Internet Routing Instability

Craig Labovitz 、 G. Robert Malan 、 Farnam Jahanian

University of Michigan

Department of Electrical Engineering and Computer Science

{labovit, rmalan, farnam}@eecs.umich.edu

Outline

- **Routing Instability**
- **Methodology**
- **Pathological Routing Information**
- **Analysis of Instability**
- **Conclusion**

Routing Instability(1/2)

◈ 『 **Route flaps** 』

-- rapid change of network reachability and topology information

◈ **Primary effect**

(1) increased packet loss

(2) delays in the time for network convergence

(3) additional resource overheard (memory, CPU, etc.)

Routing Instability(2/2)

◆ **Route Caching Architecture**

Cache miss result：(1) increased load on the CPU

(2) increased switching latency

(3) loss of packets

◆ **Severe CPU load** ：delay routing Keep-Alive packets

◆ **route flap storm**

Solution

- **ASPATH attribute**：detect and prevent forwarding loops

- **Route dampening algorithms**：not a panacea

- **Increased use of route aggregation**：

  Combines a number of smaller IP prefixes into a single，less specific route announcement。

Methodology

◇ based on data collected at Internet routing exchange points

◇ logged BGP routing messages exchanged

◇ concentrating on the logs of the largest exchange ：
 〝Mae-East 〞

◇ analyze the BGP data

◇ analyze sample BGP backbone logs

Map of major U.S. Internet exchange points

AADS、**Mae-East**、Mae-West 、 PacBell 、 Sprint

Classifications of routing information

◈ **Pathologic (or redundant) updates**

◈ **Policy fluctuation**

◈ **Forwarding Instability**

BGP updates events

◆ **WADiff** ： Forwarding instability

◆ **AADiff** ： Forwarding instability

◆ **WADup** ： oscillating reachability announcements

◆ **AADup** ： duplicate path announcements

◆ **WWDup** ： duplicate withdrawal announcements

Classless inter-domain routing

- 『 **Supernet** 』
- **multi-homing**
- **Internet address space are not well-aggregated**

Breakdown routing updates(1/2)

- AADup and WADup classifications consistently dominate other categories of routing instability
- AADup category is dominated by policy changes that do not directly affect forwarding instability
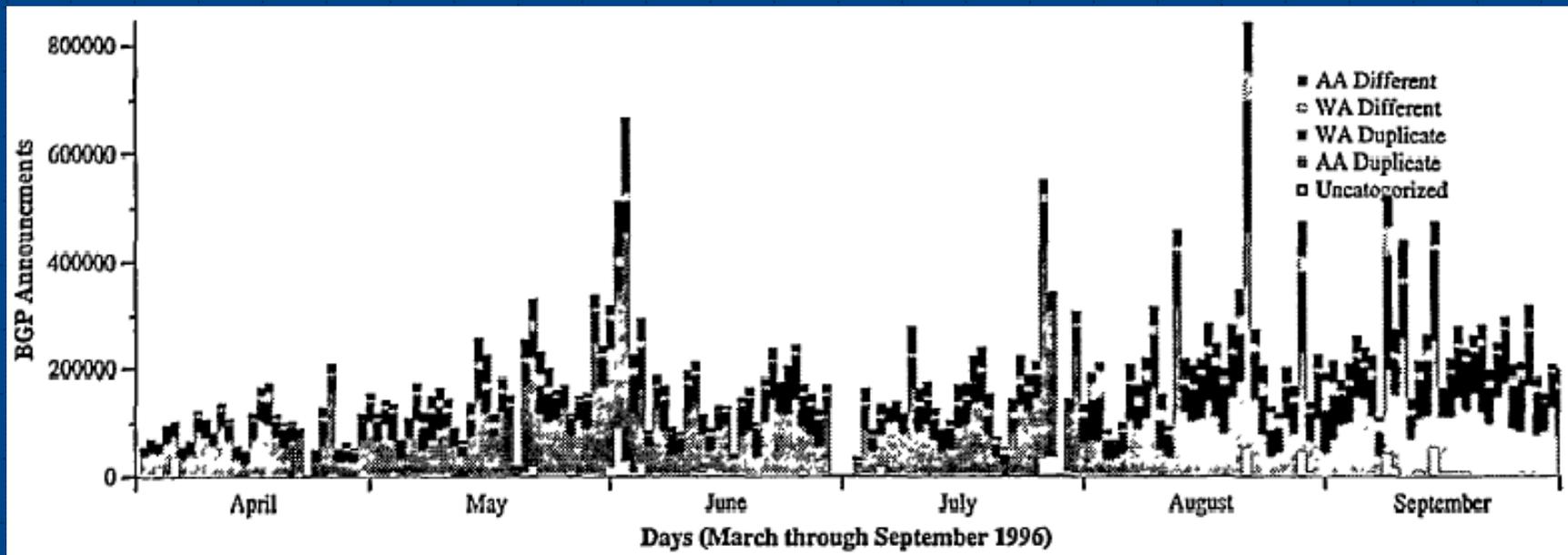
Breakdown routing updates(2/2)

o The majority of BGP updates consist entirely of WWDup

o All pathological routing incidents were caused by small service providers

Network	Announce	Withdraw	Unique
Provider A	1127	23276	4344
Provider B	0	36776	8424
Provider C	32	10	12
Provider D	63	171	28
Provider E	1350	1351	6
Provider F	11	86417	12435
Provider G	2	61780	10659
Provider H	21107	77931	14030
Provider I	250	2479023	14112
Provider J	2335	1363	853

Possible Origins of Routing Pathologies

- **stateless BGP** (IETF BGP standard)
  - -- contribute an additional O(N * U) updates
  - -- **Router vendors**：Partial state on BGP advertisements
  - -- limits distribution of WWDup updates
- **Channel Service Units (CSU) timer problems**
- **Self synchronization**

Fine-grained Instability Statistics

- No single autonomous system consistently dominates the instability statistics.

- There is not a correlation between the size of an AS (measured at the public exchange point as the number of routes which it announces to non-customer and non-transit peers) and its proportion of the instability statistics.

- A small set of paths or prefixes do not dominate the instability statistics; instability is evenly distributed across routes.
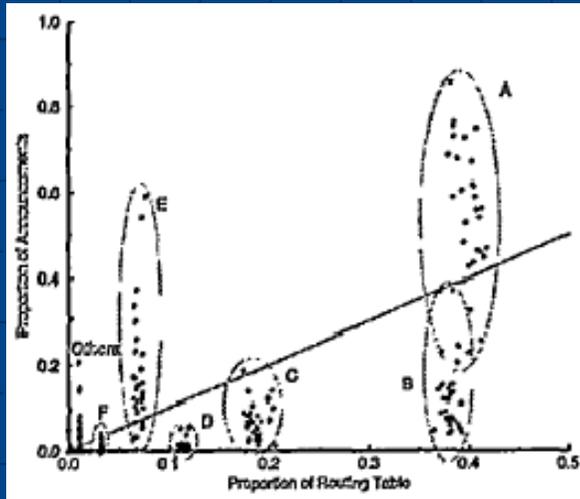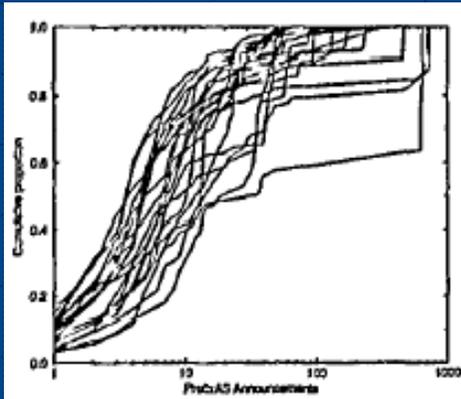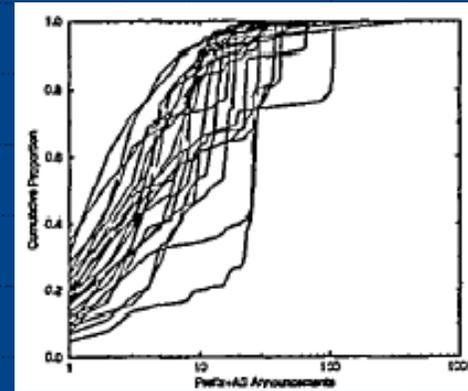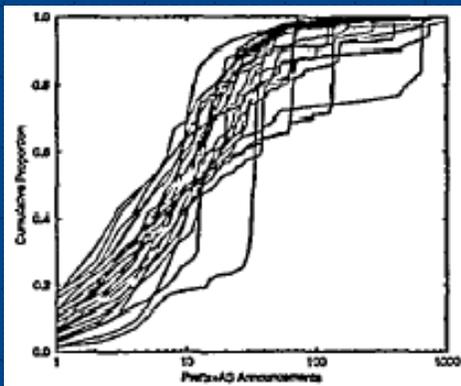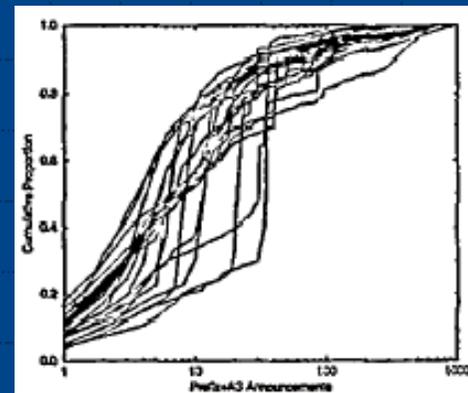
AADiff
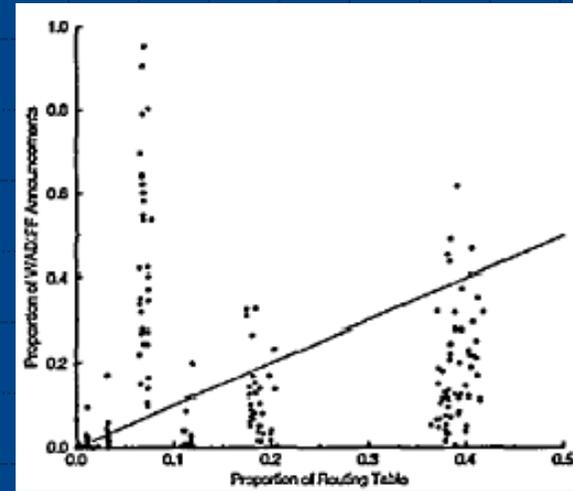
WADiff
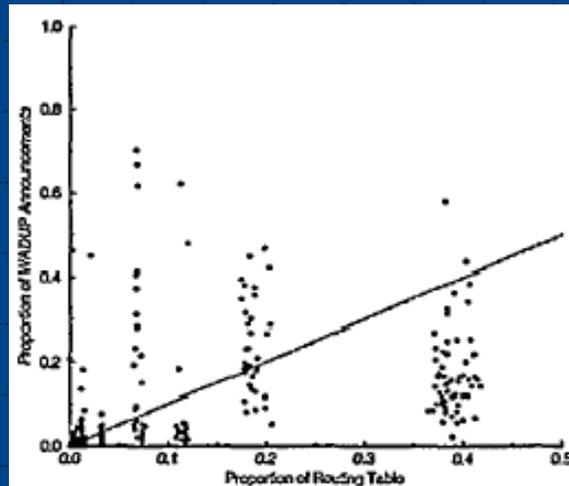
WADup

AADiff

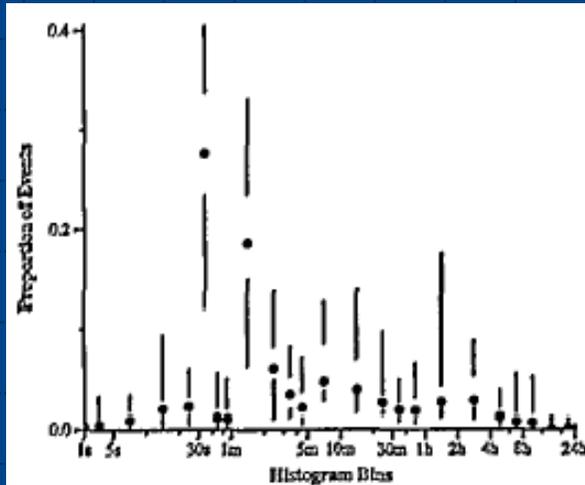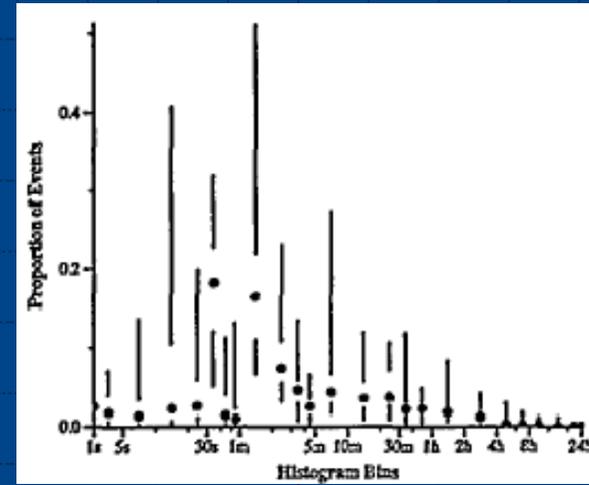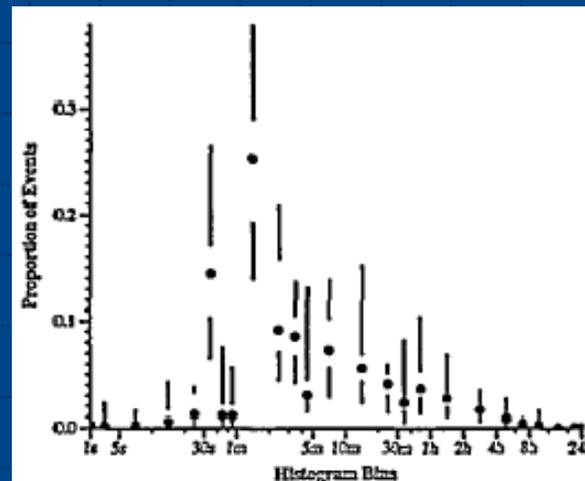**WADiff**

AADup

WADup

Temporal Properties of Instability Statistics

AADiff

WADiff

WADup

Conclusion

◆ Forwardi ng instability can have a significant deleterious impact on the Internet infrastructure

◆ majority (99 percent) of routing information is pathological and may not reflect real network topological changes

◆ sufficiently high rates of pathological updates (e.g. 300 updates per second) are enough to crash a widely deployed, high-end model of commercial Internet router