BGP SECURITY
PAST, PRESENT & PIPA

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Outline

- **Introduction**
- **Related Work**
- **Proposed Solution**
- **Experimental Results**
- **Conclusion**

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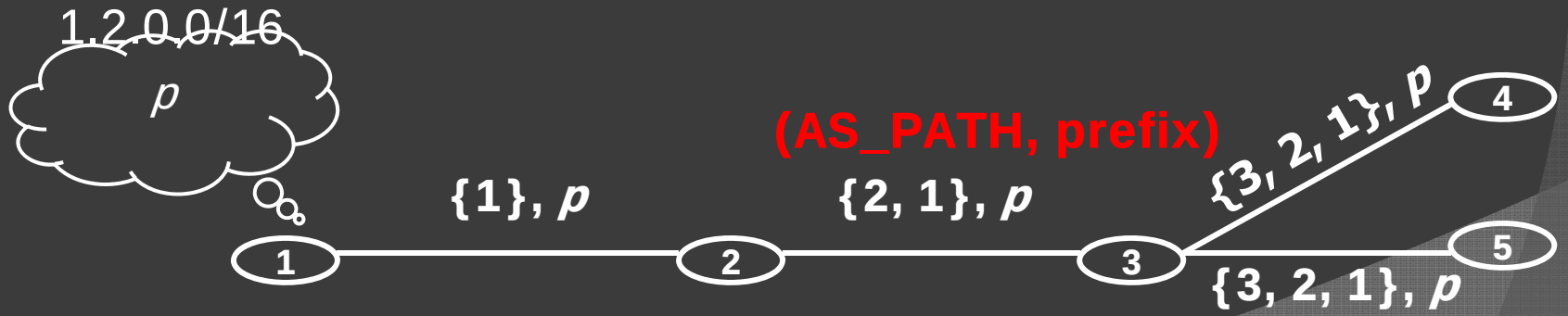
Internet Abstractions

- Collection of Hosts, Routers,Point of Presence(PoP's) or
- Autonomous System(AS)
  - An AS is a connected group of one or more IP prefixes run by one or more network operators which has a SINGLE and CLEARLY DEFINED routing policy(RFC 1930)

Border Gateway Protocol (BGP)

- Inter-domain routing protocol(Inter AS)
  - Critical Communications and Business Infrastructure!
- Vulnerable to different threats
  - Configuration/Human Errors
    - "Patches" applied as threats are exploded
    - E2E solutions require collaboration



Prefix Hijacking 101

- Announce someone else's prefix
- Announce a more specific of a someone else's prefix
- Synopsis: You are trying to “steal” someone else’s traffic by getting it routed to you.
- Capture, sniff, redirect, manipulate traffic as you wish.

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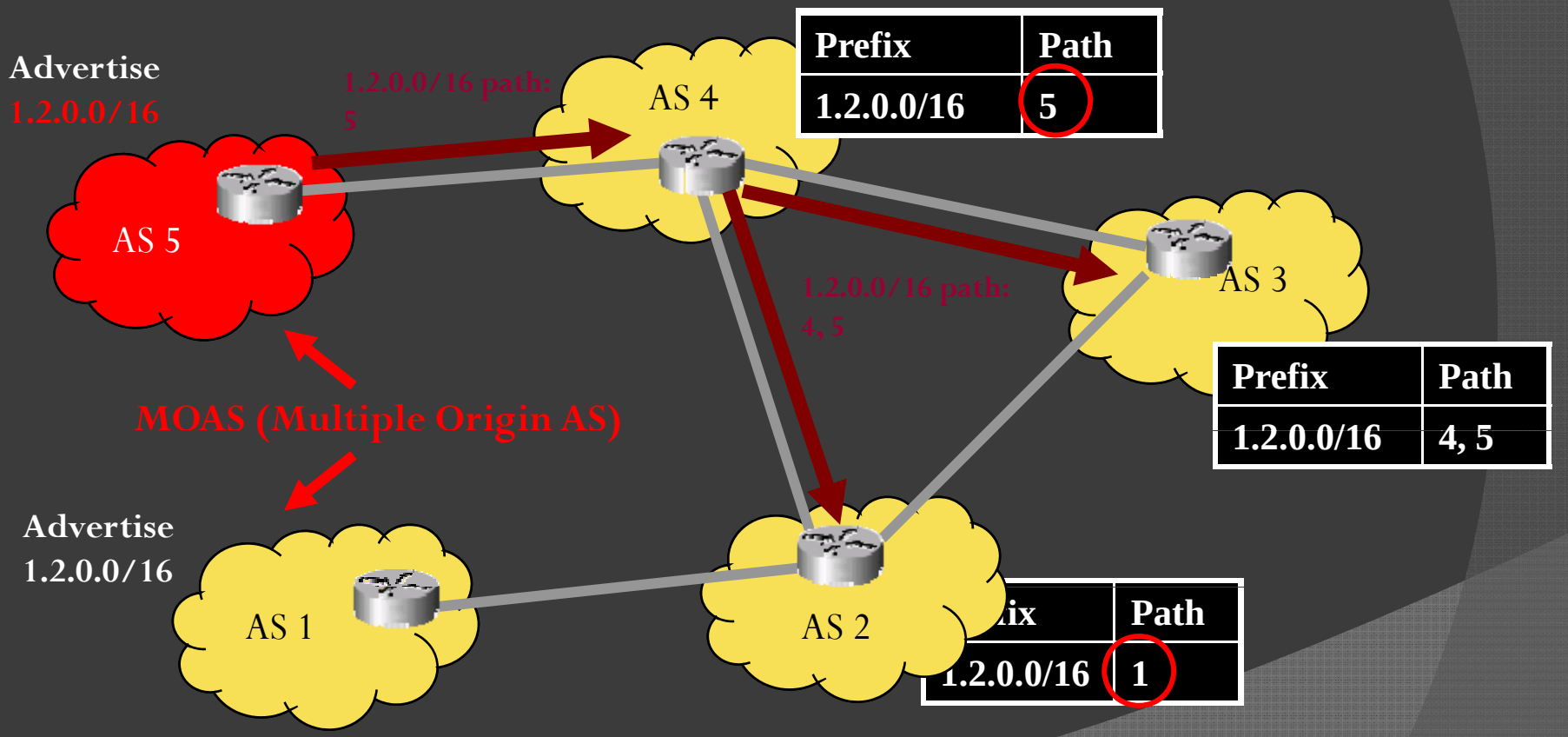
Prefix Hijacking…simple case



Types of Prefix hijacking(PH)

[Type1]Prefix hijacking /Duplicate PH

- AS1 owns 1.2.0.0/16 but advertised by AS2

[Type2]Sub prefix hijacking

- AS2 advertises 1.2.3.0/24

[Type3]AS Path Spoofing

- AS5 announce [5 1] without having peering with AS1

[Type4]Independent PH

- AS2 use Bogons (unused address space)

[Type5]Man in the middle (MITM) Attacks

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BGP Prefix hijacking Incidents

- Did AS13214 really hijack the Internet?
  - http://bgpmon.net/blog/?p=80
- Cyclops detects global routing leak by AS13214
- Don't be afraid of AS3130..April 2009
  - http://cyclops.cs.ucla.edu/
- WorldofWarcraft.com and WoWarmory.com sub-prefix hijacked (July 2008)
- YouTube's prefix hijacked by Pakistan Telecom February 2008

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Major Research Groups

- University of California Los Angeles(Lixia Zhang)
  - Internet Research Lab(irl)
- CAIDA
- Colorodo State University (Dan Massey)
  - Network Security Research Group
- University of Princeton(Jennifer Rexford)
  - Incrementally Deployable Secure Interdomain Routing
- University of Michigan(Z.Morley Mao)
  - RobustNet Group

Major Research Groups

- National Institute of Standards and Technology(Advanced Network Technologies Division)
  - Trustworthy Networking
  - BGP Security and Routing Robustness
  - http://w3.antd.nist.gov/
- University of Swinburne (Geoff Huston)
  - CAIA
- UCL,Loouvain-la-Neuve,Belgium(Olivier Bonaventure)
  - INL:IP Networking Lab

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BGP Solutions Categories

- Prevention
  - S-BGP,SO-BGP,SPV
- Mitigation
  - Wang et.al,PG-BGP,Zhang et al.Anycast Routing
- Detect & Alert
  - myASN,IAR,Phas->Cyclops,BGPmon.net
- Detect & Recover
  - Probabilistic IP Prefix Hijacking(PIPA)

Table 1 : Prefix Hijacking Solutions

	Detection System	Alarm Type	Prefix/ Duplicate PH	Subprefix PH	Super/ Independent PH	Path Spoofing	MITM
PHAS [mohit et al]	H	Origin, Last Hop, Sub Allocation	Y	Y	N	limited	N
PG-BGP [J.Karlin et al]	H	Prefix, Sub Prefix	Y	Y	N	Y	limited
K.Sriram et al. [	H+R	N	Y	Y	N	Y	N
Nemecis	R	N	Y	Y	N	N	N
Hu et al.	H	N	Y	Y	N	Y	N

Table 1 : Taxonomy of Prefix Hijacking Solutions (PH: Prefix Hijacking, Y: yes, N: No, H: History, R: Registry, Un: Unreachability, MITM: Man In The Middle)

Cyclops..AS-Centric Visualization tool

- Data sources
  - BGP routing tables + updates: Route Views, RIPE, Abilene, CERNET BGP View
  - Route Servers: Packet Clearing House, UCR, traceroute.org, Route Server Wiki
  - Looking Glasses: traceroute.org, NANOG, Looking Glass Wiki
- Others
  - Mapnet,Otter,HERMES,VAST,FixedOrbit

http://cyclops.cs.ucla.edu/

Some More tools

- PCH-Prefix Sanity Checker
- RIPE-MyASN Service
- BGPPlay
- BGPmon.net

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Tools to use & get inspiration

Linux Distribution(Ubuntu),Java,C/C++,Perl,Python, mySQL,…

- Quagga 0.99.14
- IRRd - Internet Routing Registry 2.3.9
- Irrtoolset 4.8.5
- IrrPowerTools
- StraighRV
- MRT dump file manipulation toolkit(MDFMT) version 0.2
  - BGP4MP
  - TableDump V2
- Prefixanalyzer
- Pybgpdump
- Dpkt 1.6
- LinkRank Beta 02

- ....

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PIPA Data Sources

- RIR/Internet Route Registry(IRR)
  - Registration information/Policy Information
    - RADb,RIPE,ARIN,APNIC
- BGP Data Collectors
  - RouteViews(240), RIPE-RIS(>600)
    - No. of BGP collector deployed around the world
- New Data Source [unreachability information]
  - Hubble Project/iPlane[Ethan K.et al]

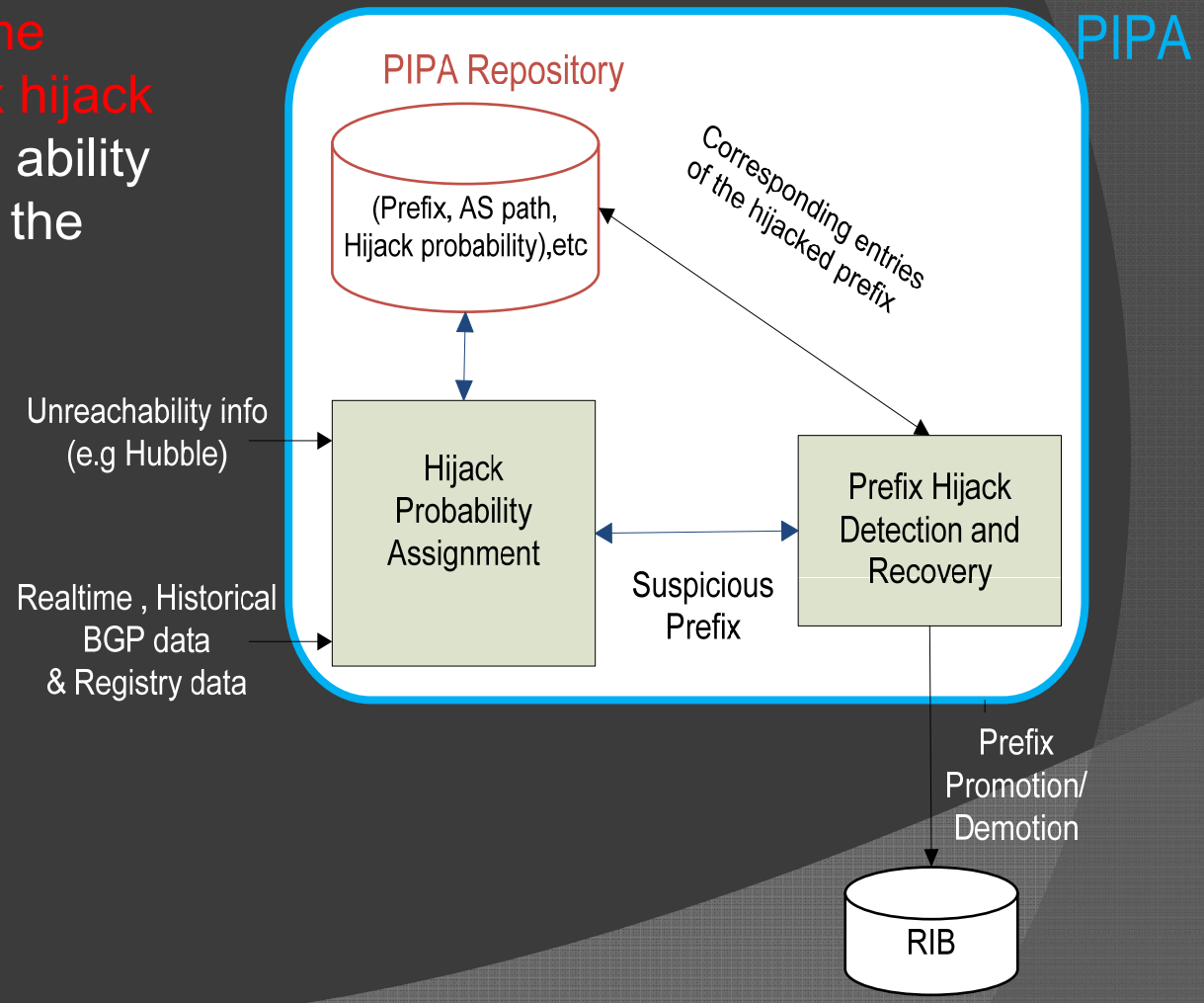
How is Unreachability helpful?

- Internet Goals : Global Reachability
- Prefix hijacking can affect some of the Ases.
  - E.g. AS5 hijacked the Prefix of AS1 and black hole all the traffic
  - Applications in some AS will observe Unreachability
- There are projects like Hubble/iPlane which provides information about the blackholes & unreachabilities duration
  - Help detecting prefix hijacking
  - Pinpointing the location of hijacker

Probabilistic IP Prefix Authentication (PIPA)

Continuously update the Probability of prefix hijack based on its reach ability information around the world

Possible promotion /demotion of historically best BGP Path of certain prefix



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Hijack Probability Assignment

- Every Prefix can be assigned a Hijack Probability based on it's conformance with
  - Historical Standings
  - Registry Standings
  - Real time Unreachability statistics
- Non conformance with History/Registry can raise early Alarms and Recovery process can be started.
  - Probability score can be continuously updated based on real time statistics i.e. BGP updates, etc.

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Prefix Hijack Detection Challenge

- How to differentiate between different unreachability
  - Unreachability due to equipment failures , line cuts, etc.
- MITM: When there are no un-reachabilities
- How to detect MOAS conflicts
  - Registry data if accurately updated
  - Maintaining knows AS home Set
    - IP Prefix: 1.2.0.0/16
    - Owner AS: AS1
    - IP Prefix Homes : AS1,…

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Prefix Hijack Recovery

- Network operator announces more specific prefix to recover from Prefix hijack situation
  - Longest Prefix Matching Wins
  - But what if that is the one already hijacked.
    - Contact the malicious/misconfigured party or its provider
- PIPA based on its results can suggest to particular AS to use Previous used route which it was using before the introduction of new malicious or erroneous prefix

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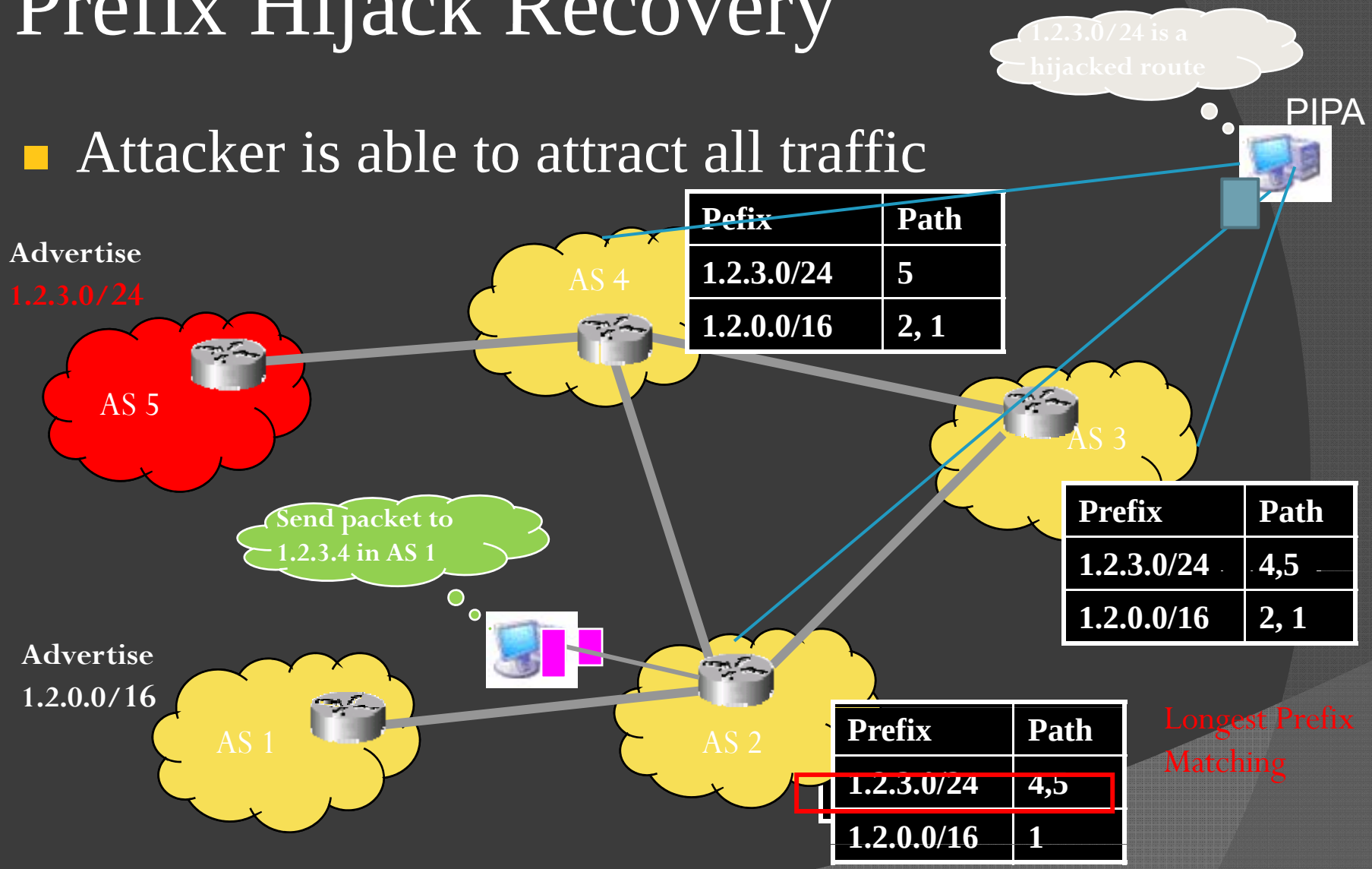
Prefix Hijack Recovery

- Attacker is able to attract all traffic



Pefix	Path
1.2.3.0/24	5
1.2.0.0/16	2, 1

Prefix	Path
1.2.3.0/24	4,5
1.2.0.0/16	2, 1

Prefix	Path
1.2.3.0/24	4,5
1.2.0.0/16	1

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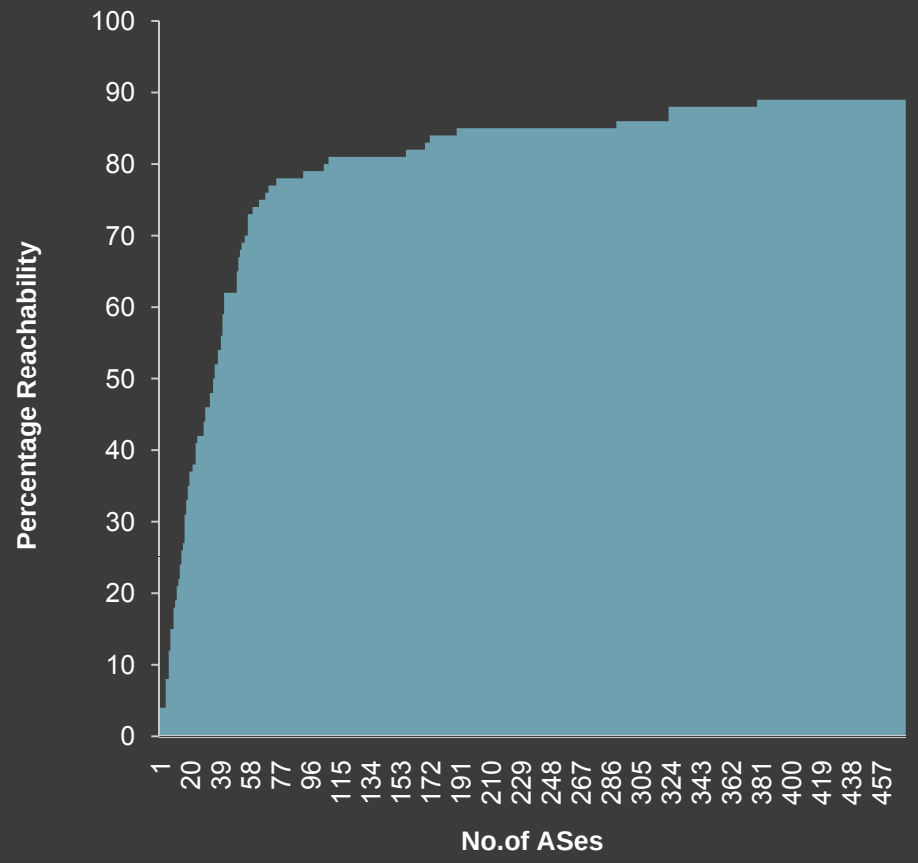
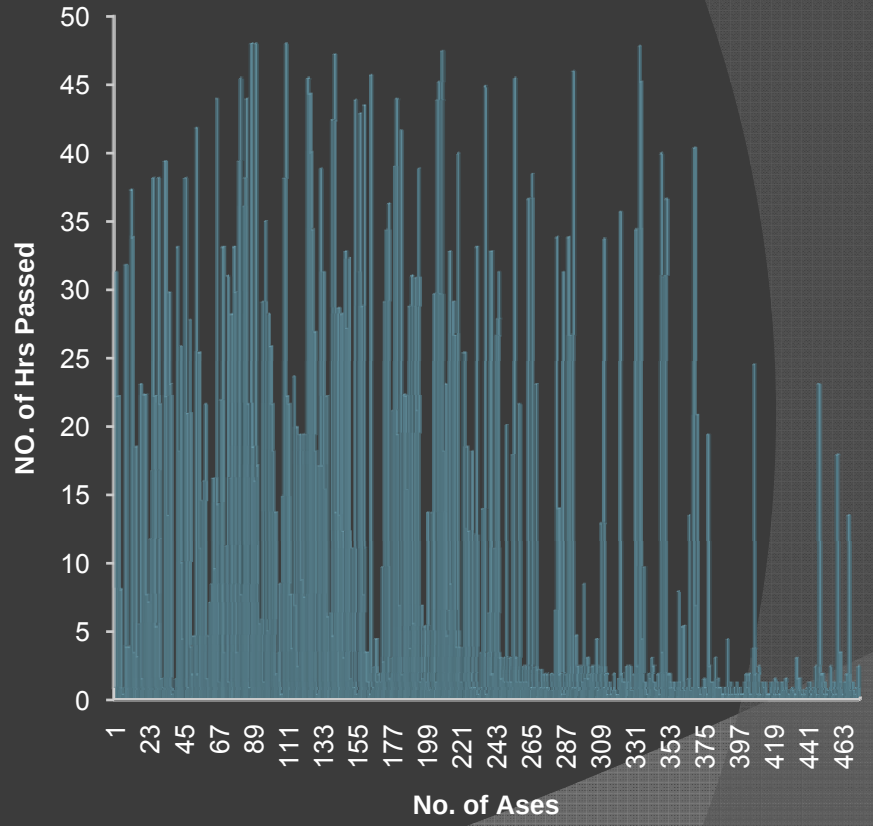
Ases Reachability



No.of Hrs Passed



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Experimental Methodology

- Initial experimental Results
  - Comparison of False Alarms with PGBGP
  - Data collected
  - PGBGP suspicious Announcements(5/2006-3/2009)
    - Provided by Josh Karlin
    - Public RIR/IRR data
    - Hubble unreachability statistics
  - Run checks to see whether routes are suspicious as announced by PGBGP IAR.

    Result: Too much suspicion is not good

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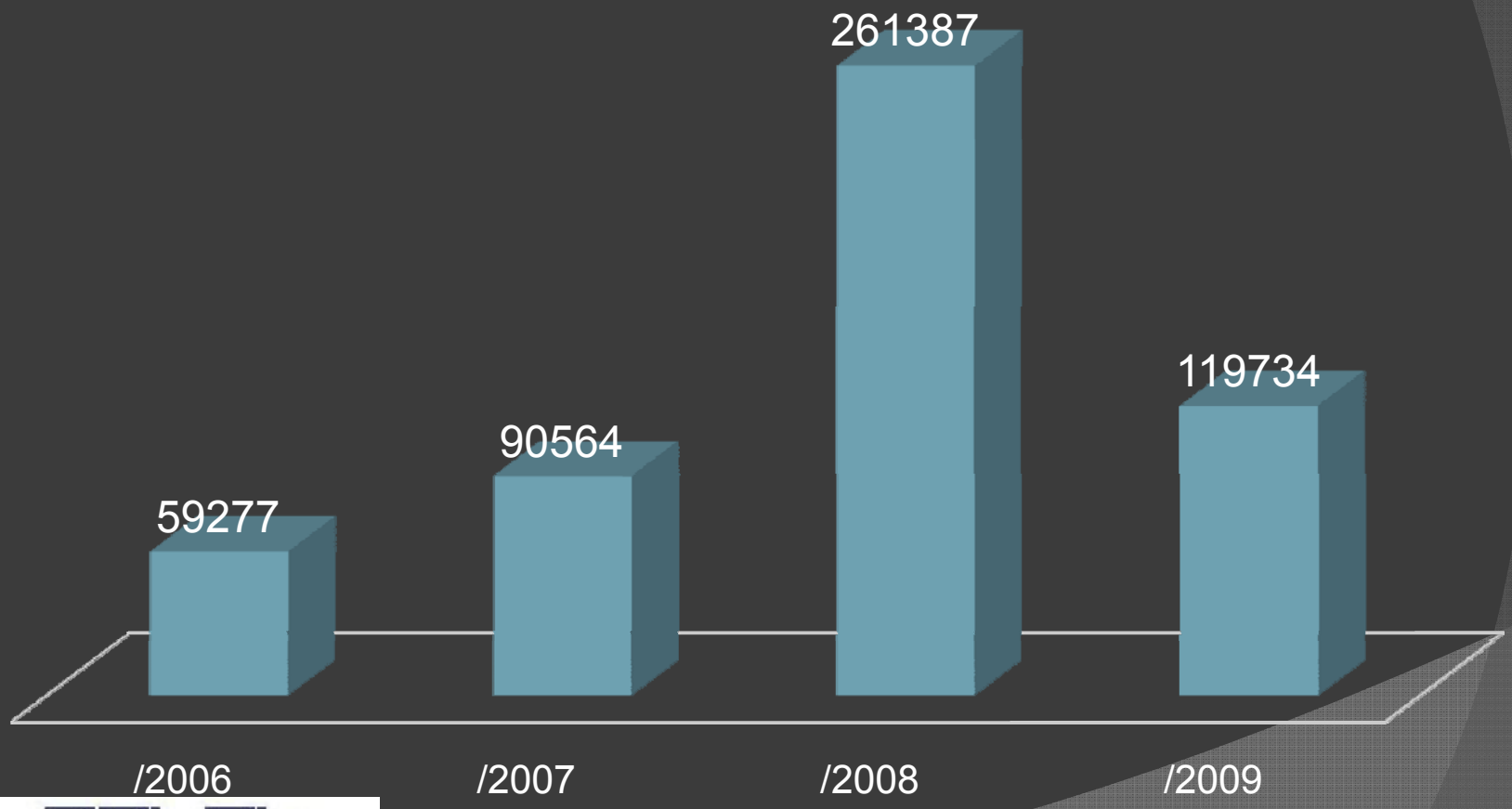
PG-BGP Alerts 5/2006-3/2009



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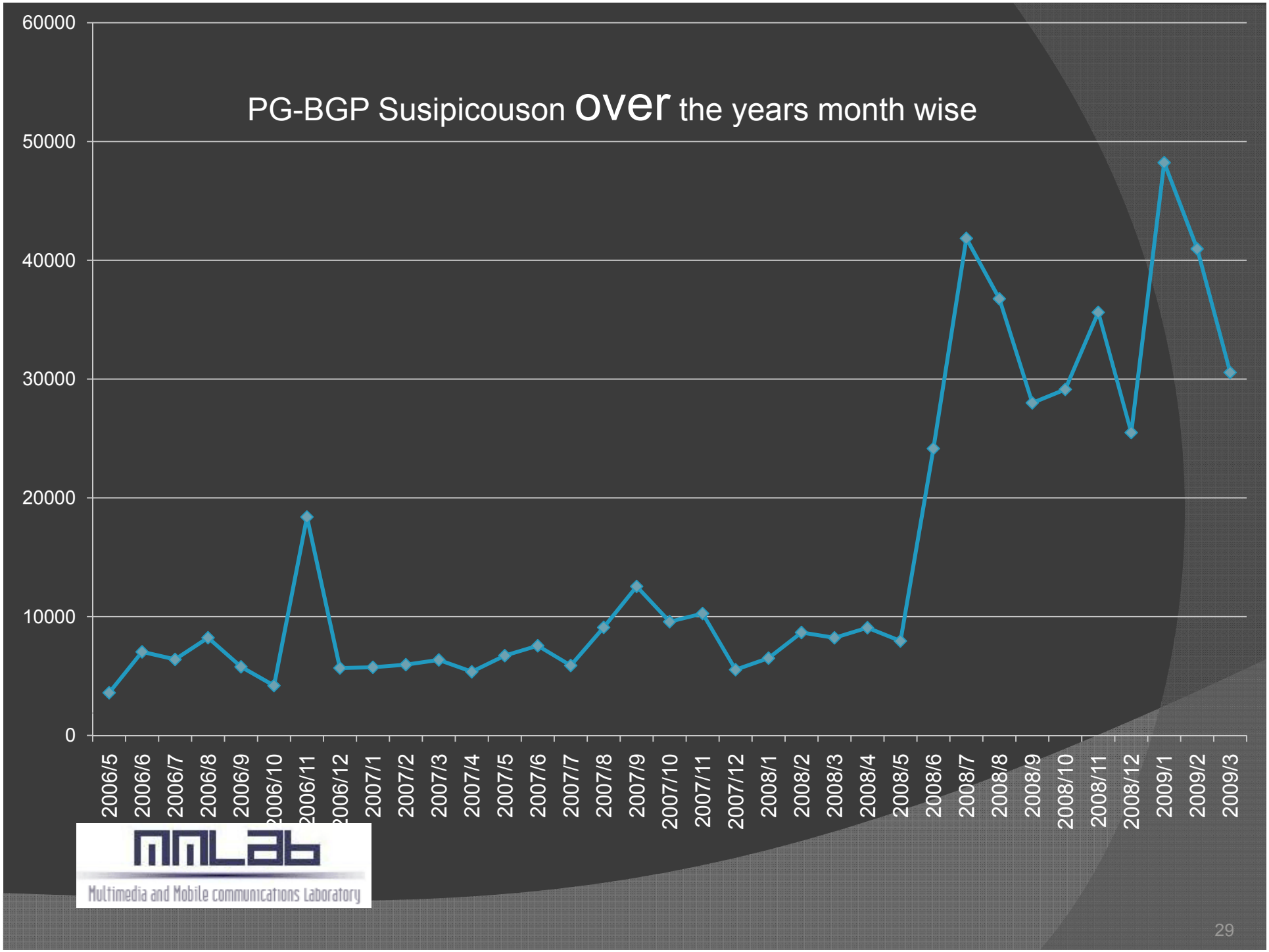

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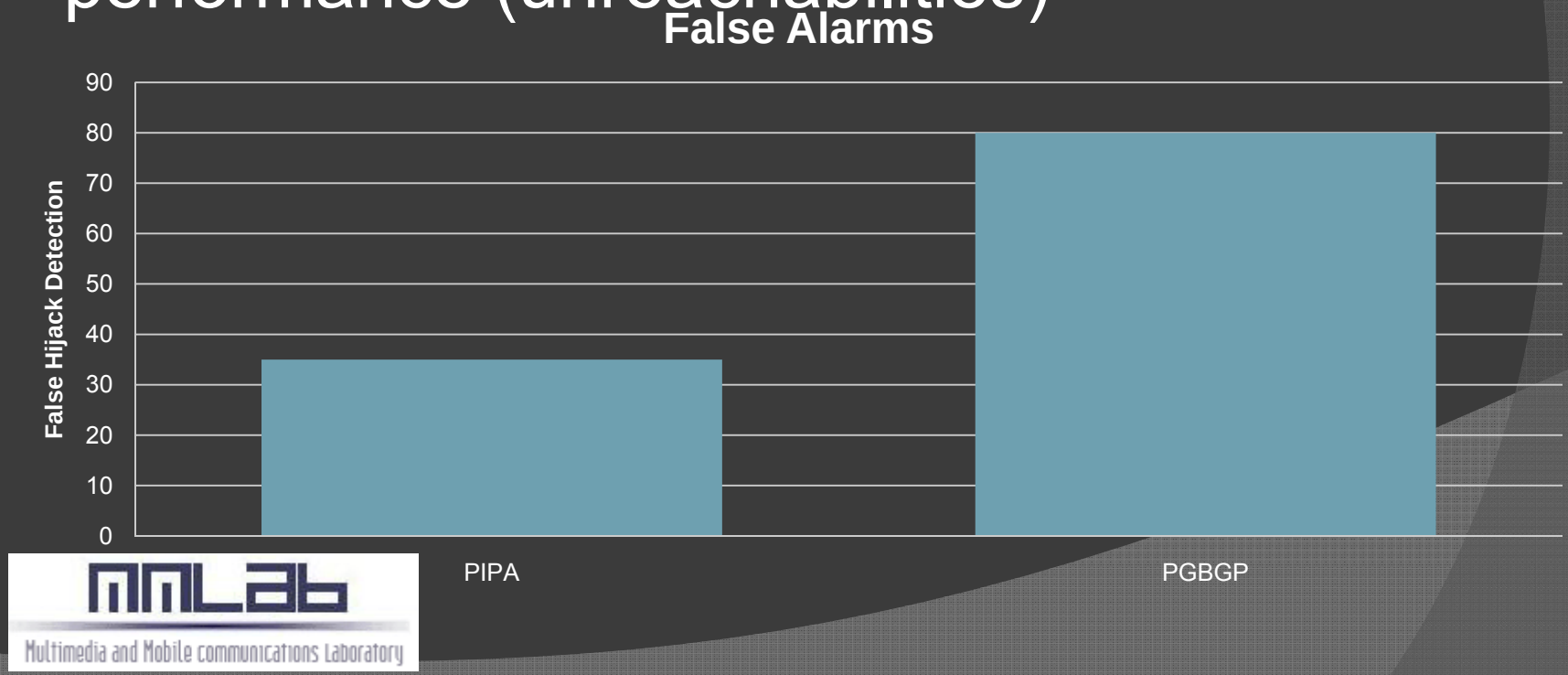
Comparison with PGBGP

- PGBGP-marks new routes suspicious if they do not conform to the History BGP[24 hrs]
- PIPA—Let them work but observer their performance (unreachabilities)



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Conclusion & Future Work

- Extensive Review of existing solutions
- Inclusion of New data source for PH detection
  - “unreachability” data collected in real time.
- Can Internet Self recover from PH?
  - Proposed PH recovery mechanism
  - Where can we find self healing property of Internet?
- We are working on the full level implementation and experimental results of

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Some ? To myself

- What about the current state of implementation of PKI for DNSSEC/Who IS.
  - How can we include/adopt that?
- How to deploy PIPA?
- How PIPA detects MITM?
- ??

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Thank You

Questions

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