Buddyguard: A Buddy System for Fast and Reliable Detection of IP Prefix Anomalies

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at:

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Routing Anomalies with an IP Prefix

- An IP Prefix (i.e. a block of IP addresses) can undergo many types of routing anomalies
  - The most well-known is probably prefix hijacking
  - Others include being unreachable, poorly reachable, or pathological routing dynamics
- Often not noticeable
- Consequences: loss of business, identity theft, or many other devastating effects

Problem Statement

- How can we monitor IP prefix anomalies reliably, even with the countermeasures from attackers?

Our Research

- *Research Goal*: investigate, design, and evaluate a new approach to reliable monitoring of IP prefixes.
- *Our Idea*: Surround a prefix with a buddy system, and monitor the behavior of the prefix against that of its buddies.

Outline of This Talk

- State of the art and limitations
- Overview of Buddyguard
- Design of Buddyguard
- Evaluation
- Discussions and conclusions

State of the Art and Limitations

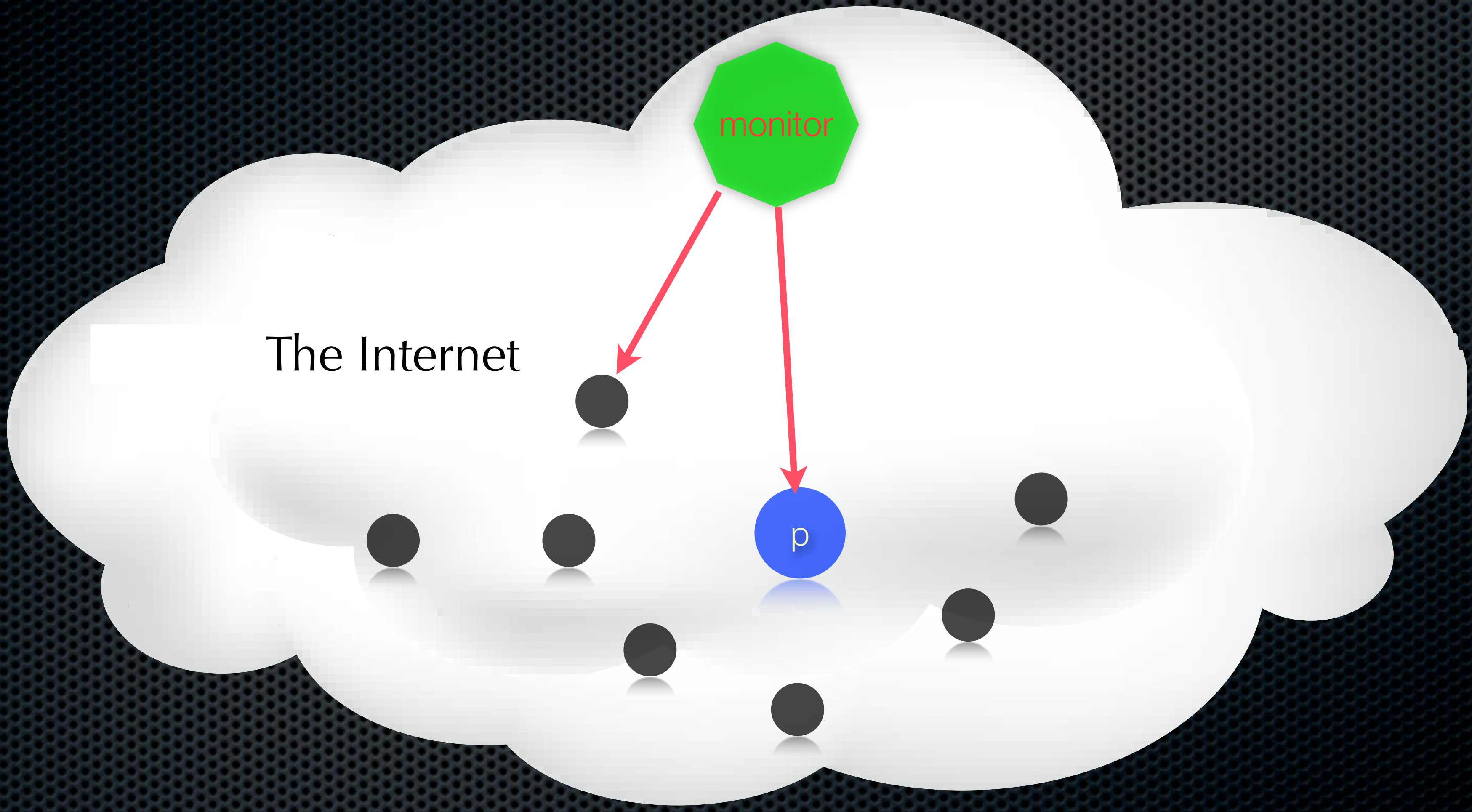
State of the Art

- Mostly on prefix hijacking
- With limitations
  - Not comprehensive: Sub-prefix hijacking, prefix interception, etc. can go undetected
  - Not robust: Intelligent attackers can circumvent them
  - Largely due to inadequate estimation on what prefix hijackers can do

Overview of Buddyguard

Main Idea

- Surround a prefix with a buddy system composed of buddy prefixes, or buddies
- Monitors the behavior of the prefix against that of its buddies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The Internet
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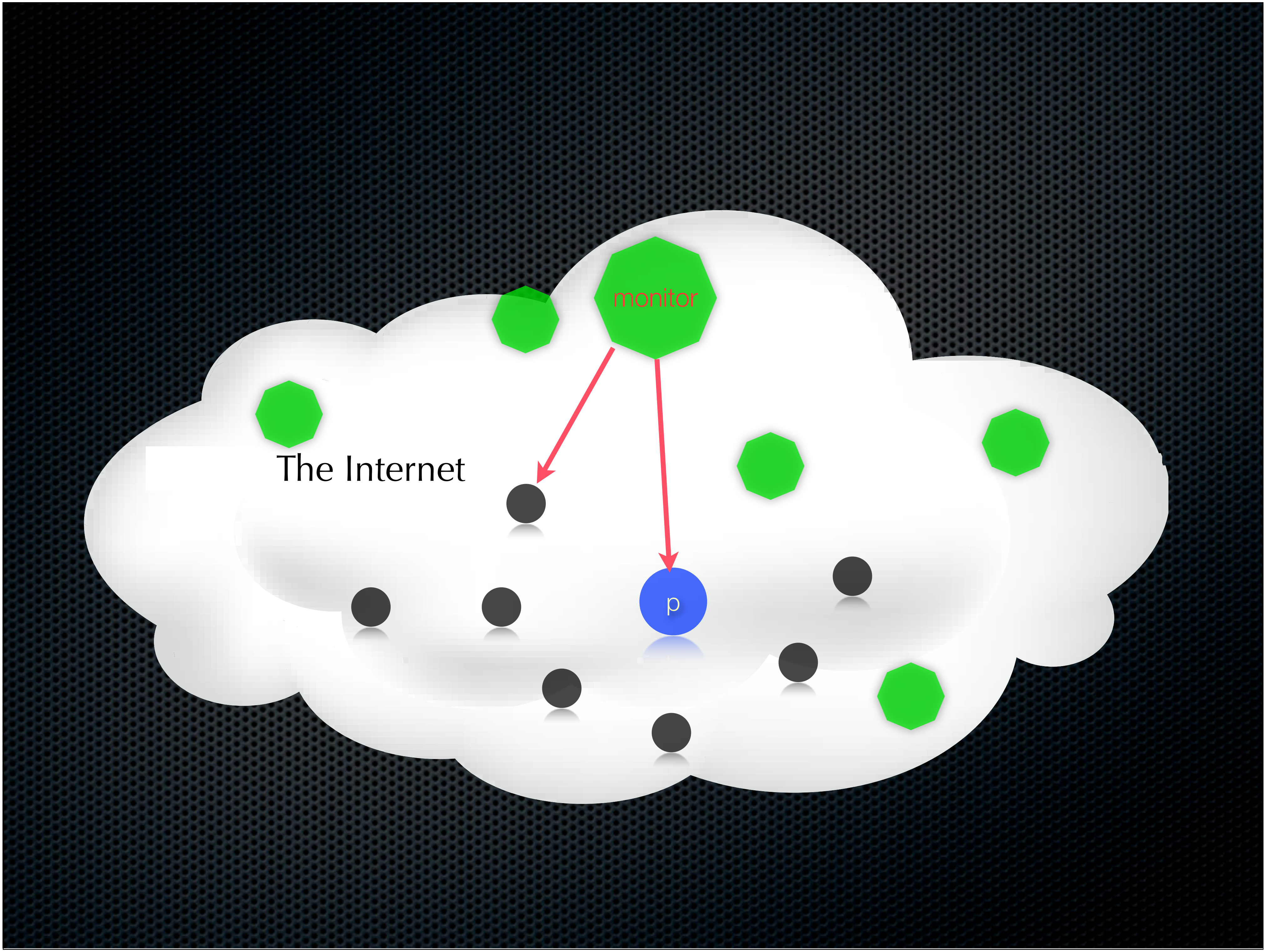
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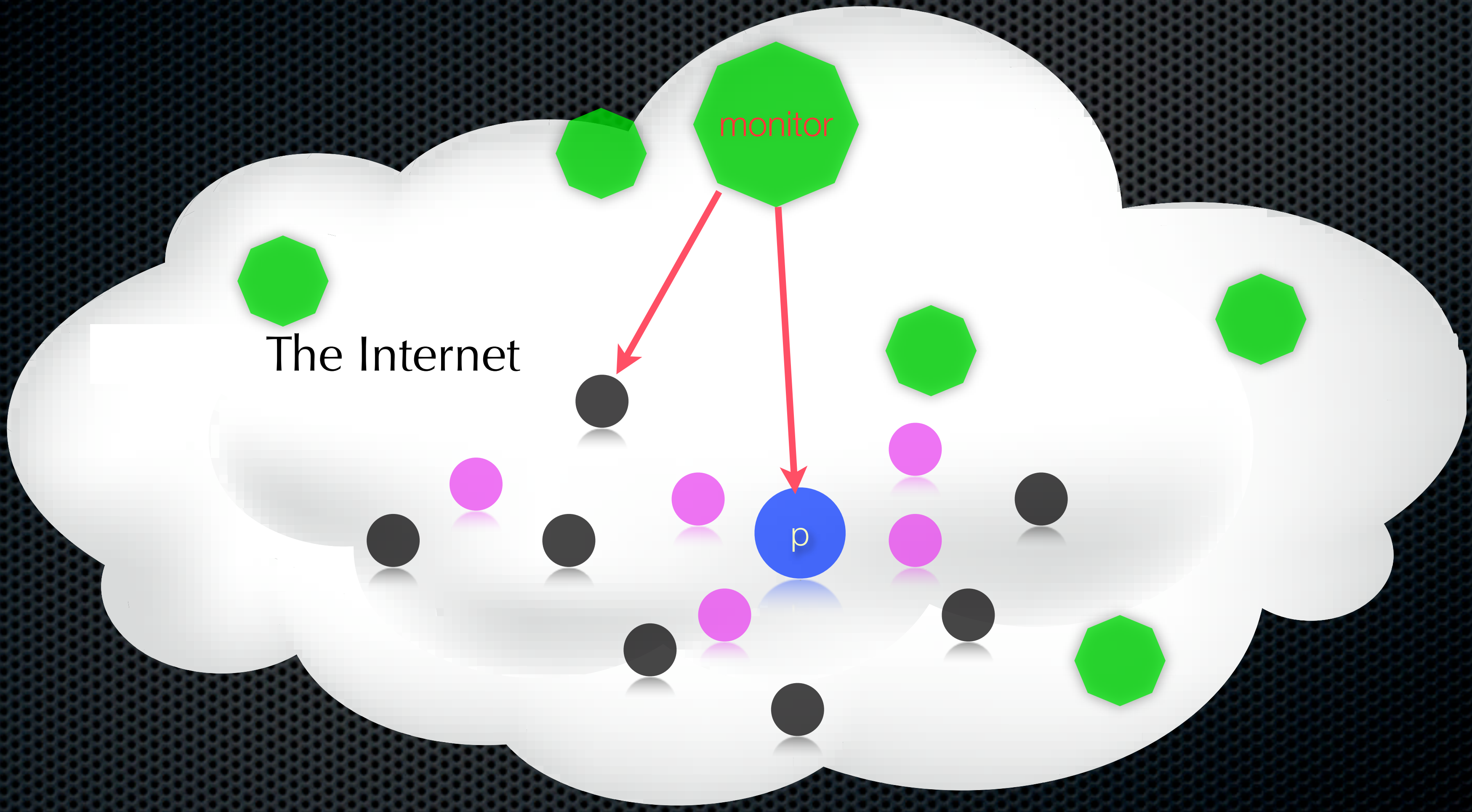
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Define (Ab)normality via Buddies

- Key to monitoring an IP prefix is to know what is normal and what is not
- When inspecting a prefix in isolation, it is difficult to know what behaviors are abnormal
  - Use historical behavior? But some new behavior can be normal too
  - Specify what is normal or abnormal? But hard to specify all cases
- A buddy system, however, allows a prefix to be compared with its buddies to determine its normality *on the fly*
  - Similar to (most) buddies? Normal. Otherwise, Abnormal!

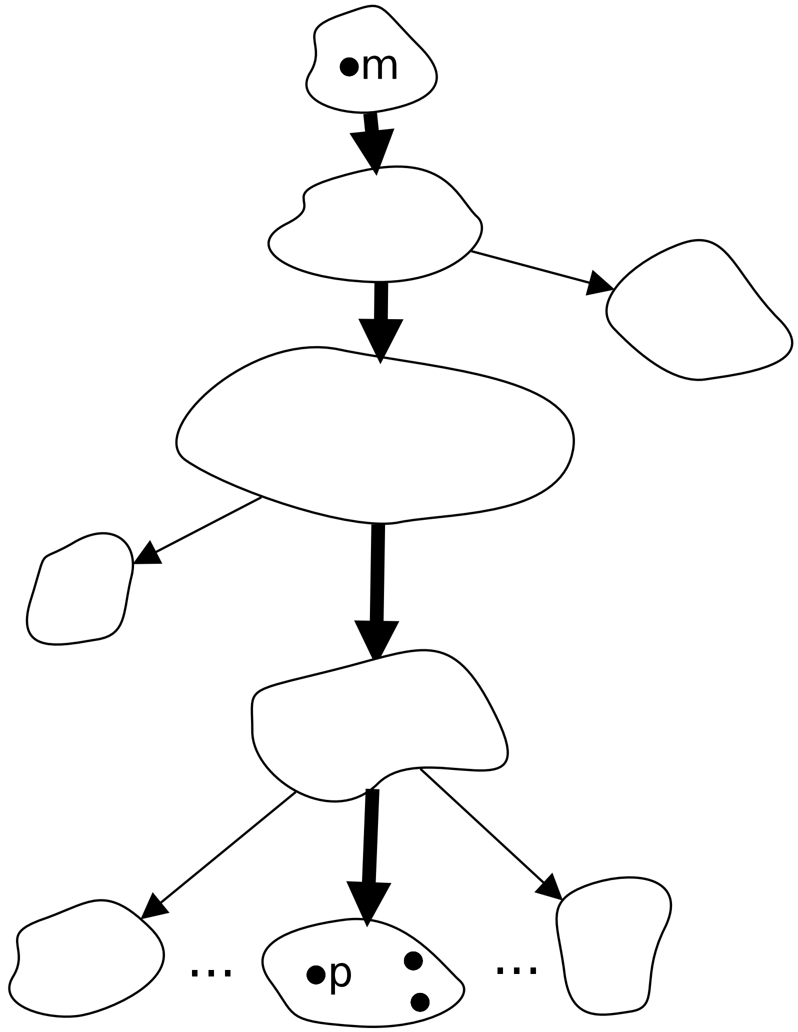
Advantages of Buddyguard

- Resilient
  - A prefix is allowed to have hundreds or even thousands of buddies from different ASes
- Deployable
  - Only passive measurement using existing BGP monitoring systems is required
- Extensible
  - One always can first determine the type of the behavior and how to measure it, and then select its buddies in terms of that behavior

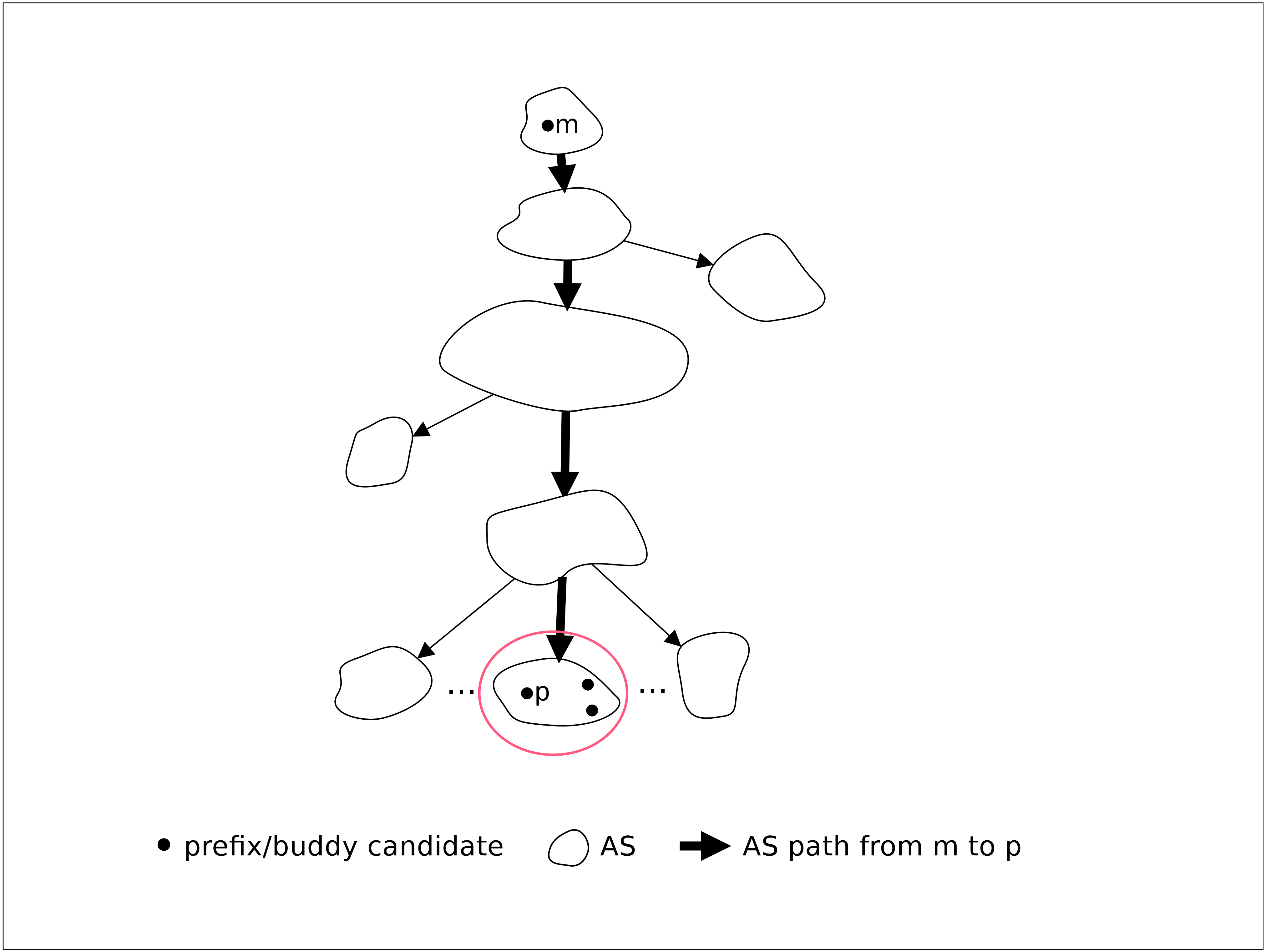
Design of Buddyguard

Buddy Discovery, Selection, and Maintenance

- What prefixes can be buddy candidates?
- Which candidates to select as buddies?
- How to maintain a good buddy system after initial selection?



● prefix/buddy candidate AS AS path from m to p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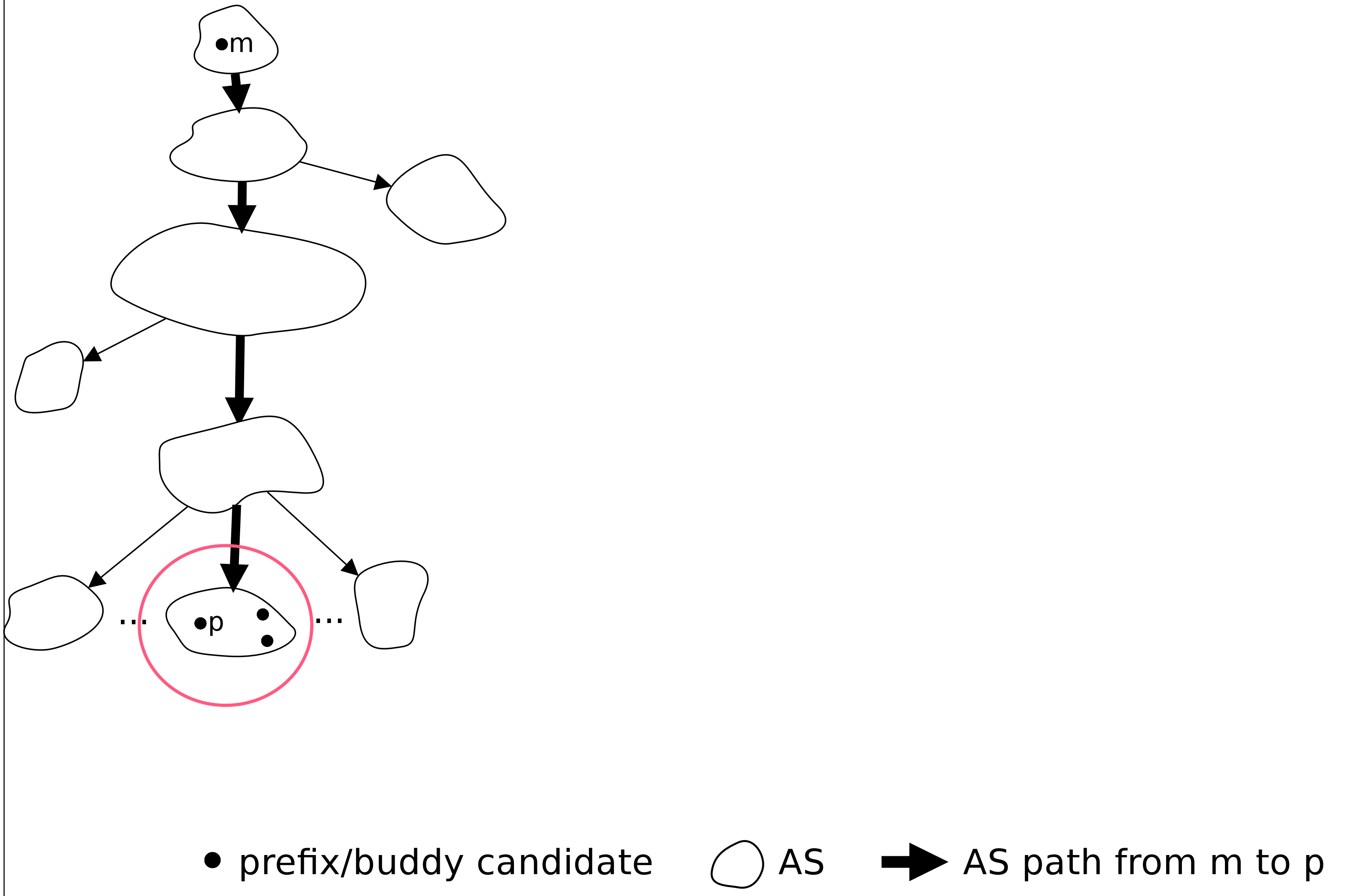
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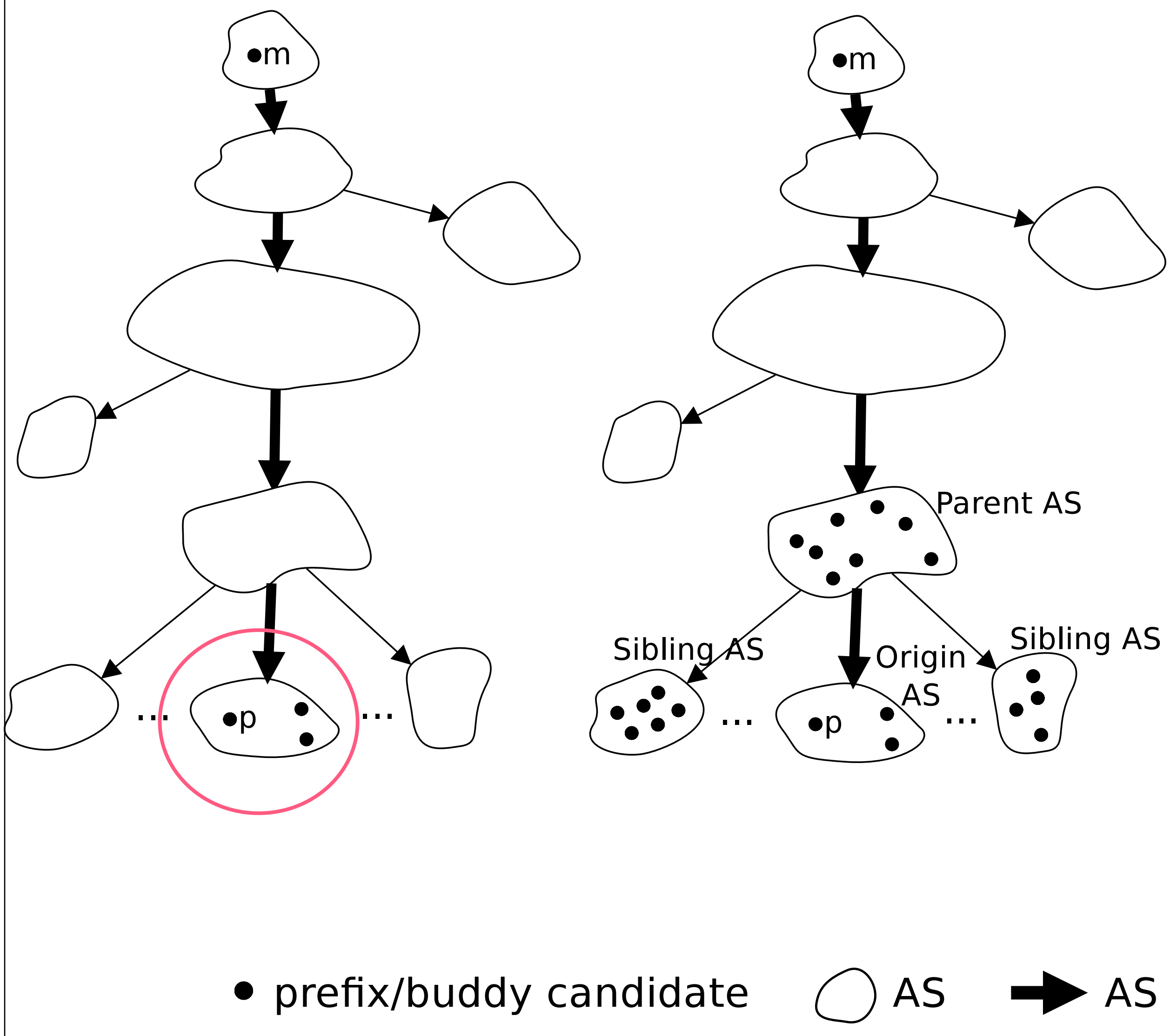
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● prefix/buddy candidate
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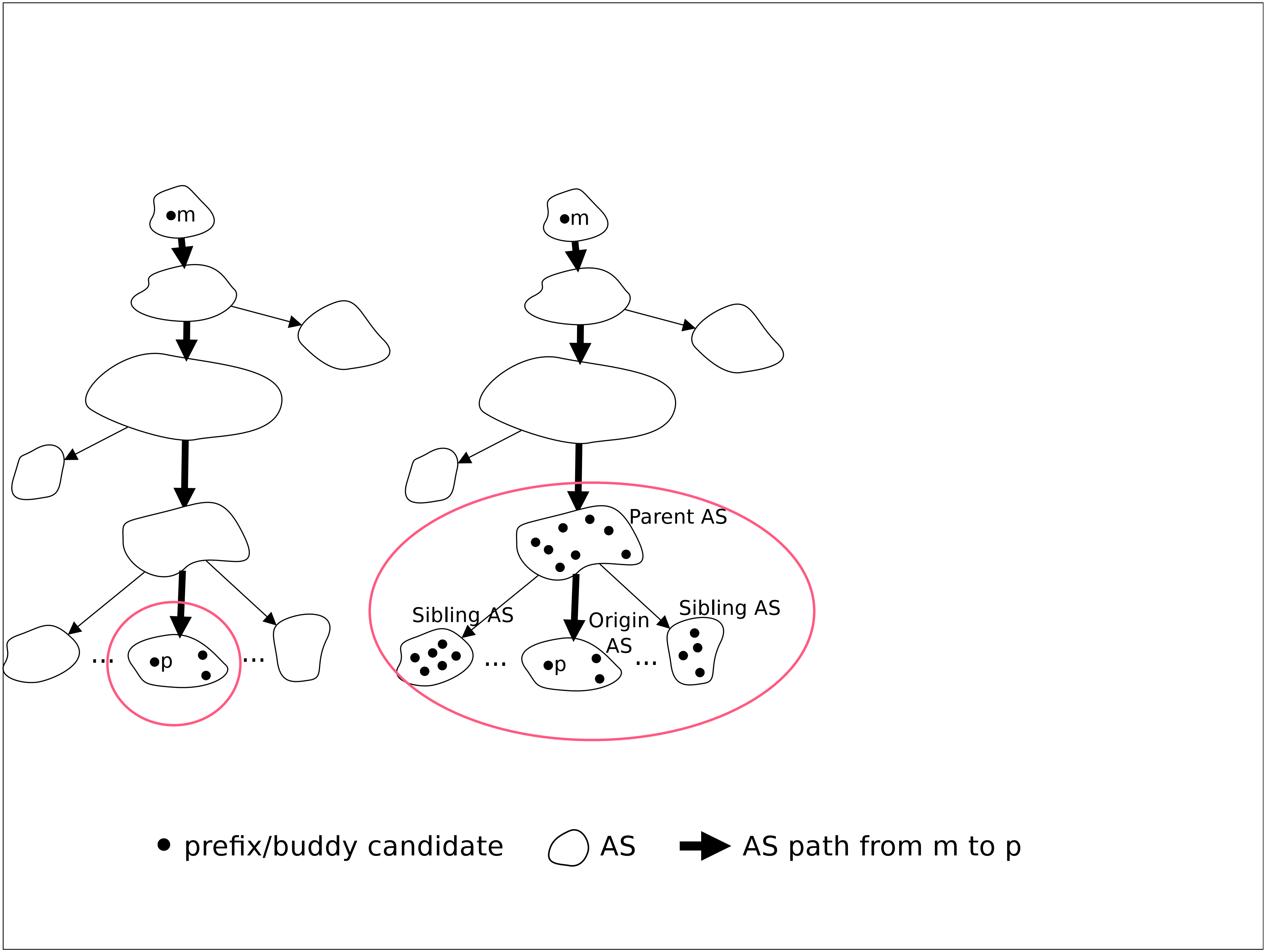
AS path from m to p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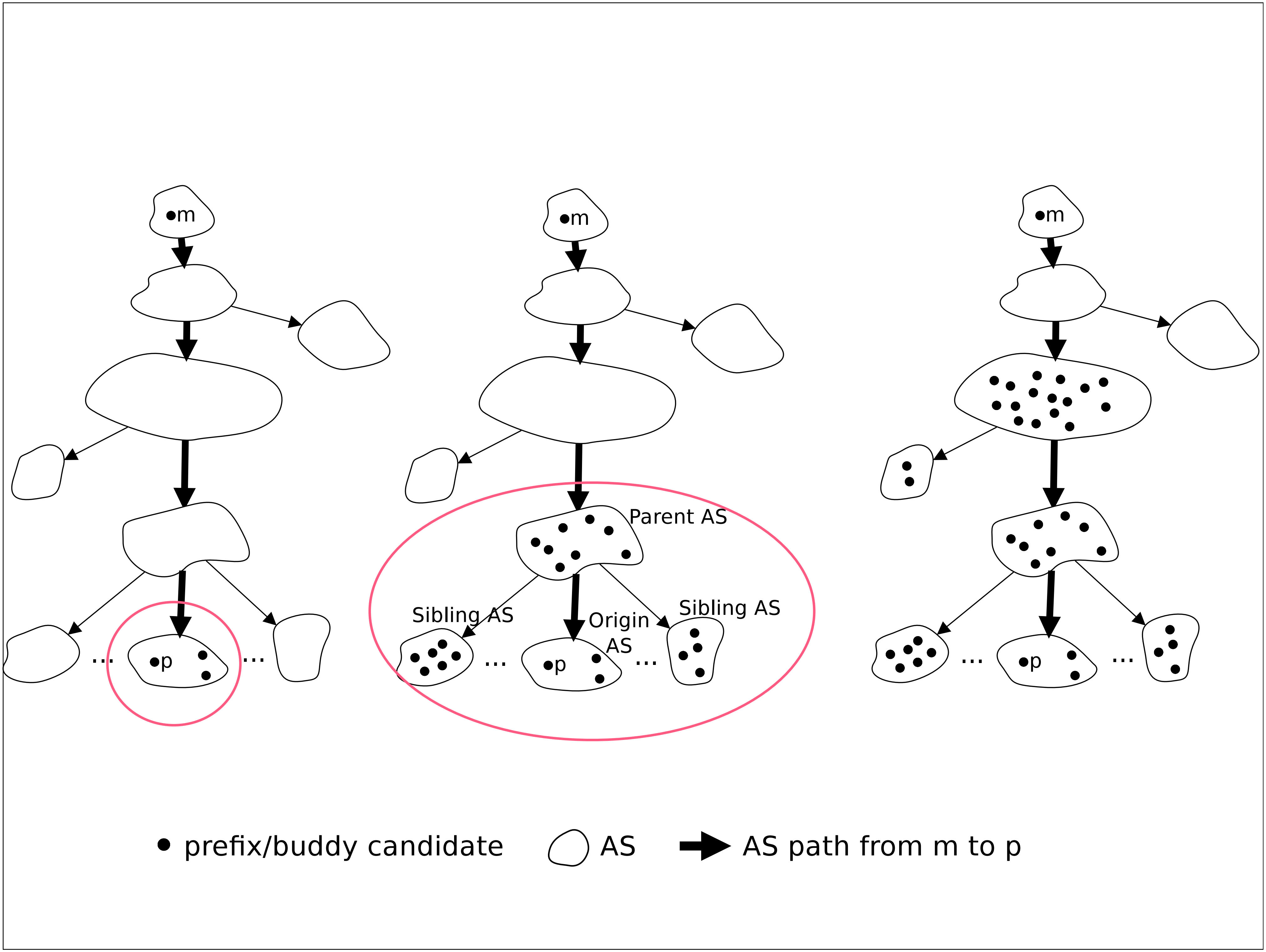
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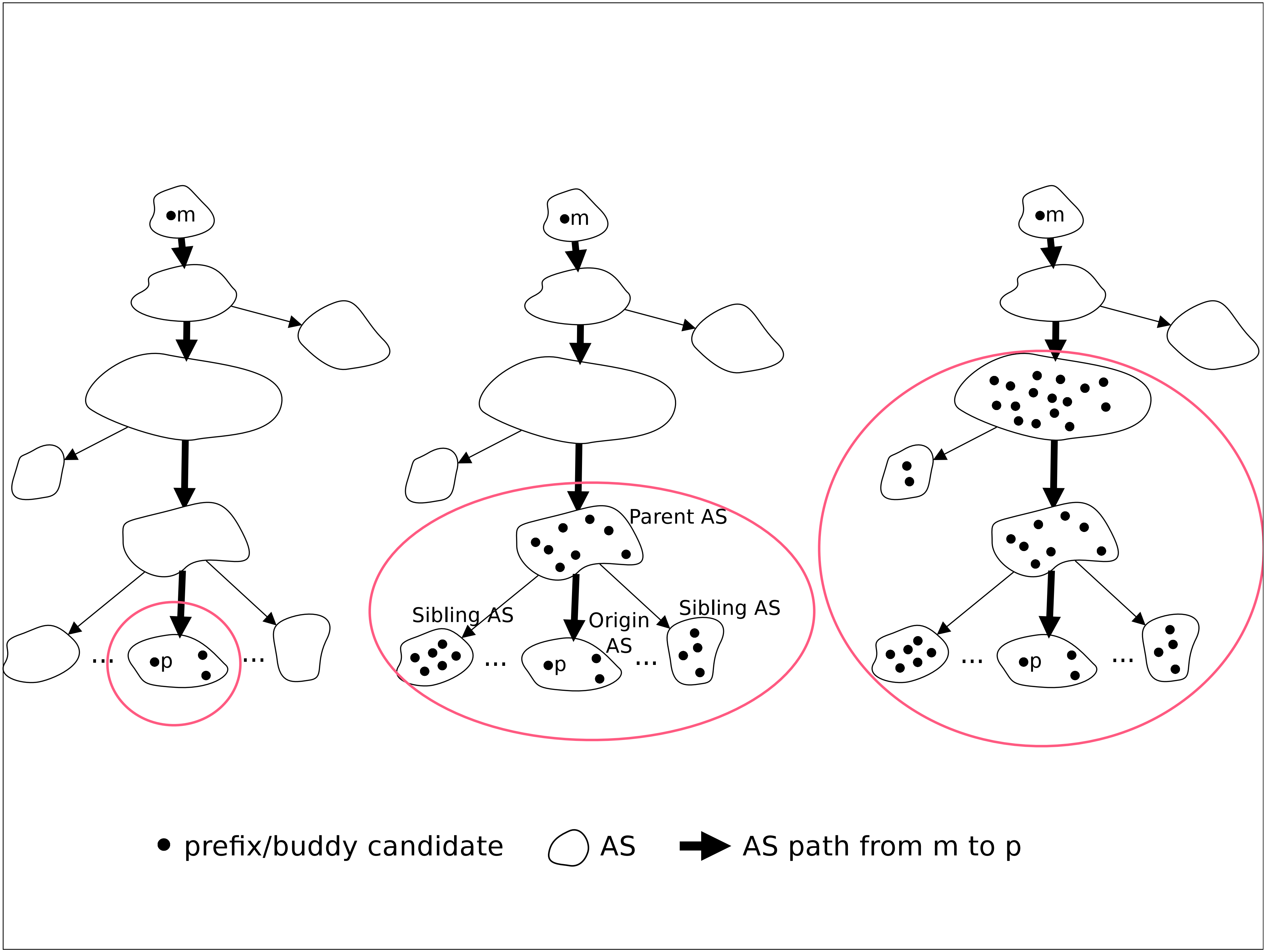
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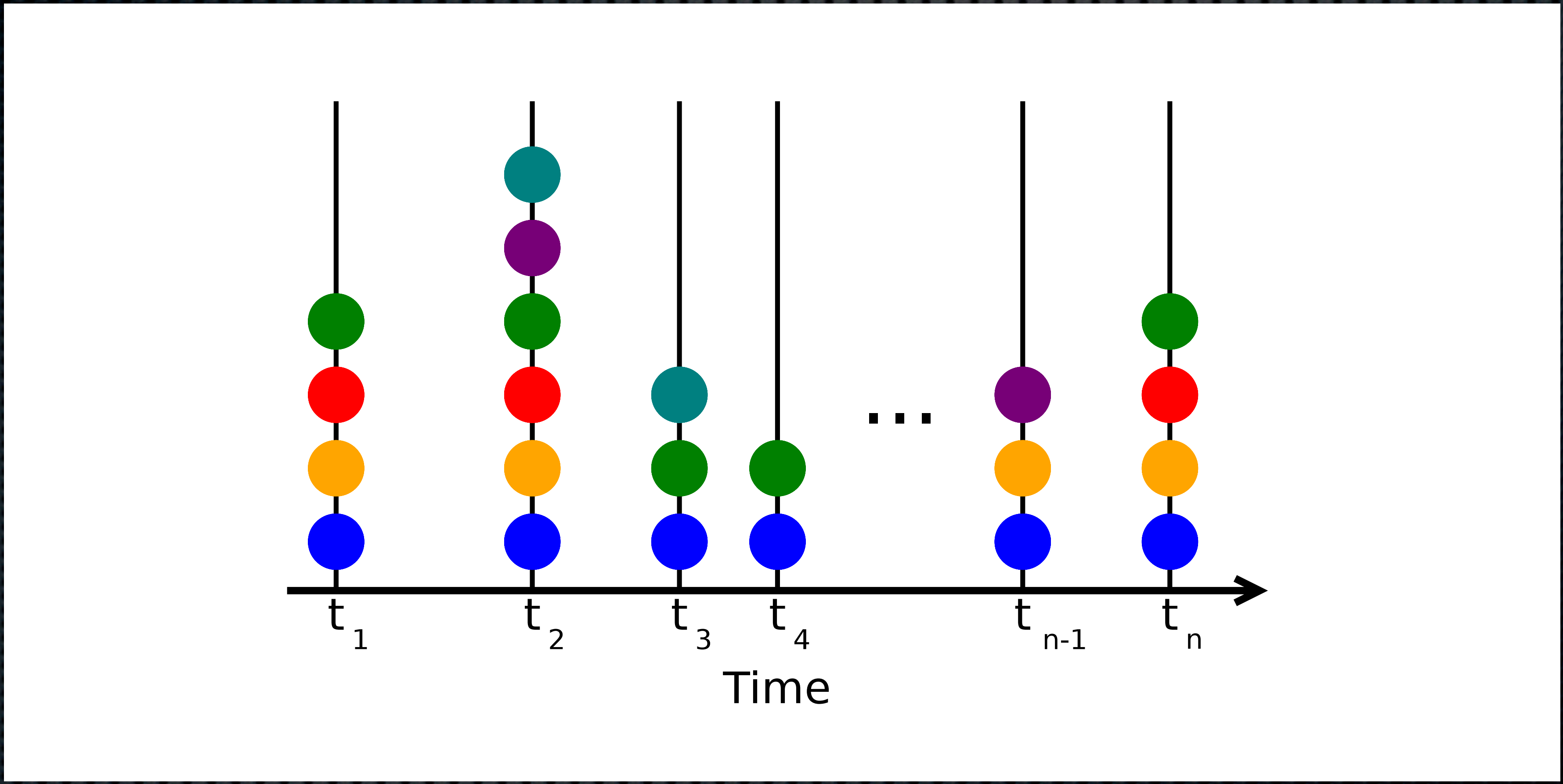
● prefix/buddy candidate
AS
AS path from m to p

Buddy Selection

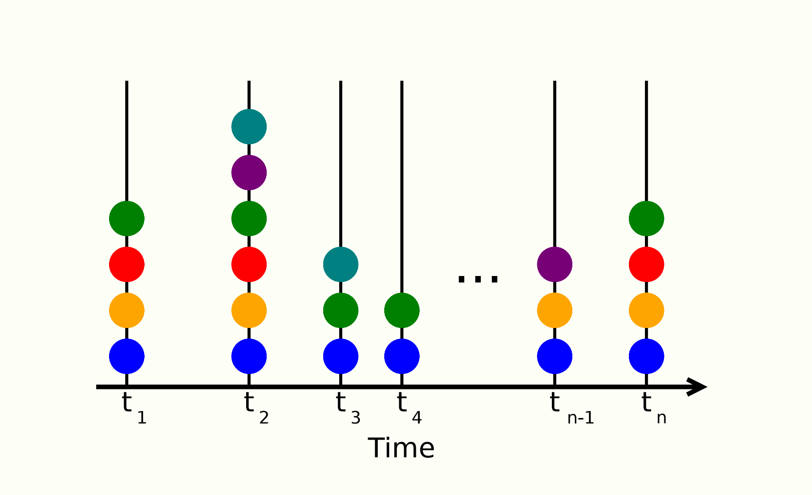
- Which buddy candidates to select as buddies?
- We observe buddy candidates during a training period
- And apply the skewer mechanism

Skewer Mechanism



Skewer Mechanism

- Choose those that
  - most frequently show path similarity,
  - ensure enough buddies exist for every path switch, *and*
  - ensure topological diversity (i.e. from multiple different ASes).



Evaluation

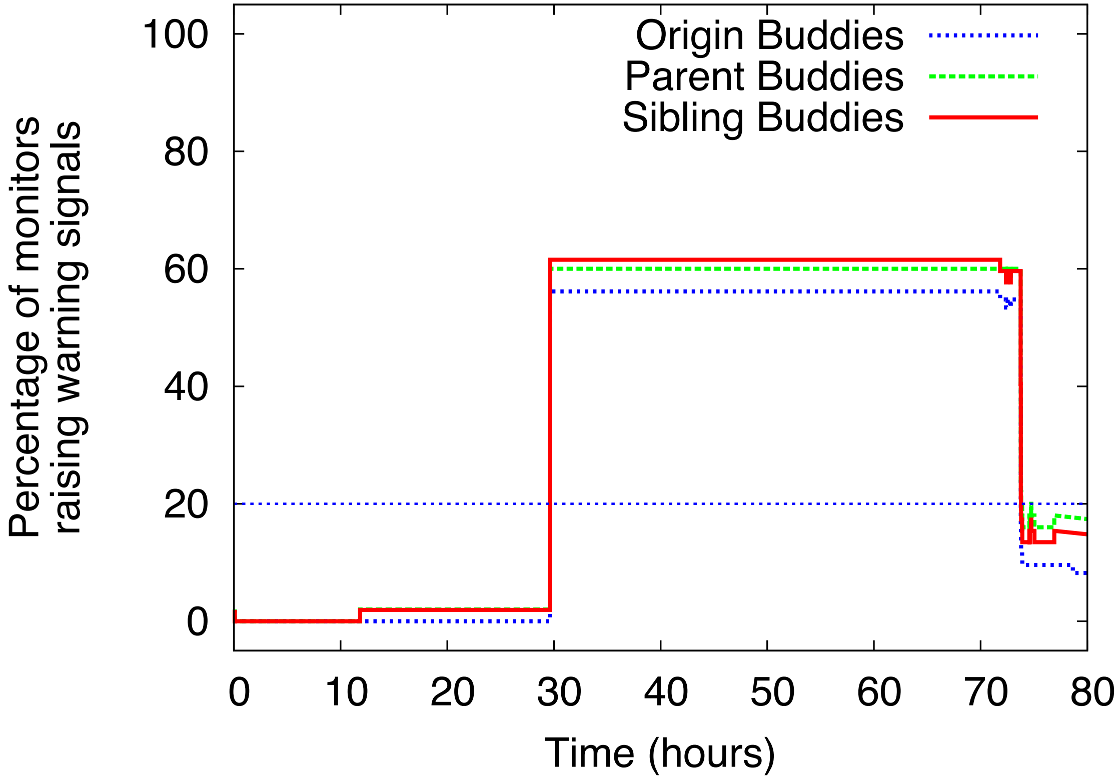
Tested Prefix Hijacking Events

- May 7, 2005—Cogent hijacked one of Google's prefixes
- January 22, 2006—Con Edison hijacked 30+ prefixes, including some belonging to their customers
- February 24, 2008—Pakistan Telecom hijacked a sub-prefix of YouTube's prefix

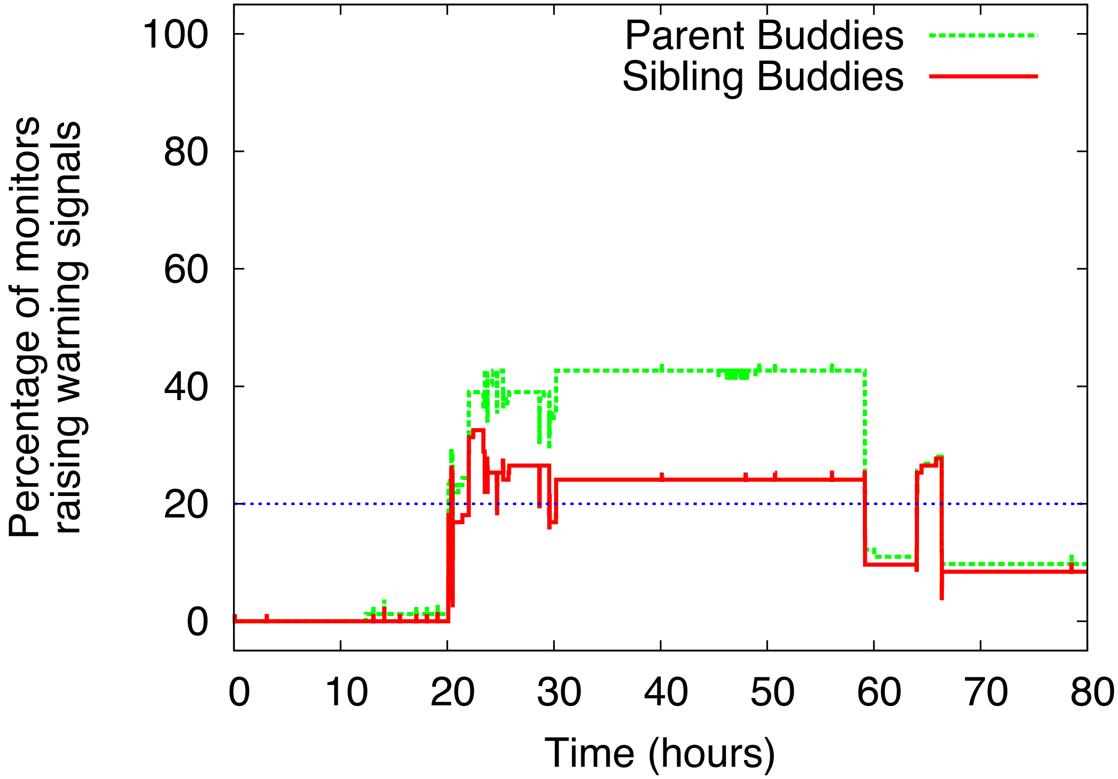
Tested Route Leak Events

- April 4, 2010—China Telecom leaked many IP prefixes from roughly 15:54 UTC to about 16:10 UTC

Cogent Hijacking Google

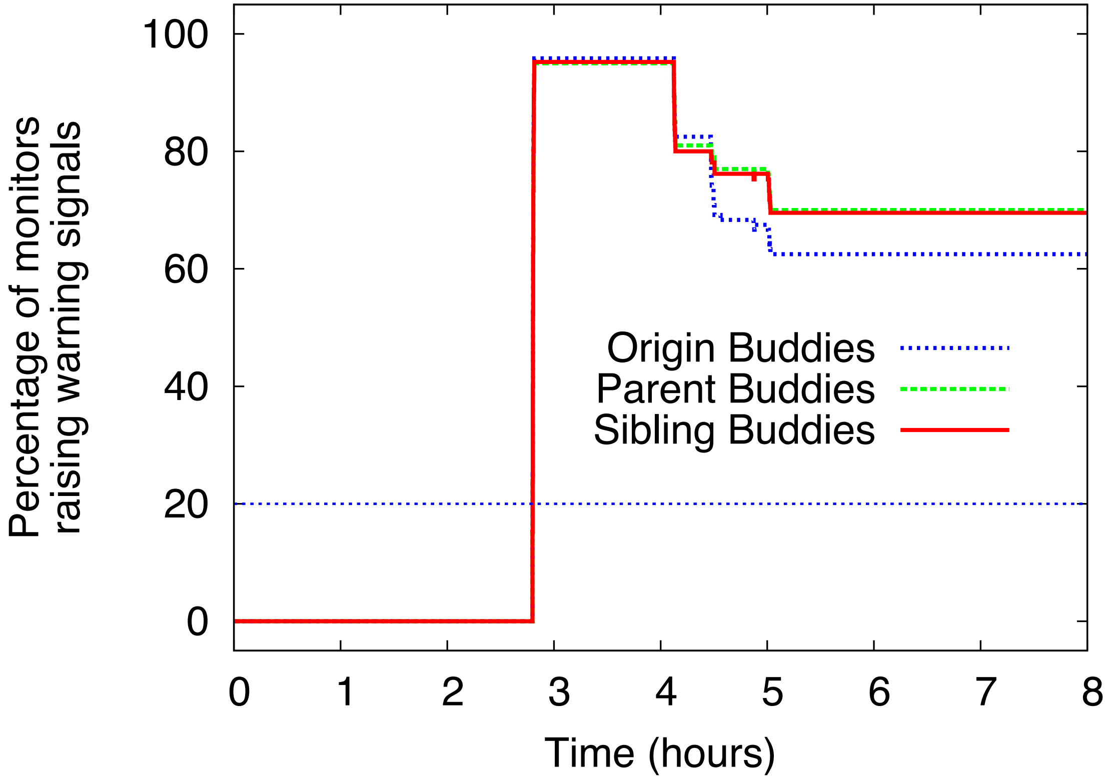


Con Edison Hijacking martha Stewart Living

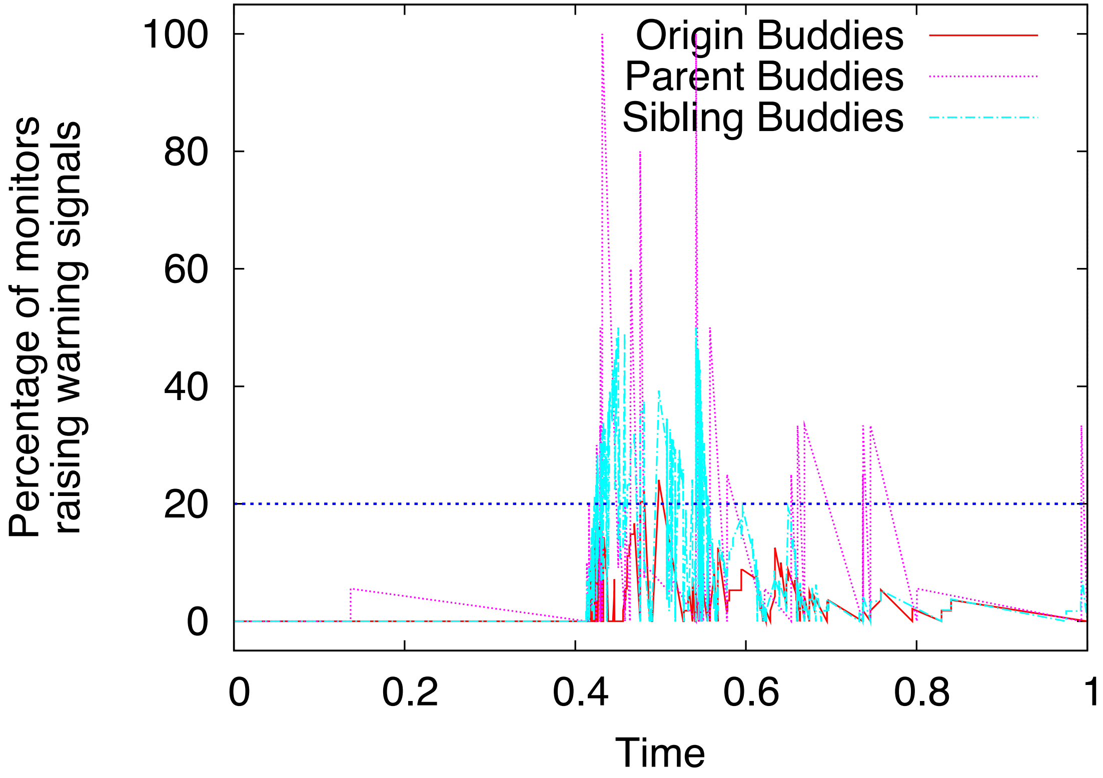


Hijacked prefix is the only prefix at the origin AS, so there is no origin buddies.

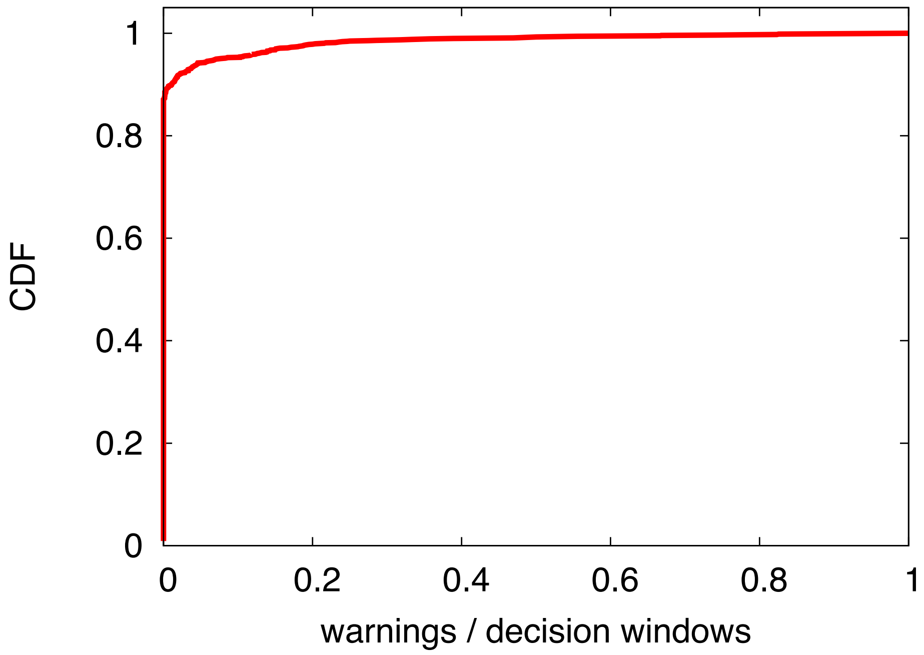
Pakistan Hijacking YouTube

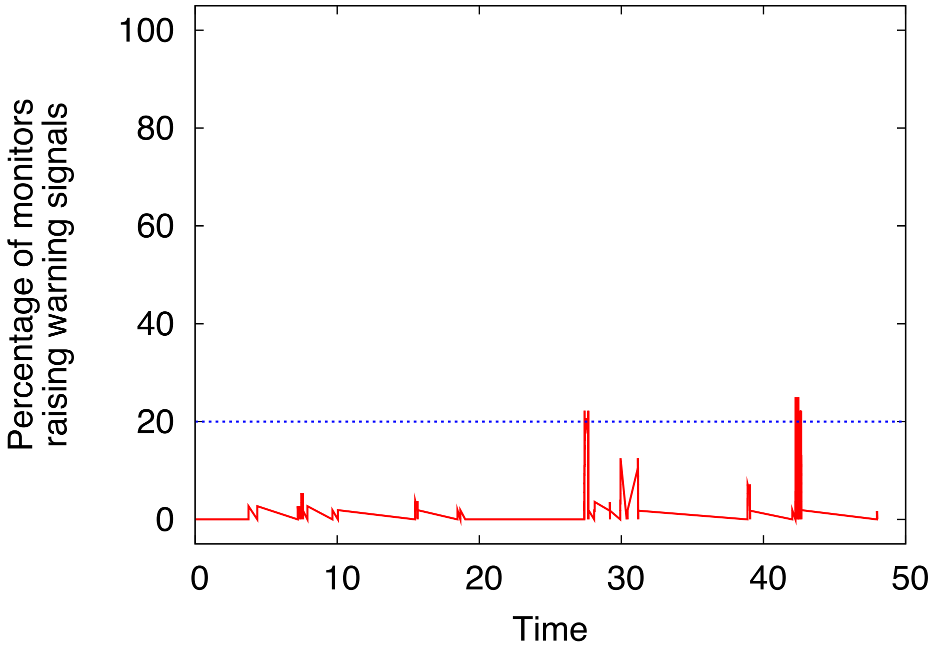


China Telecom Route Leaks



False Alerts





Discussions & Conclusions

Deploying Buddyguard

- RouteViews/RIPE BGP collectors
- BGP speakers
- Anywhere in the Internet
  - need to access BGP data in real time, such as through BGPmon

Attacking Buddyguard

- Can an attacker hijack all the buddies of a prefix to stay undetected?
- Can an attacker announce an illegitimate path that is not visible to monitors?

Conclusions

- Every IP prefix on the Internet may experience certain anomalies without being detected. And attackers are smart!
- Buddyguard monitors a prefix's behavior on the fly via a buddy system
- Results are promising
- More details in the paper

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