



INFOCOM'06 routing panel

Fast convergence

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What should be the goal of routing protocols ?

- Main goals

- Discover network and reachable destinations
- Allow routers to build correct forwarding tables to

forward **ALL** packets towards reachable destinations ...

even if the network topology frequently changes

- Secondary goals

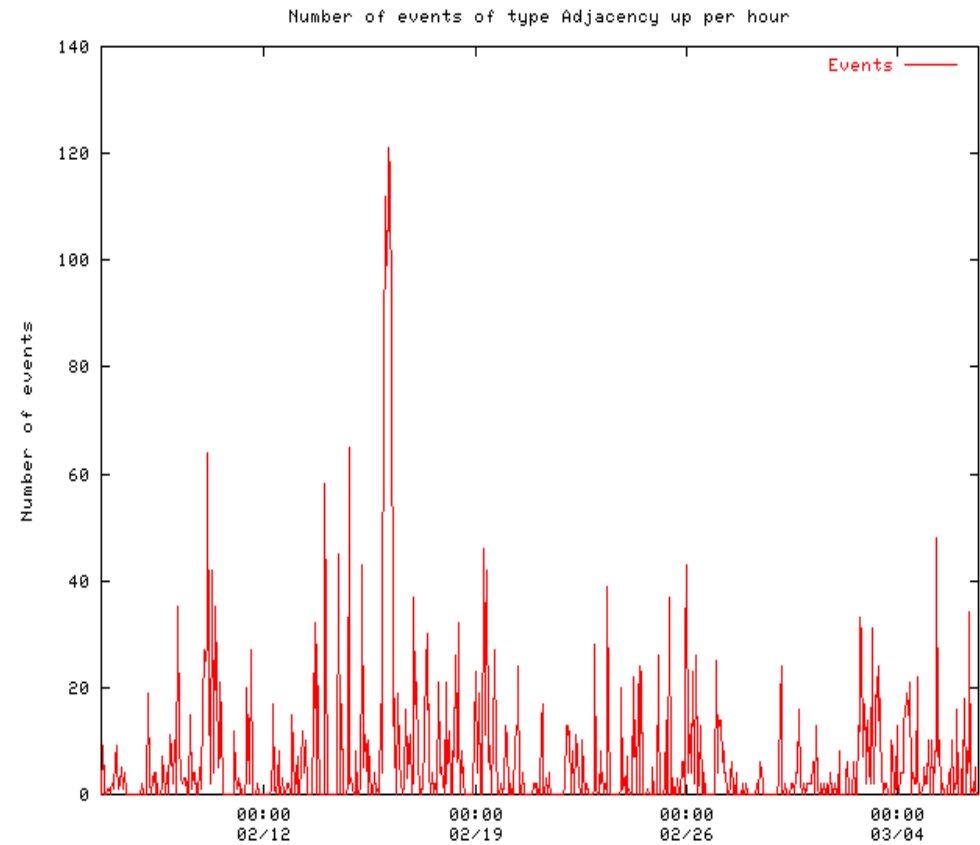
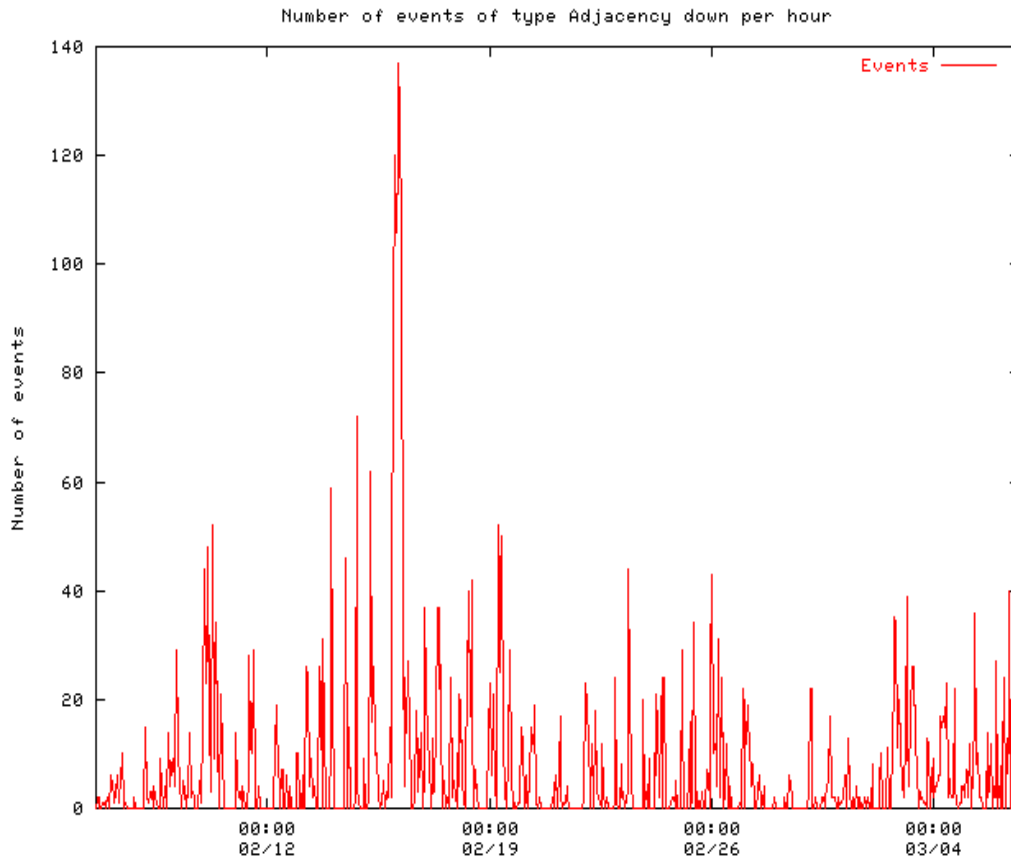
- Quality of Service routing
- Security
- Multicast
- Traffic engineering

IS-IS in a tier-1 ISP

- The Network
 - Large tier-1 transit ISP
 - 400 routers in studied ISIS area
 - IS-IS wide metrics and TE extensions are used in the network
- The trace
 - IS-IS adjacency between a PC running a modified tcpdump and a router
 - all IS-IS packets logged in libpcap format during one month
 - ◆ analysed with scripts and `lisis`
 - ◆ <http://totem.info.ucl.ac.be/tools.html>

The adjacency changes per hour

- 5276 adjacency down LSPs (left)
- 4487 adjacency up LSPs (right)



- Maintenance operations and sudden failures

How fast can link state routing converge ?

- In the past
 - Routers used their CPU to forward packets and support link state routing
 - To protect CPU, routers waited *five* seconds after a topology change to update forwarding table
- Today
 - Faster convergence is possible
 - ◆ Sub-second convergence in large ISP networks
 - Key bottlenecks in large networks are
 - ◆ Link propagation delays
 - ◆ Time to update a prefix in forwarding table
 - ◆ 100 microsecond on Cisco 12k
 - ◆ Number of prefixes advertised inside by link-state routing protocol

How to avoid loosing packets when links fail?

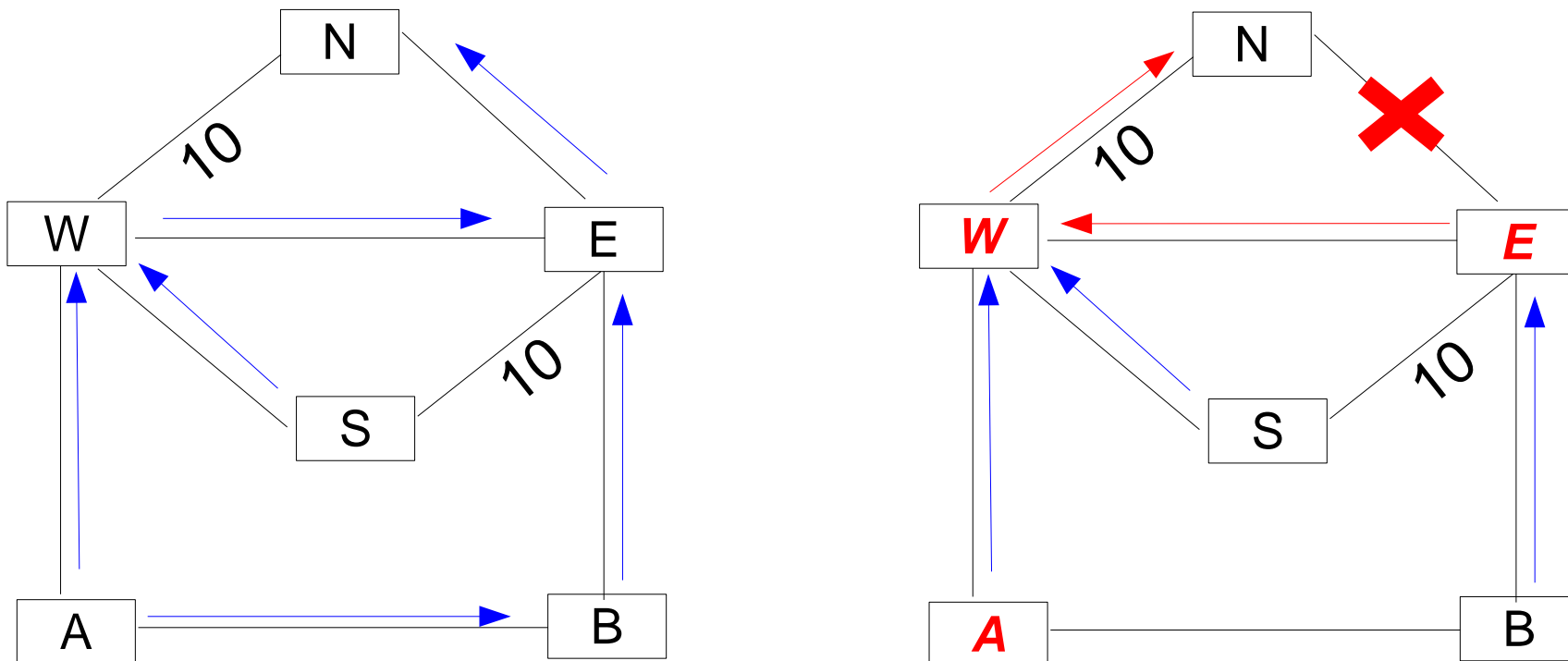
- First step
 - Quickly detect the failure
 - ◆ Physical layer aid for Packet over SONET
 - ◆ BFD protocol for other technologies
- Second step
 - Reroute the packets *at the router that detects the failure to an alternate router*
 - ◆ MPLS fast-reroute and bypass tunnels
 - ◆ IP-based techniques (loop-free alternates, tunnels, not-via addresses, ...)
- Is it sufficient ?
 - Unfortunately not, transient loops can occur during the update of the forwarding table

How to avoid loosing packets when links fail ? (2)

- First step
 - Quickly detect the failure
 - ◆ Physical layer aid for Packet over SONET
 - ◆ BFD protocol for other technologies
- Second step
 - Reroute the packets *at the router that detects the failure to an alternate router*
 - ◆ MPLS fast-reroute and bypass tunnels
 - ◆ IP-based techniques (loop-free alternate, tunnels, ...)
- Third step
 - Orderly update the forwarding tables of all affected routers to avoid all transient loops

Ordering of forwarding table updates

- Principle
 - When a link fails, routers far away from the failure must update their FIB before routers close to the failure



Packets sent to N

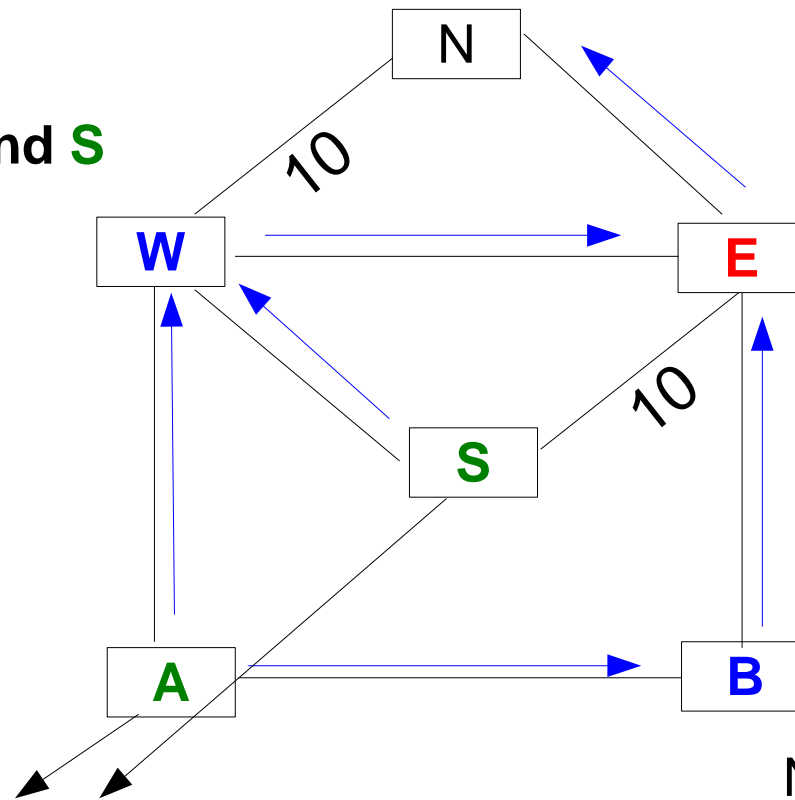
Ordering of forwarding table updates (2)

Node W :

- 1 hop from A and S
- **Updates after A and S**

Node E :

- 2 hops from A
- **Updates after W and B**



Farthest nodes from failure, **first** to update

Node B :

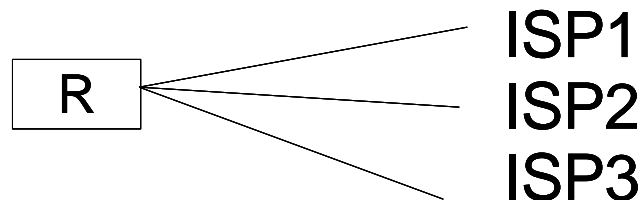
- 1 hop from A
- **Updates after A**



Paths towards N

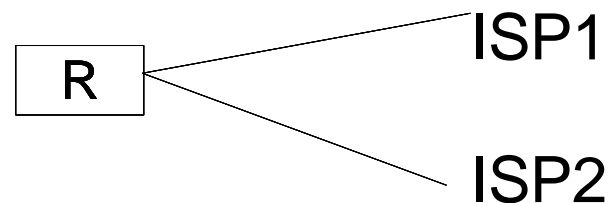
Fast convergence and interdomain routing

- Current BGP convergence times in global Internet
- Craig Labovitz's measurements
 - ◆ Several tens of seconds or more



R starts to advertise p to all
R stops to advertise p to all

- Happy packets from dual-homed beacon presented at PAM
 - ◆ BGP convergence time
 - ◆ Up to a few 100s seconds
 - ◆ Packet convergence time
 - ◆ A few tens of seconds



R advertises p via ISP1 and ISP2
R only advertises p via ISP2

Can we achieve sub-second interdomain routing convergence ?

- Is a three step approach possible ?
 - First step
 - ◆ Quickly detect the failure
 - ◆ **Possible**, same techniques as for link-state routing
 - Second step
 - ◆ Reroute the packets *at the router that detects the failure to a loop-free alternate router*
 - ◆ **Possible**, but not yet implemented
 - Third step
 - ◆ Orderly update the forwarding tables of all affected routers to avoid all transient loops
 - ◆ **More difficult**

Can we achieve sub-second interdomain routing convergence ? (2)

- Issues for ordered updates of interdomain forwarding tables
 - Routers do not know entire network topology
 - ◆ BGP is a path vector protocol
 - Some routers do not know an alternate path to reach failed destination
 - ◆ Route reflectors, non-preferred routes
 - Entire AS's may not know an alternate path

