Proactive Network Management of IPTV Networks

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IPTV service

- High visibility: direct customer impact.
- Service is very sensitive to delay and packet loss
  - Congestion on links -> packet loss-> video quality impairment
  - Need to tackle multiple failures, which are not very rare.
  - Higher layer mechanisms - FEC, retransmission based recovery of lost packets - can handle (with reasonable delays), burst losses of about 50 milliseconds
    - Fast restoration is critical

AT&T's IPTV service:

- 2+ million customers;
- Triple play: video, internet, and voice

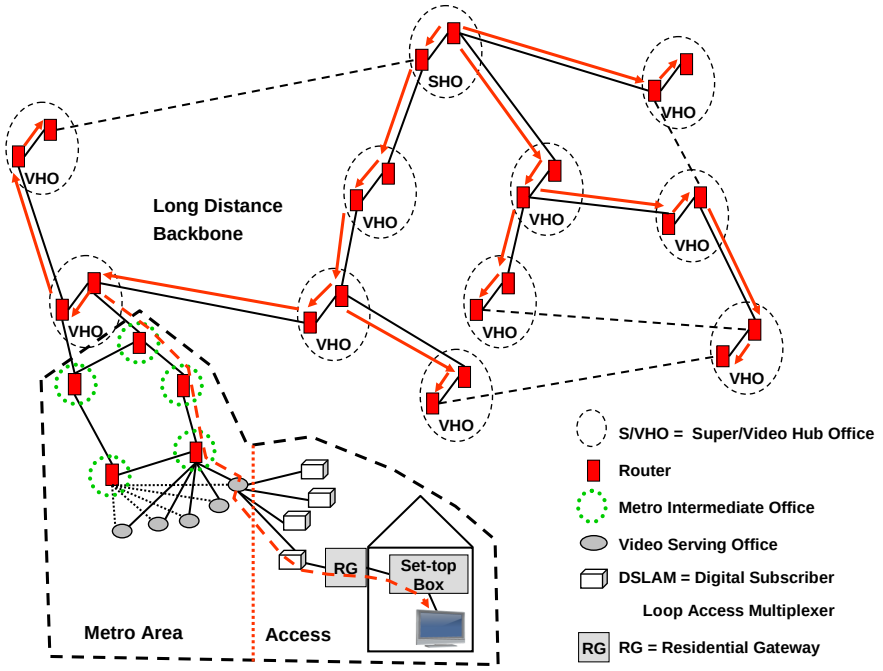
Network backbone

- One Video hub office (VHO) per metro area
- National content is acquired at Super hub office (SHO)
- Content is distributed to VHOs using single source specific mode multicast tree

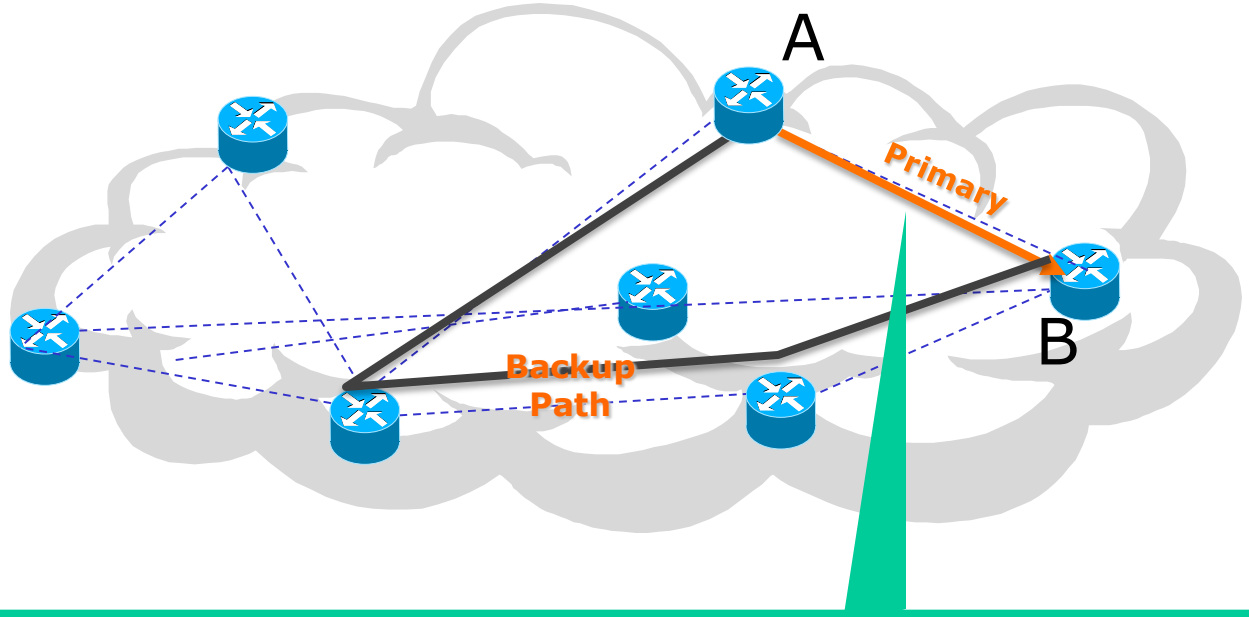
  (PIM-SSM)

  – a separate multicast tree for each channel

Details in 2009 'IEEE Internet Computing' Paper



Local Link-Based Fast Re-Route (FRR)



"Virtual link" between AB with virtual interfaces

Virtual link consists of both a primary and backup

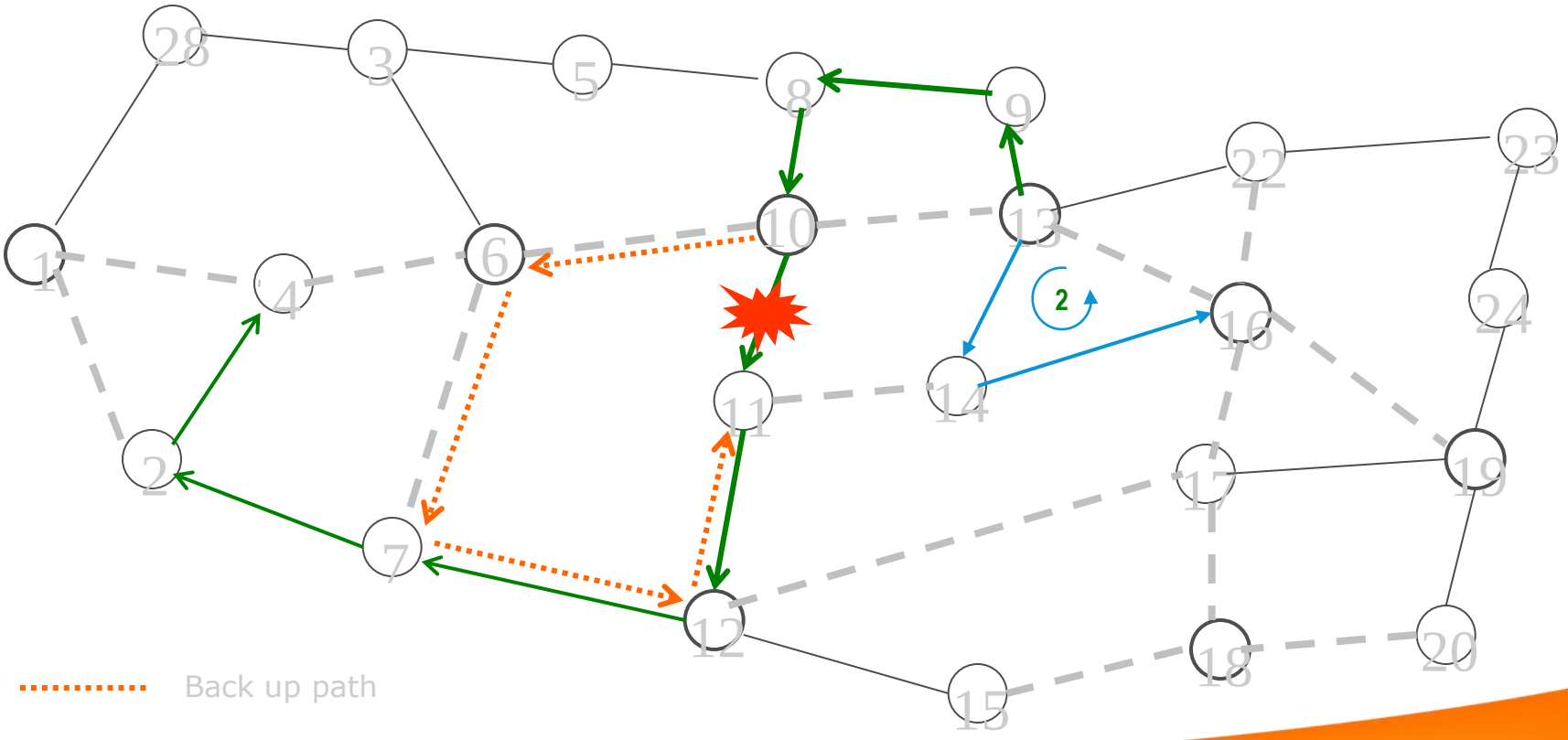
Path: The OSPF topology (and multicast tree) built on top of the virtual link

FRR example on virtual link (10,11)

Normal traffic forwarded on primary link (10,11)

When primary link fails, link layer mechanism using FRR switches to backup

No OSPF/PIM-SSM convergence required



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Challenges in implementing IPTV services

- Due to high sensitivity of IPTV service, must plan for multiple, concurrent outages
  - In a study of link outages over 4 months, we found that in 17% of cases, at least 2 links were down concurrently.
- IP Multicast results in a very efficient network -> smaller overbuild capacity -> requires more careful multi-layer restoration planning, design, and management.
- Because FRR is invisible to IGP/PIM, these protocols can potentially interact in a ‘bad’ way creating congestion in the network.

Our approach

- Be proactive in dealing with the effect of multiple failures
- Maintenance activity is often planned far in advance and is often agnostic to real-time network state
  - We coordinate planned network maintenance activity with real-time network state.
- Need a comprehensive view across many different network layers.
  - Example (details later): an SNMP based tool can tell when a link is congested but by looking at a variety of data sources, we can pinpoint to one of 3 or 4 different reasons for link congestion.

Dealing w/ Network component failures

- (Reactive) Use FRR whenever backup path is available; Use IGP otherwise. There is potential for congestion with multiple failures
  - overlap of two FRR paths, OR
  - overlap of FRR path with multicast tree.
- (Proactive) Avoid potential overlap by using a cross-layer approach to reconfigure the multicast tree after a successful FRR event. [COMSNETS 2010]

Another issue: Alert the operator to any changes in network state. E.g,

- An FRR event may reroute traffic to a different set of links
- A PIM re-convergence may alter the multicast tree

Dealing w/ Network maintenance

- Maintenance activity is often planned far in advance and is often agnostic to real-time network state
- Coordinate planned network maintenance activity with real-time network state. Examples
  - any link carrying traffic should not have a maintenance activity
  - IPTV networks are typically shared as an access network providing Internet connectivity to customers and a pair of routers within a metro office maintain BGP sessions with ISP edge routers. If one of these BGP sessions is down, its 'mate' router should not be touched.

Pinpoint the cause of link congestion

- An SNMP based tool can point out which links are congested. However knowing the underlying cause can for congestion gives an insight in how to fix it.
- Holistic view needed to disambiguate cause
- Different ways that a link can get congested
  - Oversubscribed? Too many TV channels/VoD
  - Overlap between different FRR paths and/or multicast tree
  - Lots of parallel links between offices and sometimes we can get load imbalance: high bandwidth channels on one link and low bandwidth channels on the other link.

Multiple views of the network

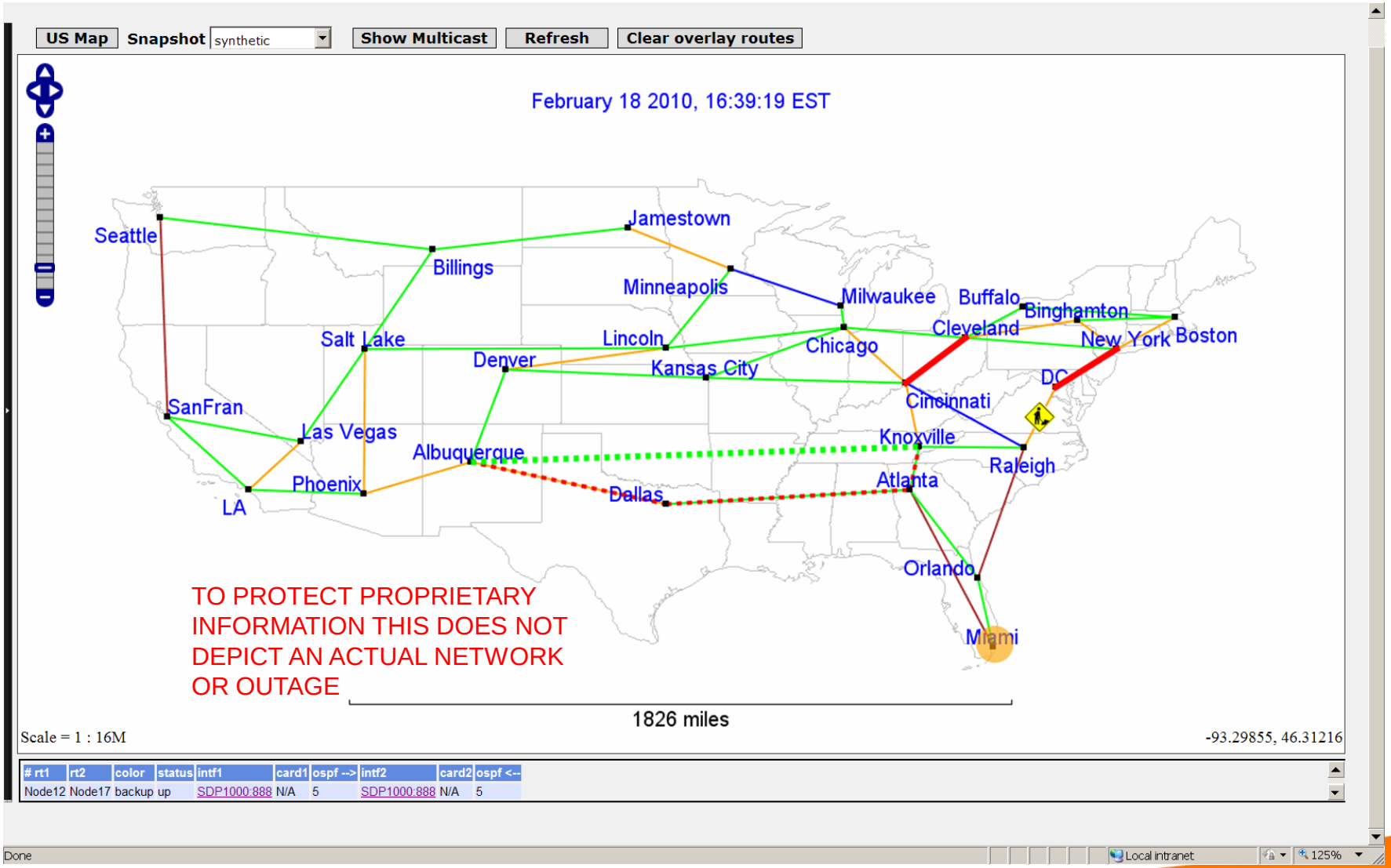
- NetDB tool (developed at AT&T Research): parses router configuration files to build failure-free topology
- OSPFMon tool (developed at AT&T Research): establishes a partial adjacency with one or more routers to receive LSAs and create a real-time topology
- FRR is invisible to IGP and may appear self-healing but it alters the network state significantly
  - Need logic to infer that successful FRR has happened
  - Use NetDB to get links in the back-up path being used
- MRTG tool: collects link utilizations
- BGP reachability: compare number of routes to a threshold; also monitor various alarms
- Operations Support System: list of links scheduled to undergo maintenance during the next 24 hours.

Web based visualization tool: Birdseye

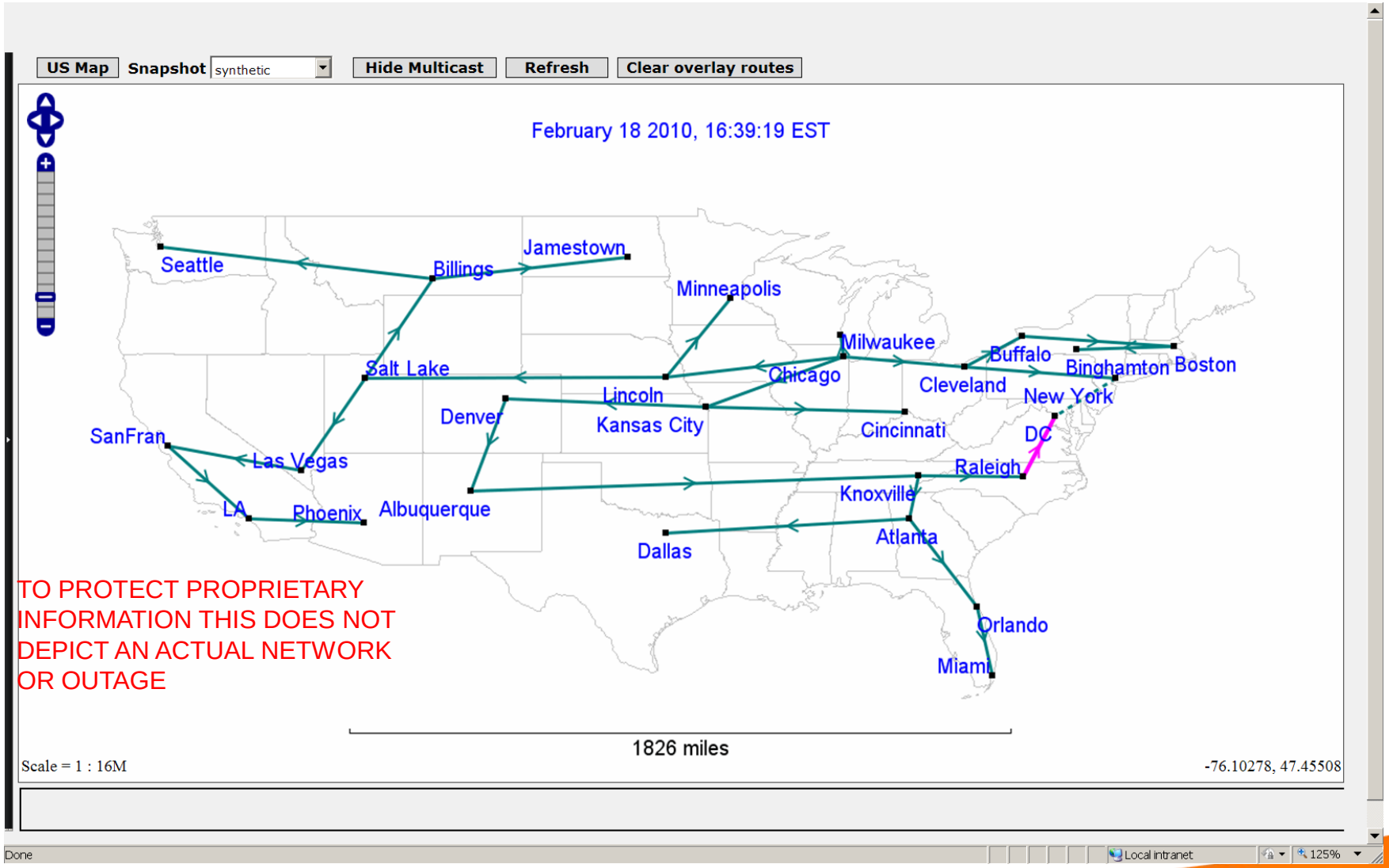
Synthesizes and interprets data from a variety of data sources to obtain a comprehensive network view. Our overall philosophy is to

- Maintain an idealized, failure-free state
  - List of links and routers, link capacities, multicast tree, FRR backup paths, etc.
- Maintain real-time state
  - Real-time topology, link utilization, BGP reachability, database of links planned for scheduled maintenance
  - Either directly from tools or by interpreting data from multiple tools.
- Parse the differences and show necessary alerts to the operator
- Has been in use in AT&T Network Operations Center for 1+ yr.

Sample GUI snapshot: triple link failure



Sample snapshot: updated multicast tree



Conclusion

- IPTV services have high sensitivity to impairments and high visibility in terms of customer impact
- Need careful designing of network protocols to deal with multiple failures
- Operators need a comprehensive view of the network
- Our Birdseye tool distills network data from multiple AT&T-developed systems and public tools and domain knowledge of networking protocols to compile a holistic view to the operators
- Has been in use at Network Operation Center for over a year for a service with 2+ million customers