td>0.020</td>
<td>0.025</td>
</tr>
<tr>
<td>Verizon FiOS</td>
<td>0.000</td>
<td>0.005</td>
<td>0.010</td>
<td>0.020</td>
<td>0.025</td>
</tr>
</tbody>
</table>

Monday, November 7, 11
Next steps

Collect more data

Isolate power failures

Determine where the failures are in the network

Where can we get weather data for your country?

schulman@cs.umd.edu