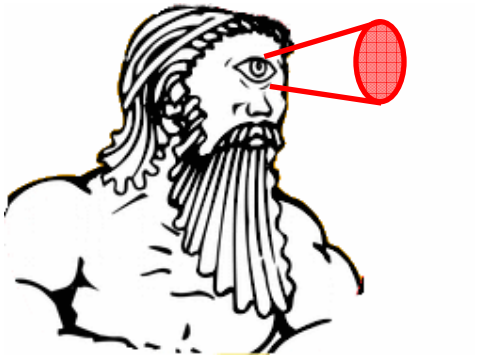
Cyclops: The AS-level Connectivity Observatory



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“Did AS9318 leak routes from Yahoo?”
@Nanog mailing list, July 8th 2007

“Did Cogent depeer Limelight, WV Fiber and nLayer?”
@Nanog mailing list, Sept 28th 2007

“Can anyone confirm a partition between Telia 1299 and Cogent 174?”
@Nanog mailing list, March 14th 2008

Need #1: AS connectivity

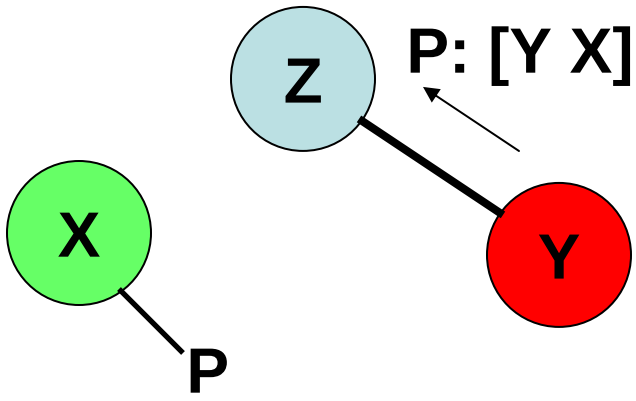
- Even though AS connectivity can be inferred from BGP updates collected from hundreds of vantage points - the **public view (PV) …**
- … there's no tool to gather this info to infer **the AS connectivity and changes**

Need #2: fault detection

• Each ISP knows who its neighbors are: **the ground truth**

• Public view captures part of the ground truth and **more**…

• **False link prefix hijack and misconfigurations**

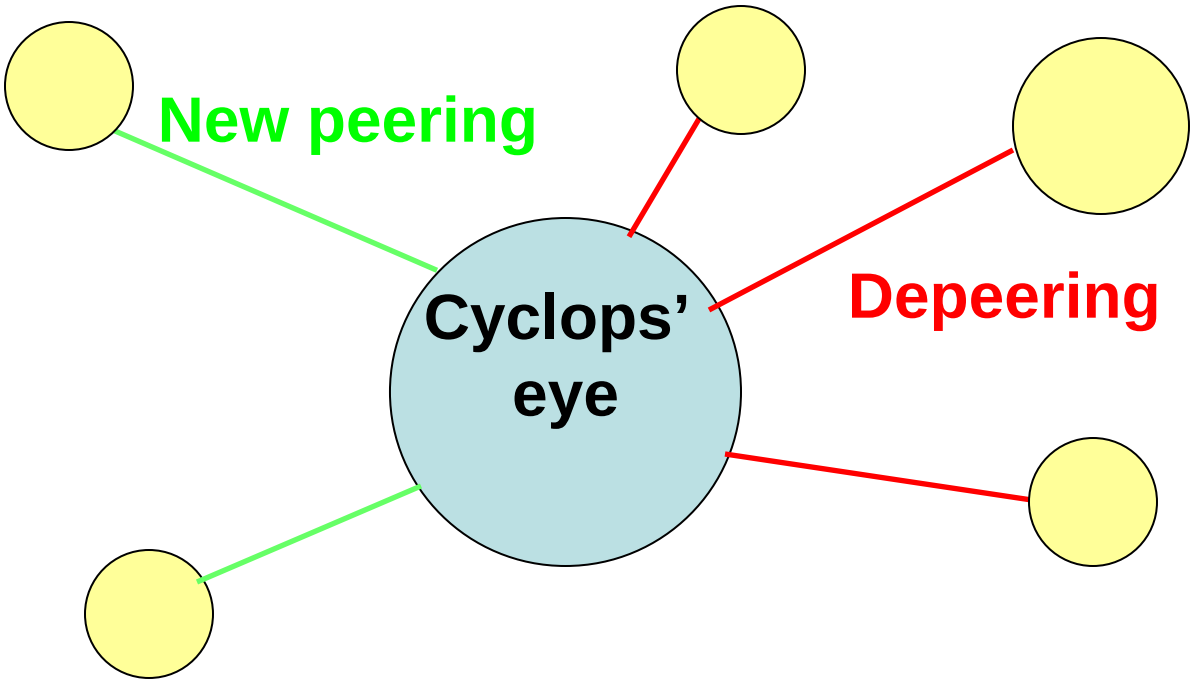


• Y starts announcing a false link to Z w/ X's prefix P

• In this case the link X-Y will appear in the PV

Cyclops concept

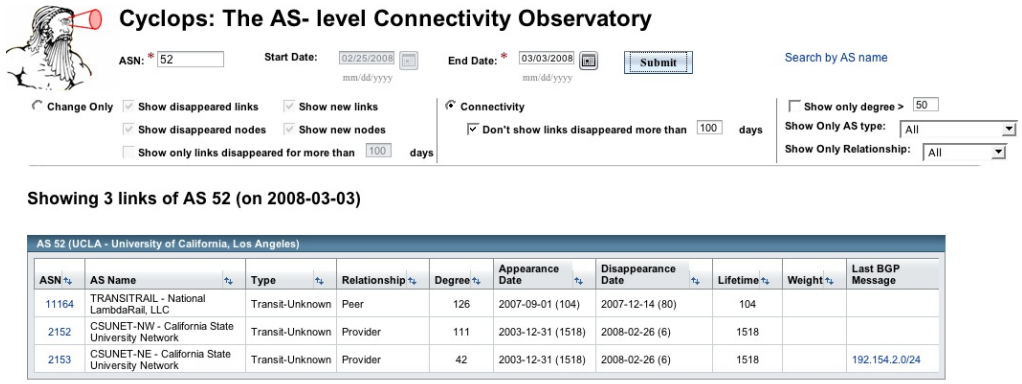
- Show 1-hop connectivity of specific AS at a time: **eye of the cyclops**



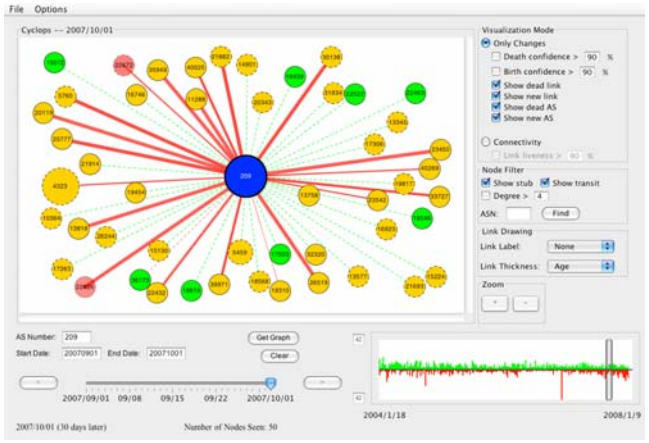
The 3 flavors of Cyclops

Raw data: raw connectivity data to be processed at ISP side

•2153@CSUNET-NE - California State University Network@Transit-Unknow@Provider@42@2003-12-31@2008-03-13@1532@TABLE_DUMP|1205284560|B|134.55.200.1|293|128.97.0.0/16|293 2153 52|IGP|||||||



Web interface: quick way of getting list of neighbors and changes for a specific network

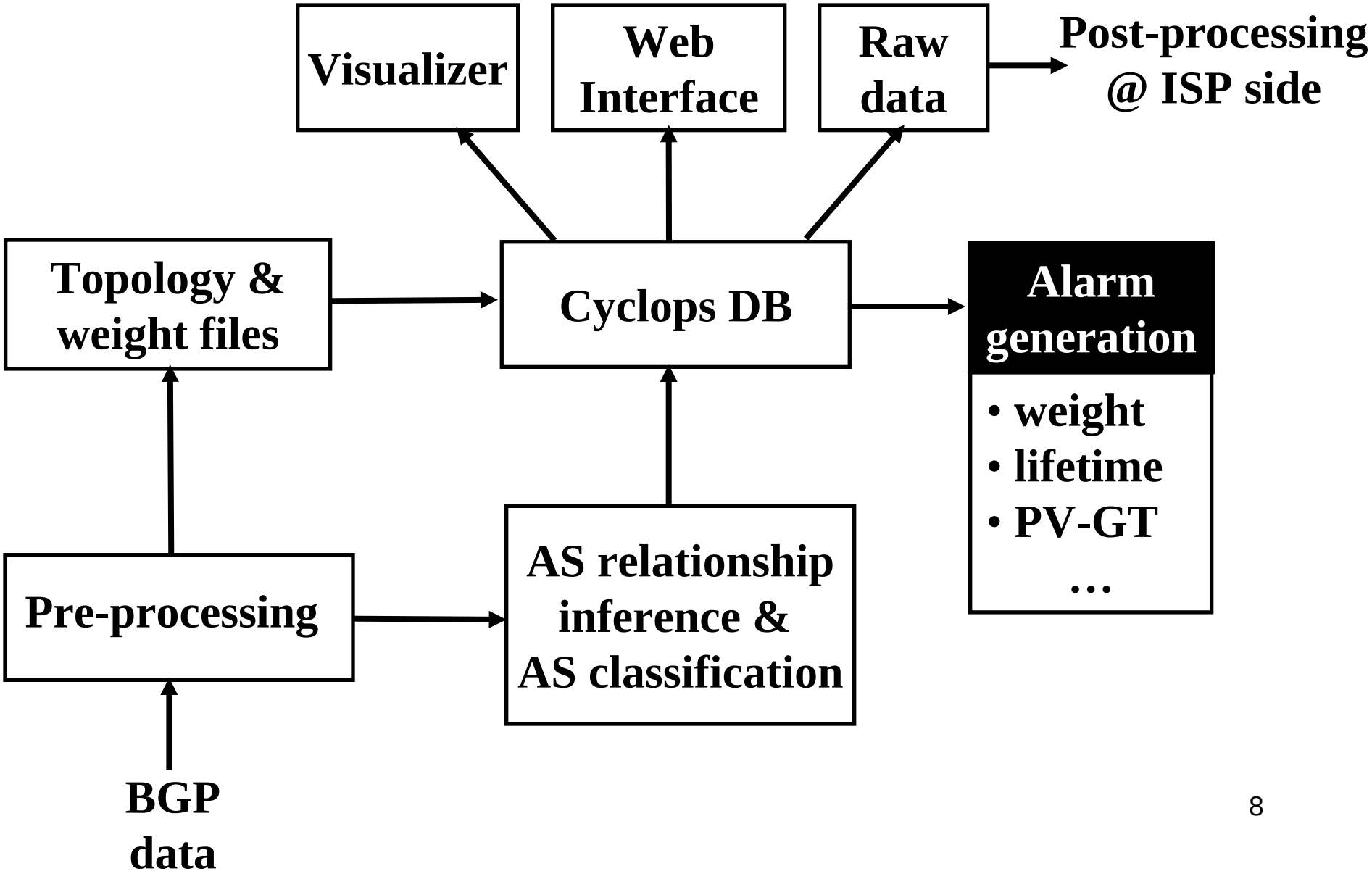


Visualizer: enables visual correlation of changes

Cyclops in a nutshell

- Comparison between **PV and ground truth;** contrast the **observed** connectivity with the **intended** connectivity
- Display changes-only view + snapshot view
- Search for **anomalous** (de)peering events
- **Event correlation** and root-cause inference

Cyclops architecture



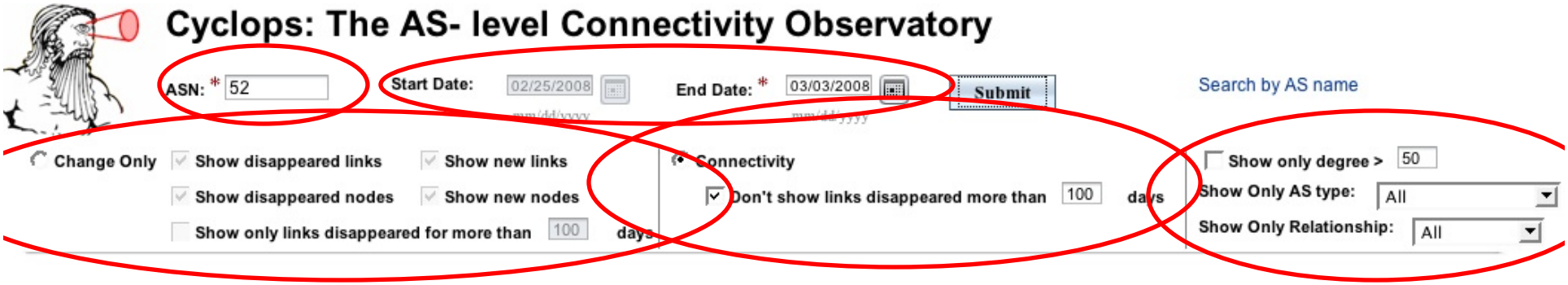
Cyclops raw data

- Available at **http://cyclops.cs.ucla.edu/rawdata**
- Last digit of ASN is the directory to look at, e.g. UCLA AS-52 is at **http://cyclops.cs.ucla.edu/rawdata/2/52.20080313**
- `2153@CSUNET-NE - California State University Network@Transit-Unknow@Provider@42@2003-12-31@2008-03-13@1532@TABLE_DUMP|1205284560|B|134.55.200.1|293|128.97.0.0/16|293 2153 52|IGP||||||`
- Known valid UCLA neighbors: AS2153 an AS2152
  - Everything else that appears connected to UCLA should trigger an alarm
- Easy to setup a script to periodically download these files and process them using filters to produce **an alarm list**

Web interface

- Allow users to have a quick view of the snapshot+connectivity
- Two modes:
  - **“Change only”**
  - **“Connectivity”**
- Allow filtering and sorting by relevant parameters

Web Interface

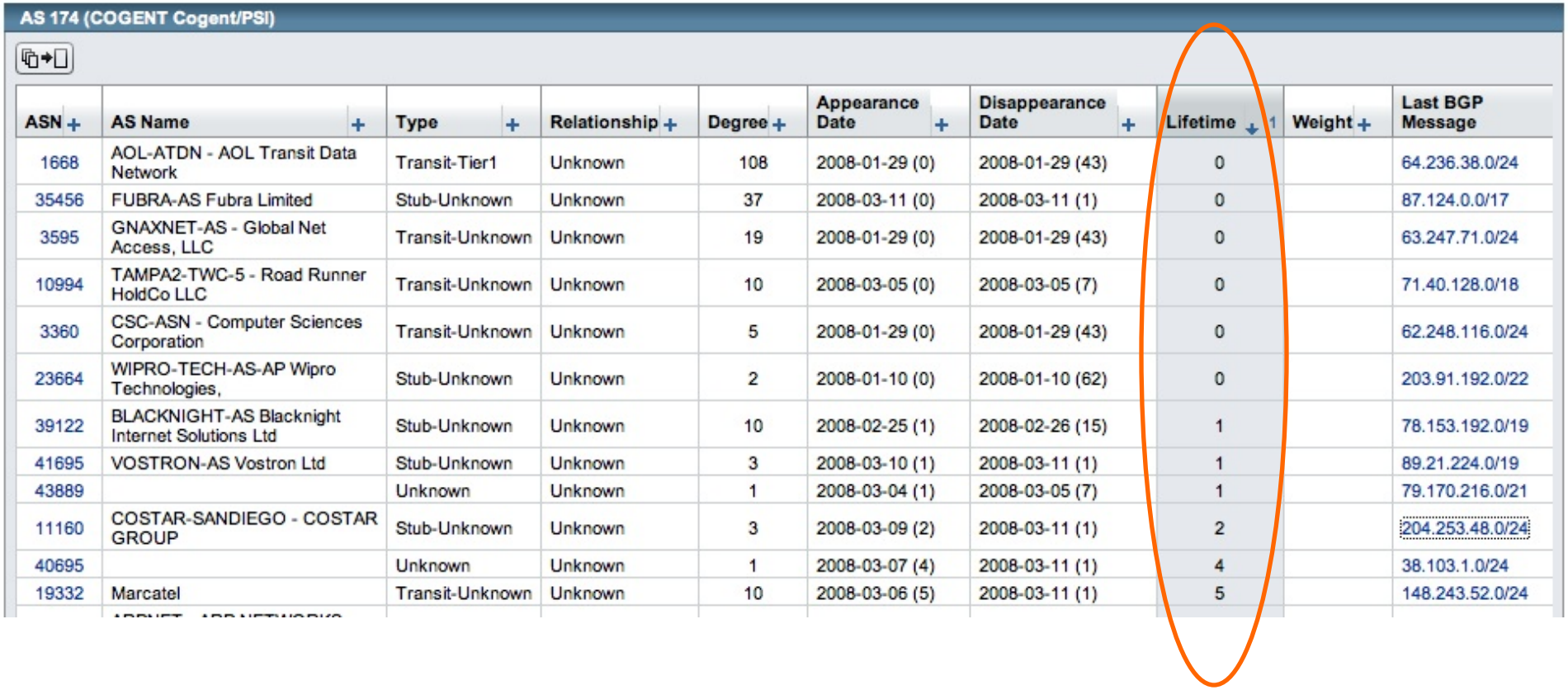


Showing 3 links of AS 52 (on 2008-03-03)

AS 52 (UCLA - University of California, Los Angeles)

ASN	AS Name	Type	Relationship	Degree	Appearance Date	Disappearance Date	Lifetime	Weight	Last BGP Message
11164	TRANSITRAIL - National LambdaRail, LLC	Transit-Unknown	Peer	126	2007-09-01 (104)	2007-12-14 (80)	104		
2152	CSUNET-NW - California State University Network	Transit-Unknown	Provider	111	2003-12-31 (1518)	2008-02-26 (6)	1518		
2153	CSUNET-NE - California State University Network	Transit-Unknown	Provider	42	2003-12-31 (1518)	2008-02-26 (6)	1518		192.154.2.0/24

Detecting anomalies



AS 174 (COGENT Cogent/PSI)

ASN	AS Name	Type	Relationship	Degree	Appearance Date	Disappearance Date	Lifetime	Weight	Last BGP Message
1668	AOL-ATDN - AOL Transit Data Network	Transit-Tier1	Unknown	108	2008-01-29 (0)	2008-01-29 (43)	0		64.236.38.0/24
35456	FUBRA-AS Fubra Limited	Stub-Unknown	Unknown	37	2008-03-11 (0)	2008-03-11 (1)	0		87.124.0.0/17
3595	GNAXNET-AS - Global Net Access, LLC	Transit-Unknown	Unknown	19	2008-01-29 (0)	2008-01-29 (43)	0		63.247.71.0/24
10994	TAMPA2-TWC-5 - Road Runner HoldCo LLC	Transit-Unknown	Unknown	10	2008-03-05 (0)	2008-03-05 (7)	0		71.40.128.0/18
3360	CSC-ASN - Computer Sciences Corporation	Transit-Unknown	Unknown	5	2008-01-29 (0)	2008-01-29 (43)	0		62.248.116.0/24
23664	WIPRO-TECH-AS-AP Wipro Technologies,	Stub-Unknown	Unknown	2	2008-01-10 (0)	2008-01-10 (62)	0		203.91.192.0/22
39122	BLACKNIGHT-AS Blacknight Internet Solutions Ltd	Stub-Unknown	Unknown	10	2008-02-25 (1)	2008-02-26 (15)	1		78.153.192.0/19
41695	VOSTRON-AS Vostron Ltd	Stub-Unknown	Unknown	3	2008-03-10 (1)	2008-03-11 (1)	1		89.21.224.0/19
43889		Unknown	Unknown	1	2008-03-04 (1)	2008-03-05 (7)	1		79.170.216.0/21
11160	COSTAR-SANDIEGO - COSTAR GROUP	Stub-Unknown	Unknown	3	2008-03-09 (2)	2008-03-11 (1)	2		204.253.48.0/24
40695		Unknown	Unknown	1	2008-03-07 (4)	2008-03-11 (1)	4		38.103.1.0/24
19332	Marcatel	Transit-Unknown	Unknown	10	2008-03-06 (5)	2008-03-11 (1)	5		148.243.52.0/24

Suspicious ephemeral routes, most likely misconfigurations or malicious attacks

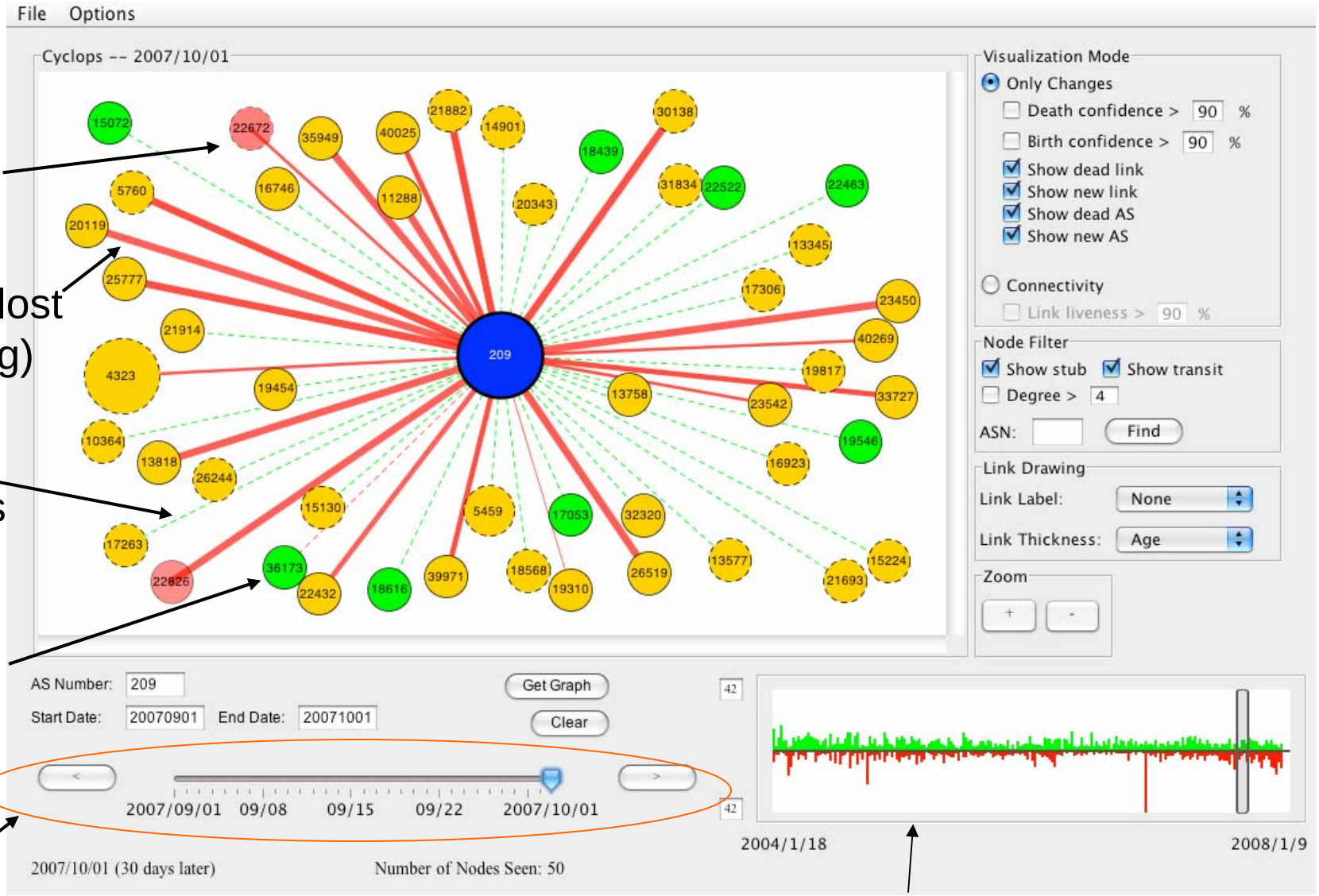
Detecting anomalies

AS 174 (COGENT Cogent/PSI)

ASN	AS Name	Type	Reltn.	Deg.	First App.	Disapp. Date	Age	Weight (To) Avg.	Weight (To) Diff.
30912	DCSNET-GLOBAL-TRANSIT-AS DCS.net	small ISP(17)	Provider	8	2007-02-26		455	1182.63	1182.63
16559	REALCONNECT-01 - RealConnect, Inc	Stub(1)	Provider	72	2005-03-23		1160	2037.92	466.72
3267	RUNNET-AS RUNNet	large ISP(252)	Provider	238	2007-11-15		193	1322.39	419.74
6730	SUNRISE sunrise (TDC Switzerland AG)	large ISP(111)	Provider	659	2004-02-17		1560	255.77	255.77
20485	TRANSTELECOM JSC Company TransTeleCom	large ISP(1746)	Provider	572	2005-08-11		1019	165.78	165.78
5462	CABLEINET Telewest Broadband	large ISP(52)	Provider	408	2004-03-03		1545	158.07	158.07
2914	NTT-COMMUNICATIONS-2914 - NTT America, Inc.	Tier-1(10603)	Provider	757	2003-12-31		1608	617.41	147.97
812	ROGERS-CABLE - Rogers Cable Communications Inc.	large ISP(88)	Provider	110	2003-12-31		1608	440.97	142.66

Cyclops also keep tracking of number of routes in each link; possible to sort links by weight variation

Cyclops Visualizer



Dead AS

Peerings lost (depeering)

New peerings

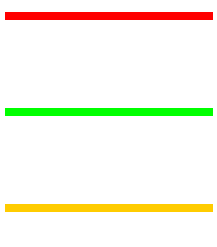
New AS

Time slider

Activity Plot

Visualizer Components

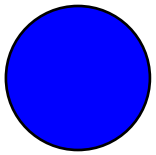
- **Main layout**



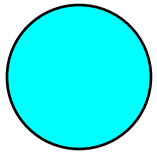
Disappeared link/node

New link/node

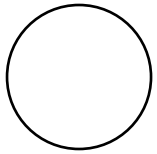
Existing link/node



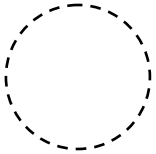
Cyclops' eye



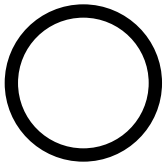
Expanded node



stub



transit



tier-1

• Link thickness represents link weight (#prefixes, age)

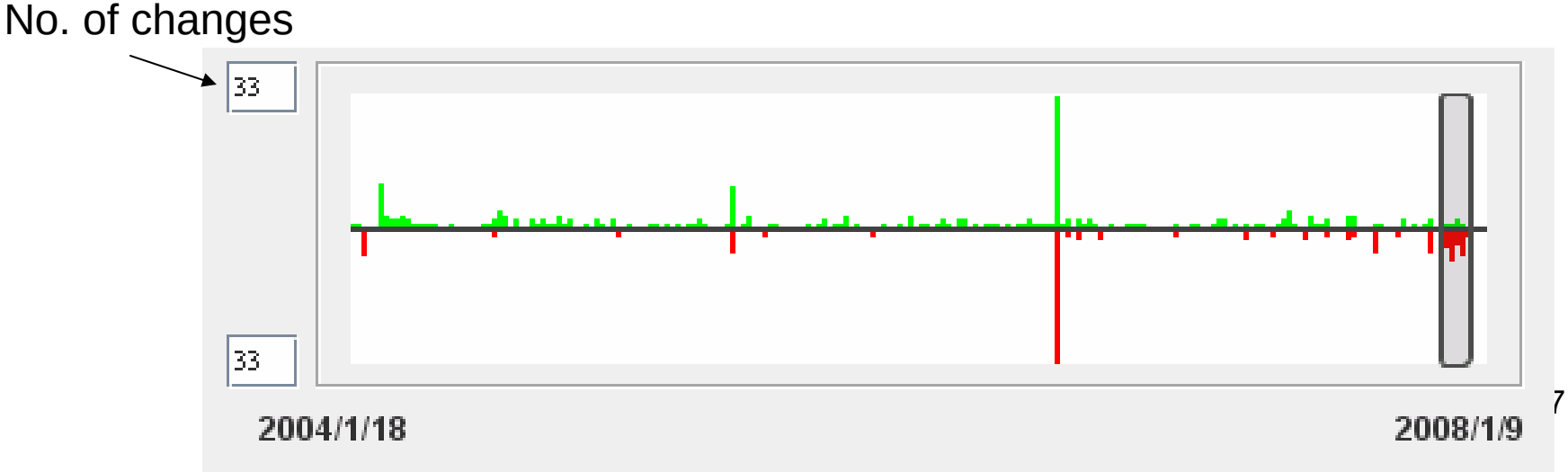
• Transparency represents change confidence

Cyclops Visualizer

- **Event correlation:** enables visual correlation of events happening in different ASes
- **Activity plot:** help identify periods of "anomalous" number of AS connectivity changes
- **Time slider:** finer control over time window

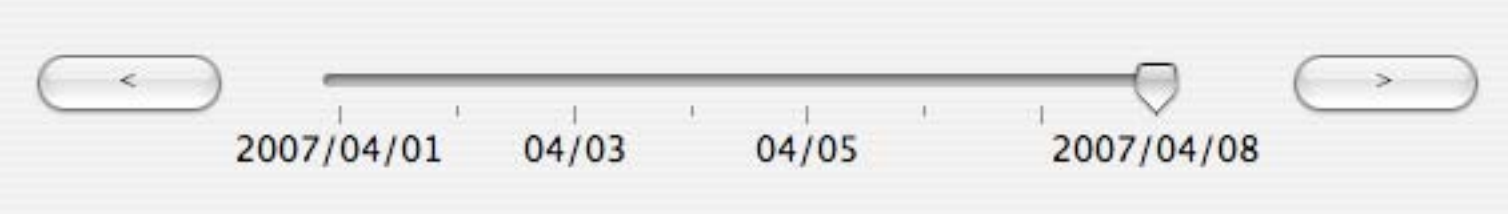
Visualizer components

- **Activity graph:** makes it easier to spot abnormal events, e.g. massive depeerings
  - each bar represents changes aggregated over 1 week
  - top green bars represent new peerings; bottom red bars represent depeerings
  - Vertical scale can be set by the user
  - Grey slider allows to focus on period of interest

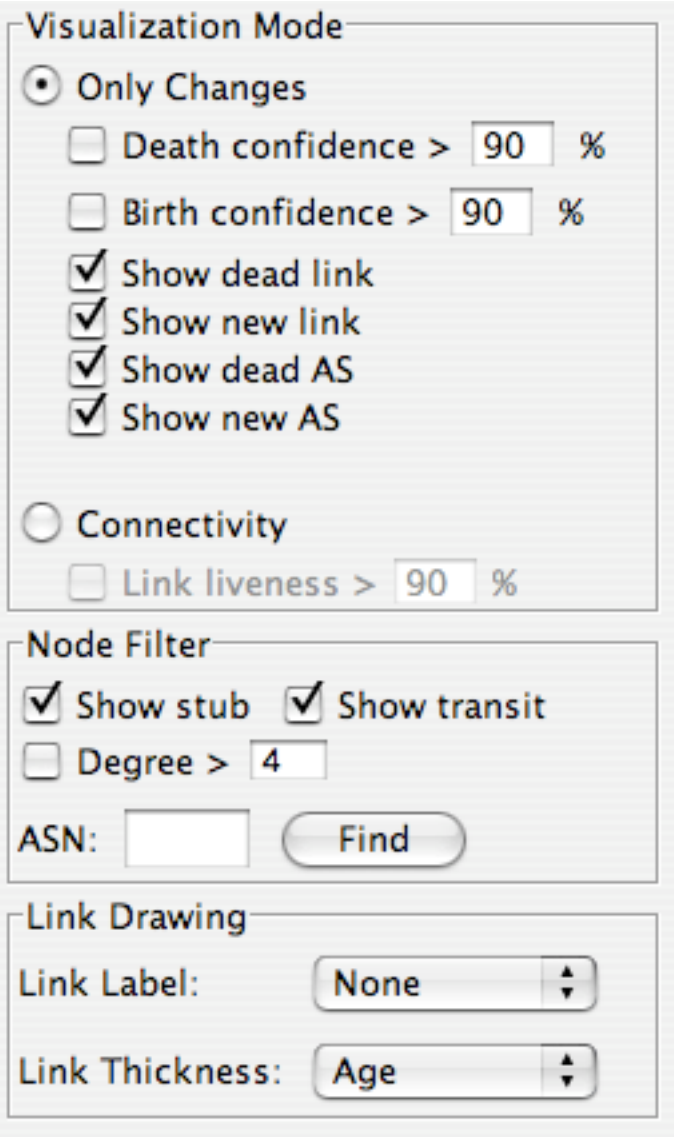


Visualizer Components

- **Time slider**: fine gain control of the observation time we're interested; allows to move to next/previous change



Visualizer components



- **Visualization modes:**

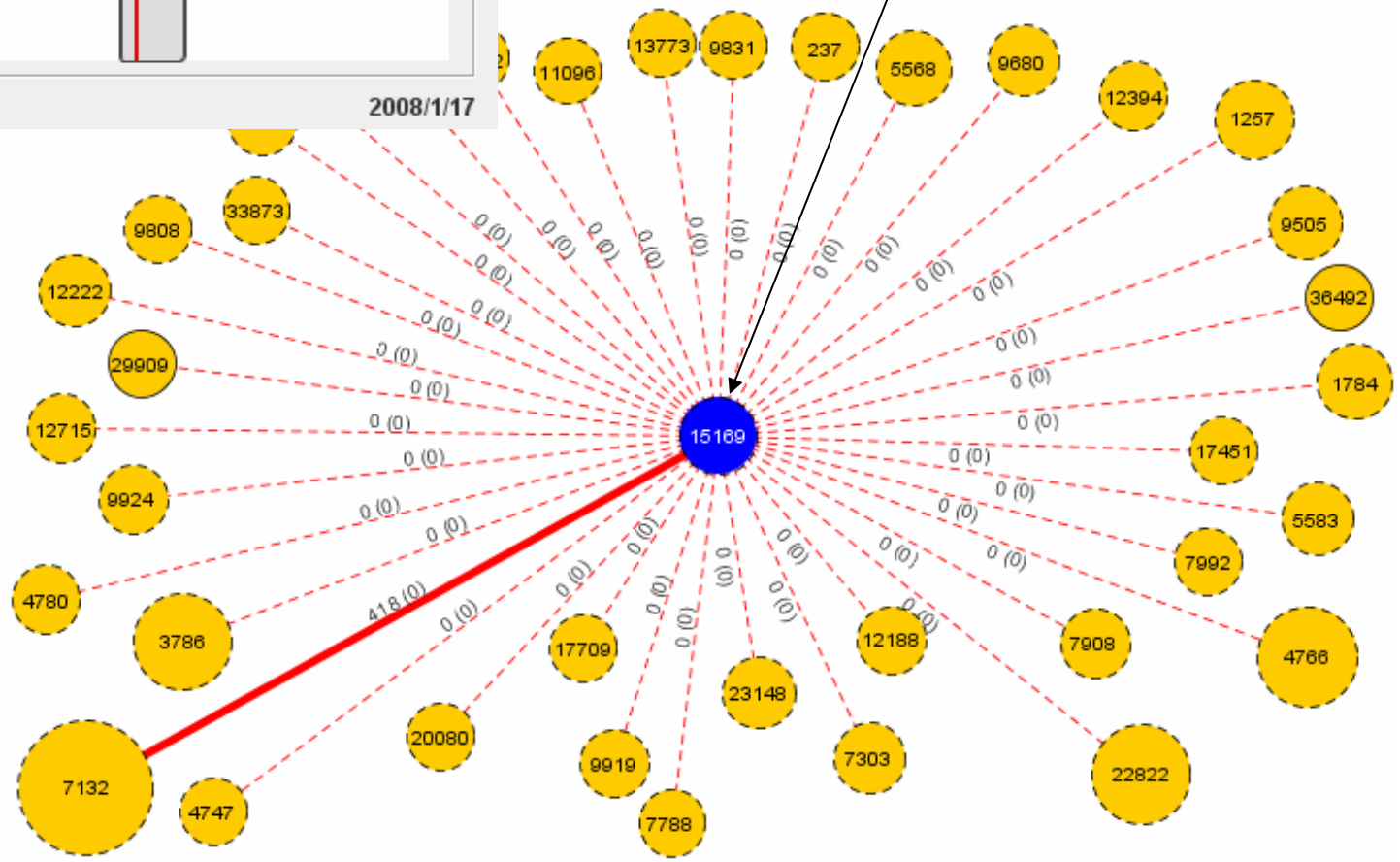
- "*Only changes*" display only the changes in the relevant time period; changes can be filtered by confidence [sigcomm'07]

-"*Connectivity*" displays the topology snapshot at a given time

- **Other options:**

- filters by type of AS and degree
- configure link labels and thickness, e.g. #routes, age

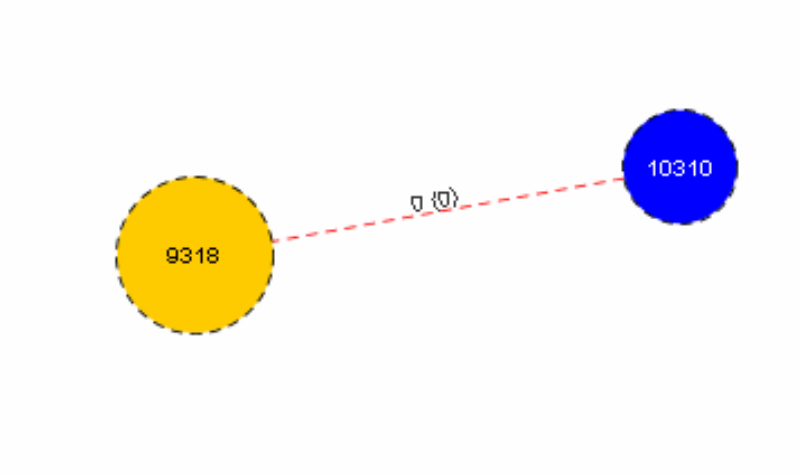
Case study #1: Google's route leakage



July 19, 2006

Activity plot helps spot anomalous changes

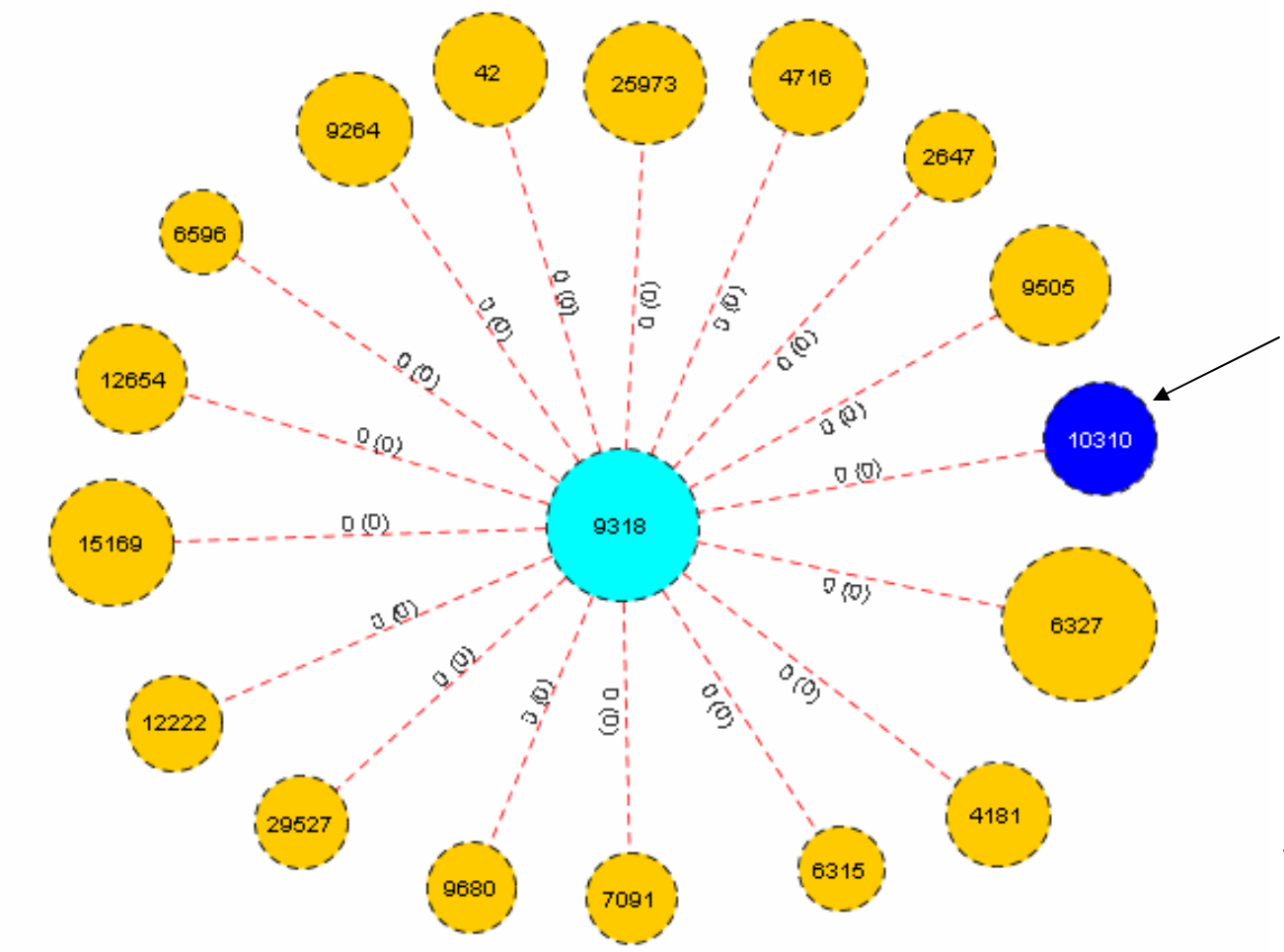
Case #2: Yahoo's outage



July 6, 2007

After studying Yahoo's connectivity, we noticed a transient peering with AS9318

Case #2: Yahoo's outage



July 6, 2007

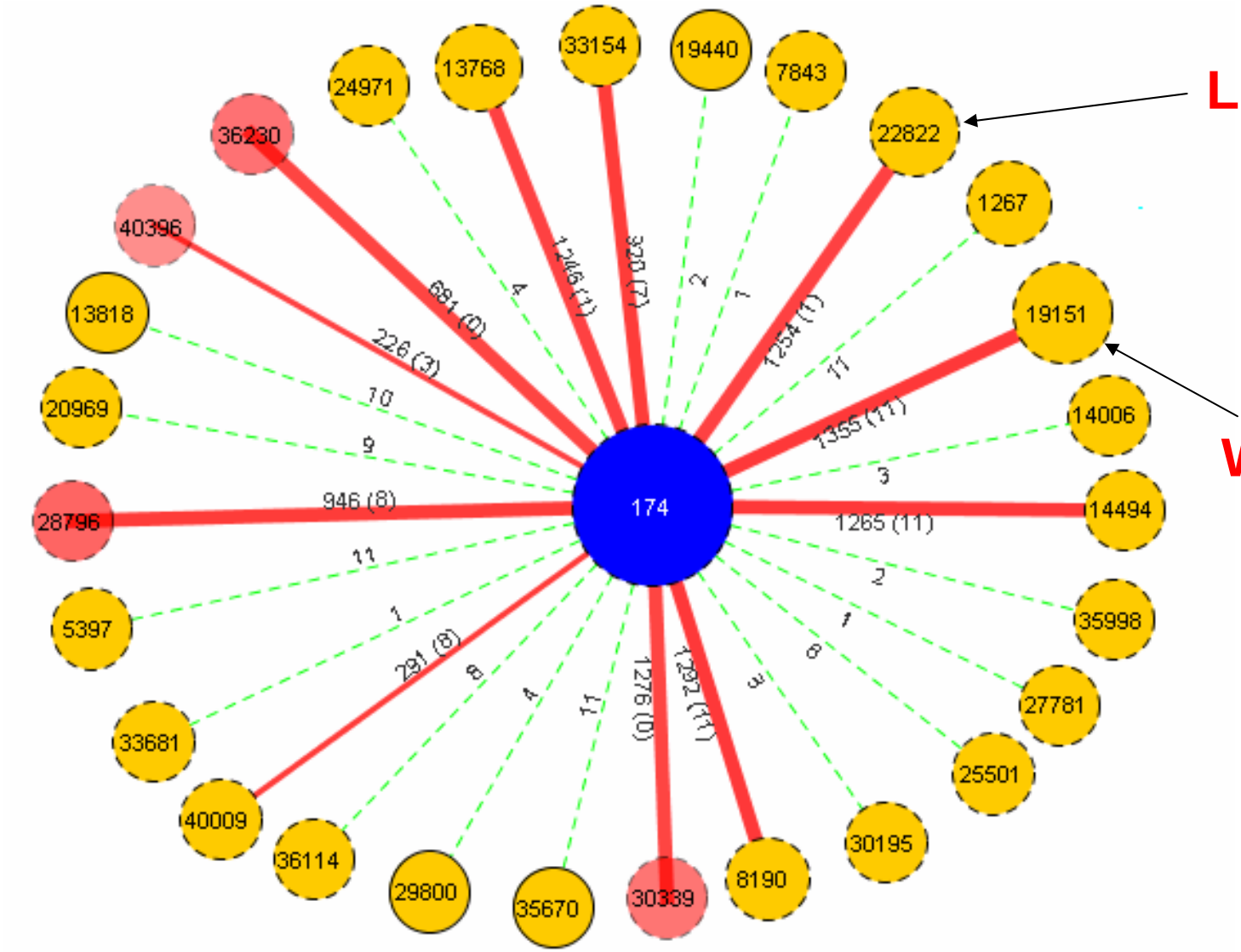
AS 9318's route leakage caused Yahoo's outage

`http://isc.sans.org/diary.html?storyid=3112`

Case#3 Cogent depeerings (9/15 – 29)

“Did Cogent depeer Limelight, WV FIBER, and nLayer?”
@Nanog mailing list, Sept 28th 2007

Case#3 Cogent depeerings (9/15 – 29)



Apparently nLayer not depeered…

Future work: Cyclops' alarms

- Idea is to allow ISPs to register for alarms; examples of alarms are:
  - Large shifts in number of routes/link
  - Links with very short lifetime
  - Differences between PV-GT (ground truth)
- Feature under development, would like to hear ISP ideas about this; who would like to sign up for these alarms?

Req Feedback

- We encourage everybody to try it out (the server can be down if all try at same time;))

  http://cyclops.cs.ucla.edu

- What would you like to change in Cyclops?
- What new functionality you would like to see?
- Did it help diagnosing some problem in your network? Let us know!
- And please report any data inconsistency

More resources

- AS-level connectivity raw data
  http://cyclops.cs.ucla.edu/rawdata

- Cyclops mailing list:
  http://www.cs.ucla.edu/mailman/listinfo/cyclops

- IRL topology page
  http://irl.cs.ucla.edu/topology

Send all questions and comments to **cyclops@lists.cs.ucla.edu** Thanks!