WebWitness: Investigating, Categorizing, and Mitigating Malware Download Paths

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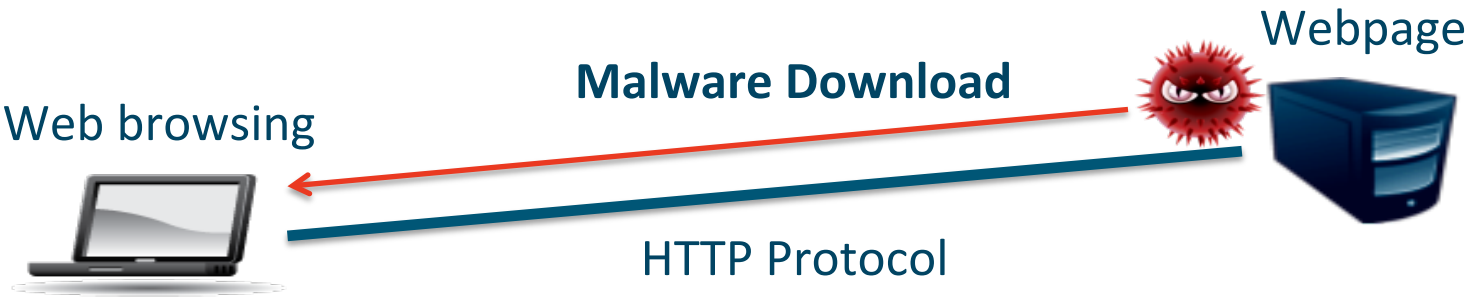
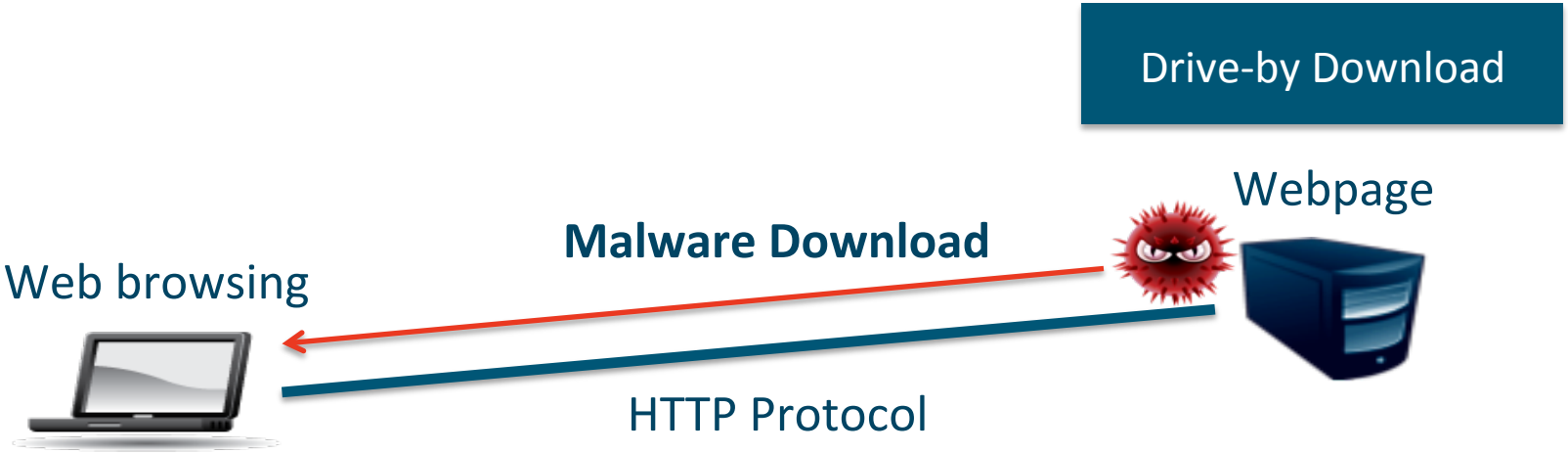
Web Browser – Popular Infection Vector



How do users get infected?



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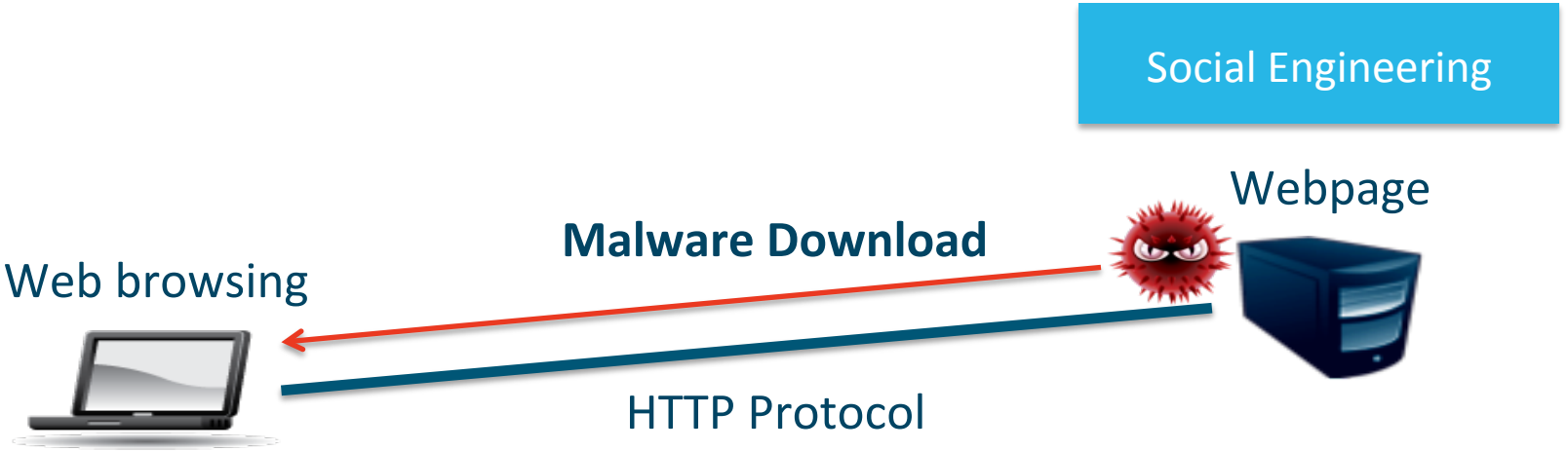
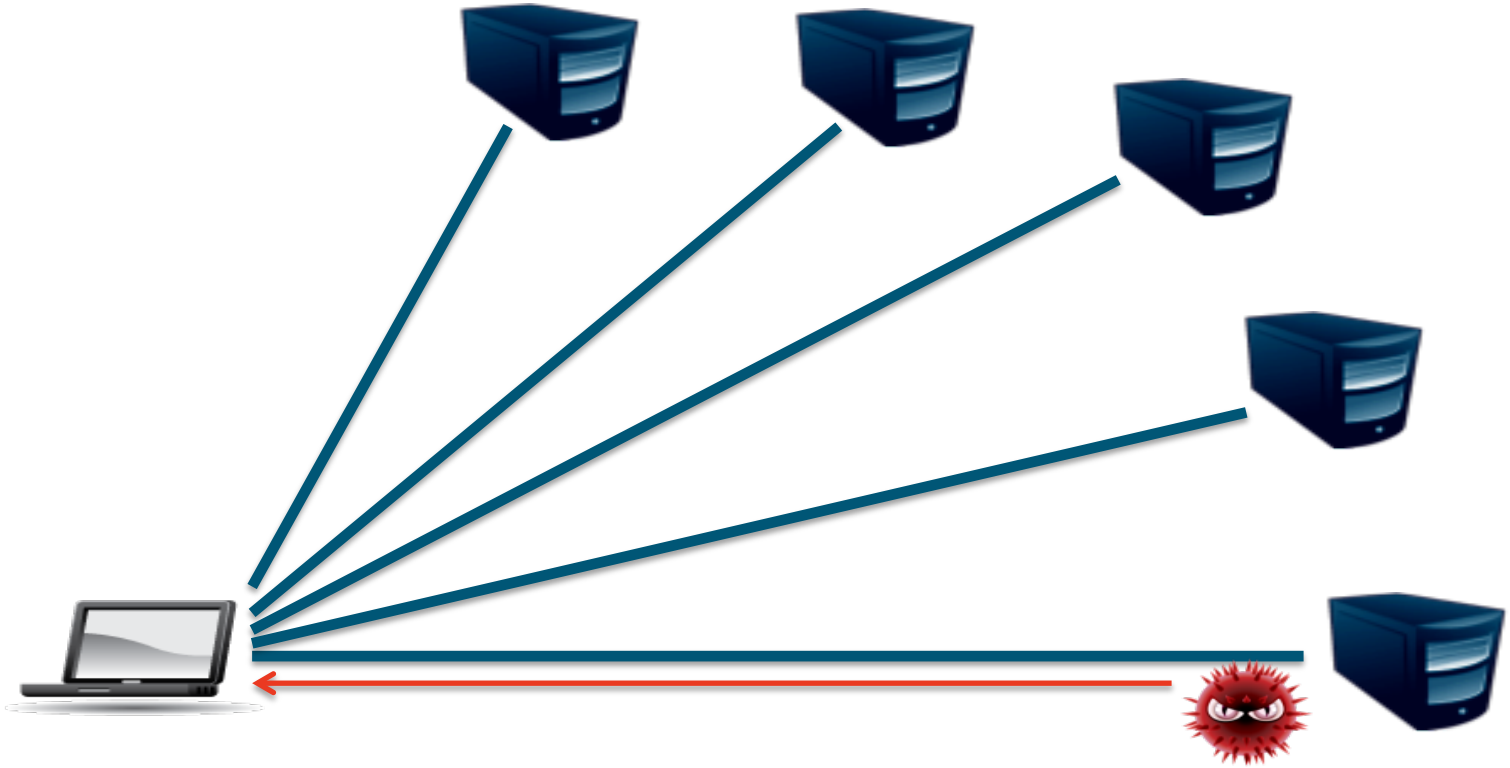


What happened before the download?



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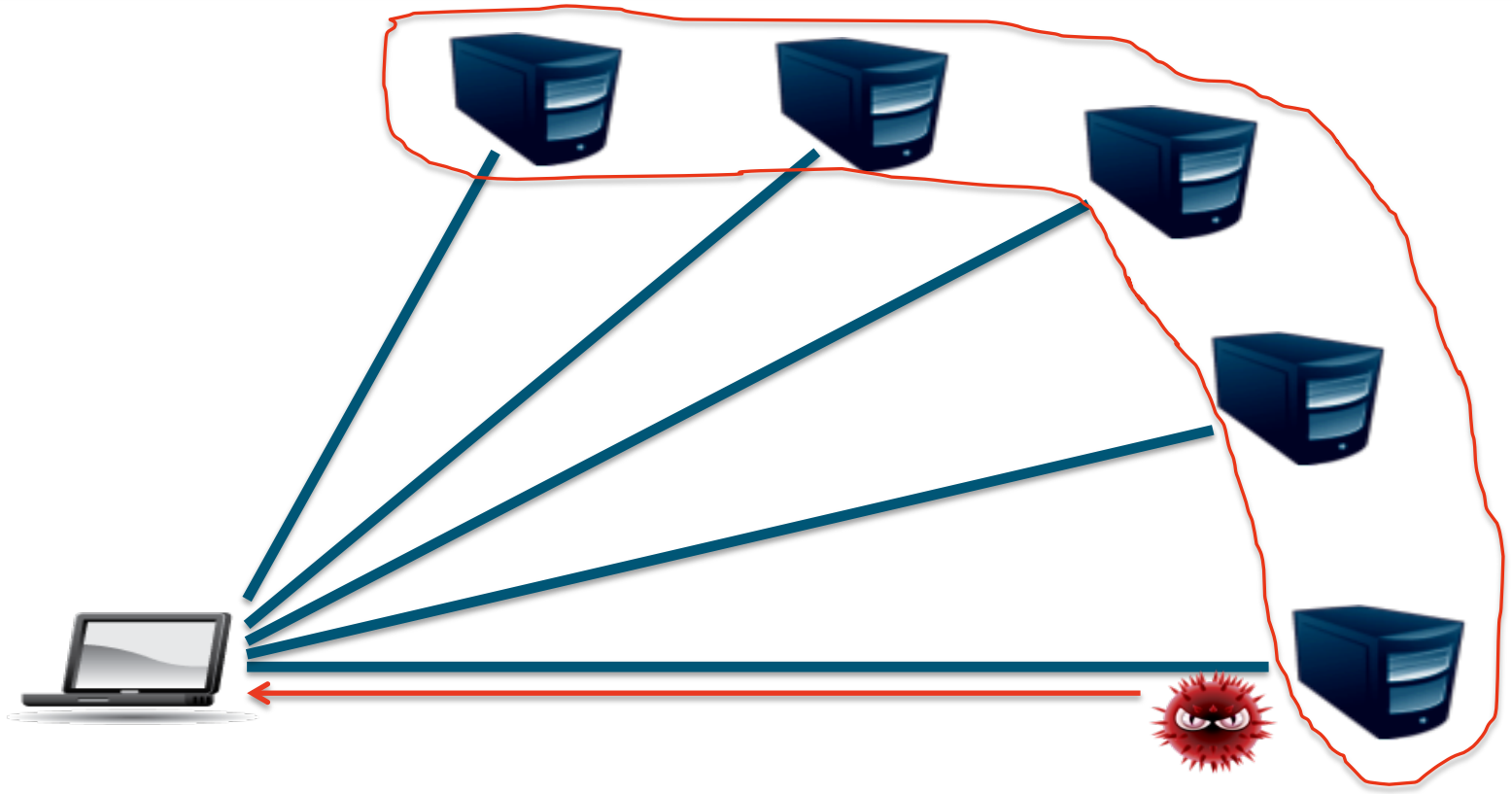

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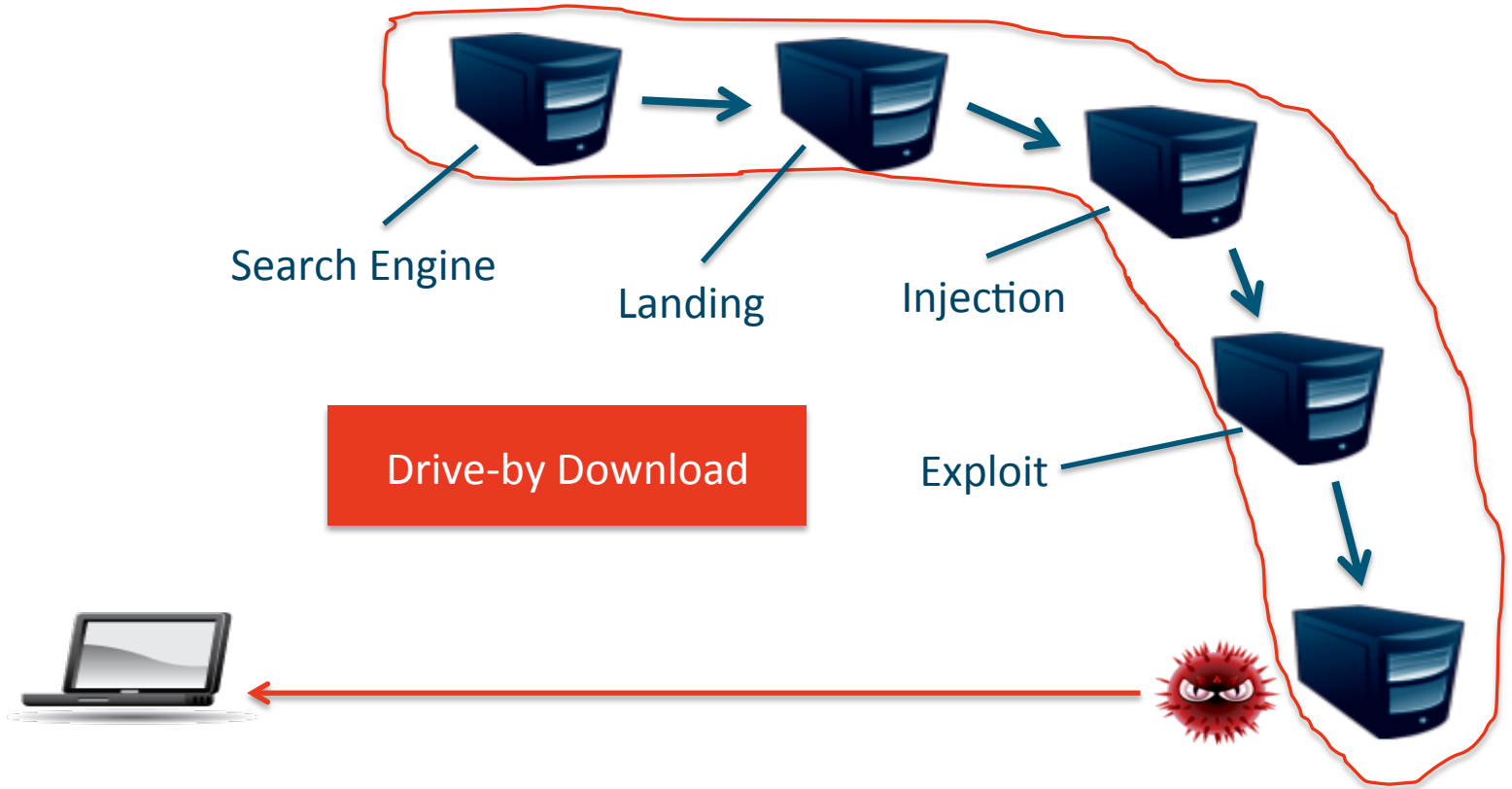
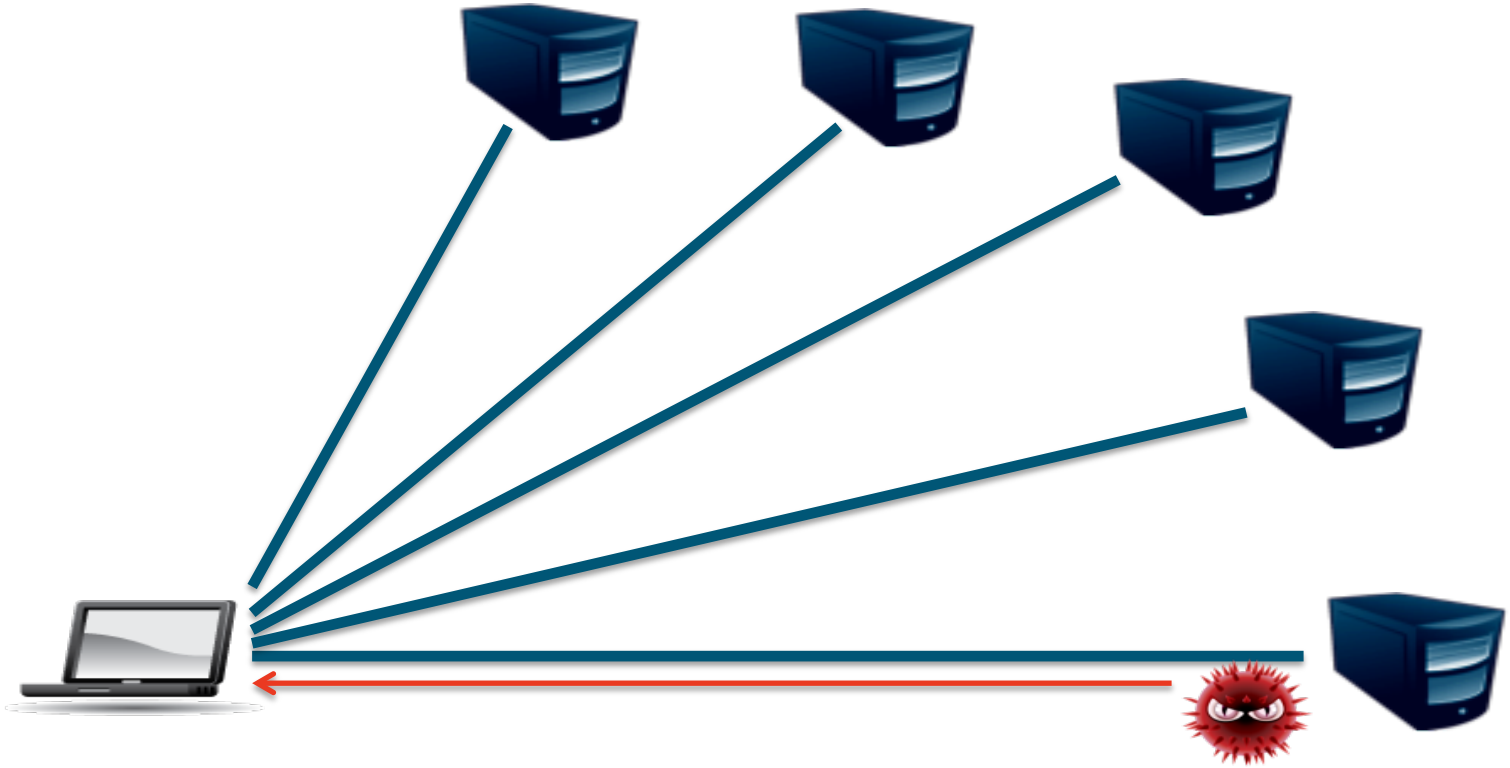


Our Work

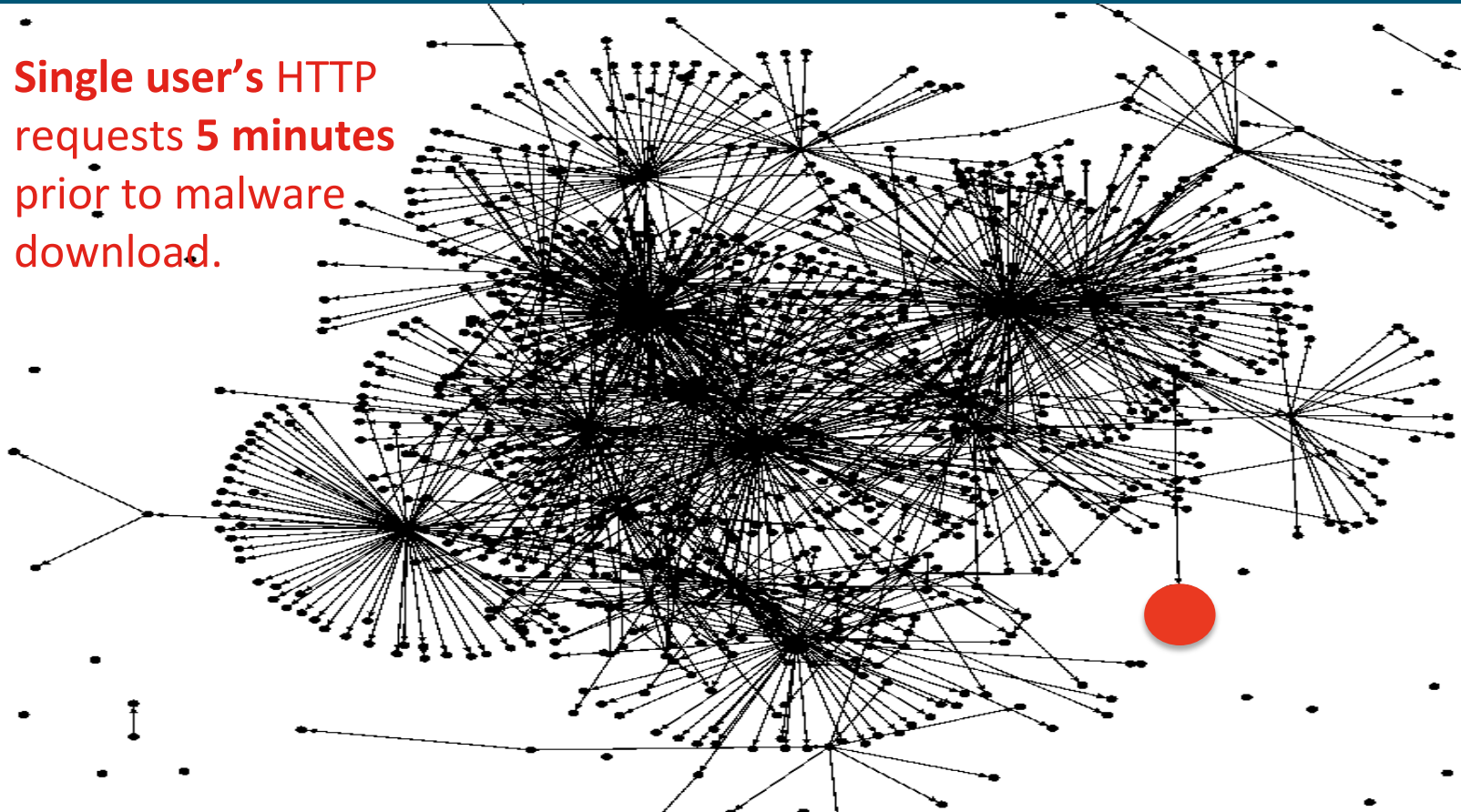
- Automatically provide context to attacks.
  - Reconstruct download path.
  - Identify download cause.
- Understand current attack trends.
- Develop more effective defenses.

How hard is it to find the download path?

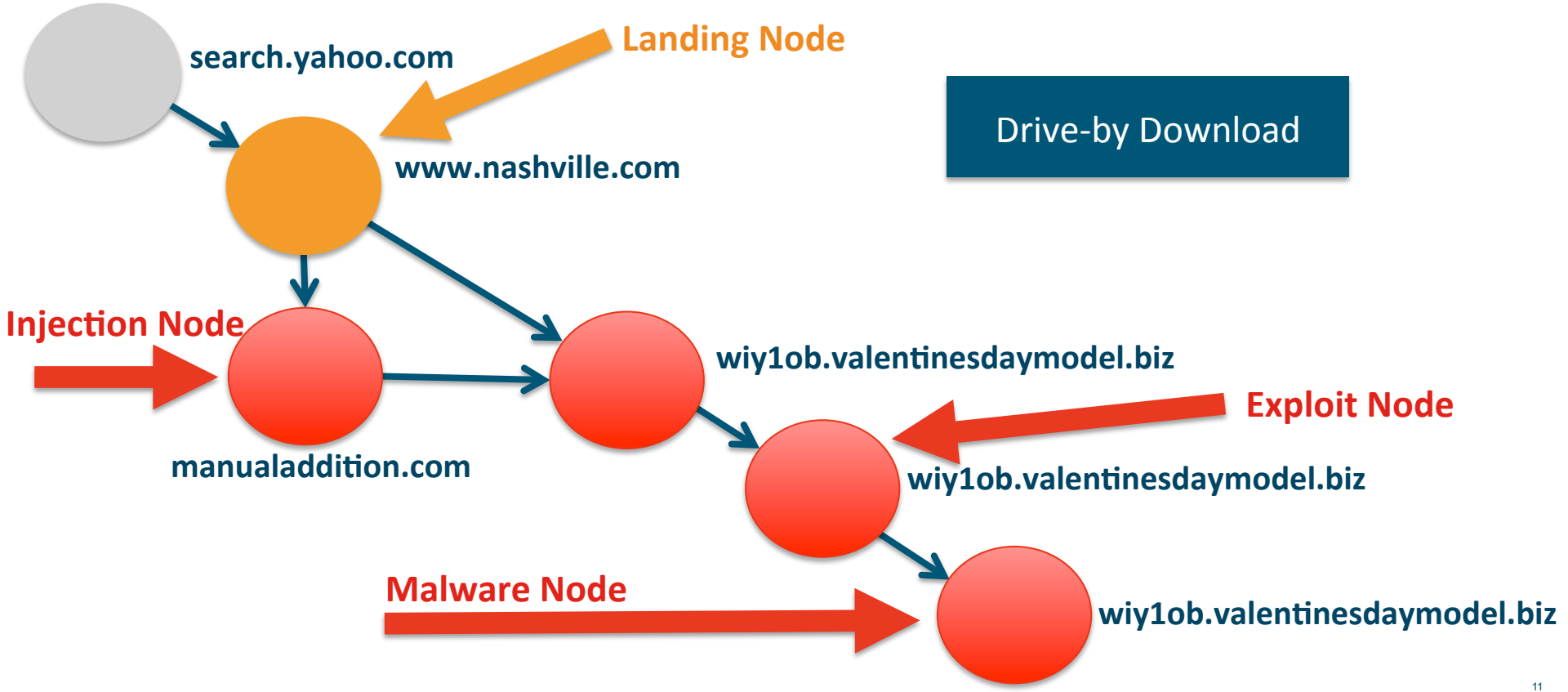


Web Traffic Graph

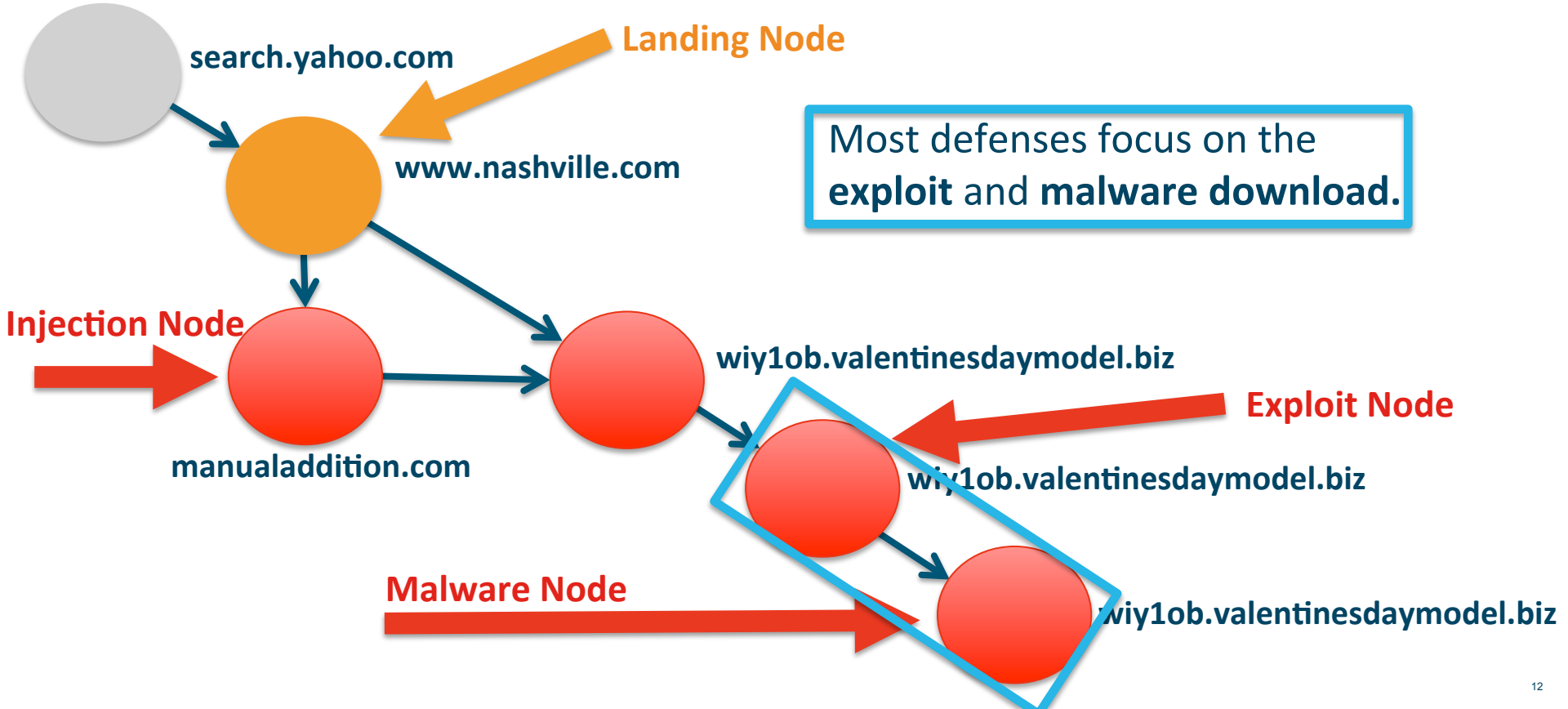
Single user's HTTP requests **5 minutes** prior to malware download.



Annotated Drive-by Download Path



Drive-by Download Defense



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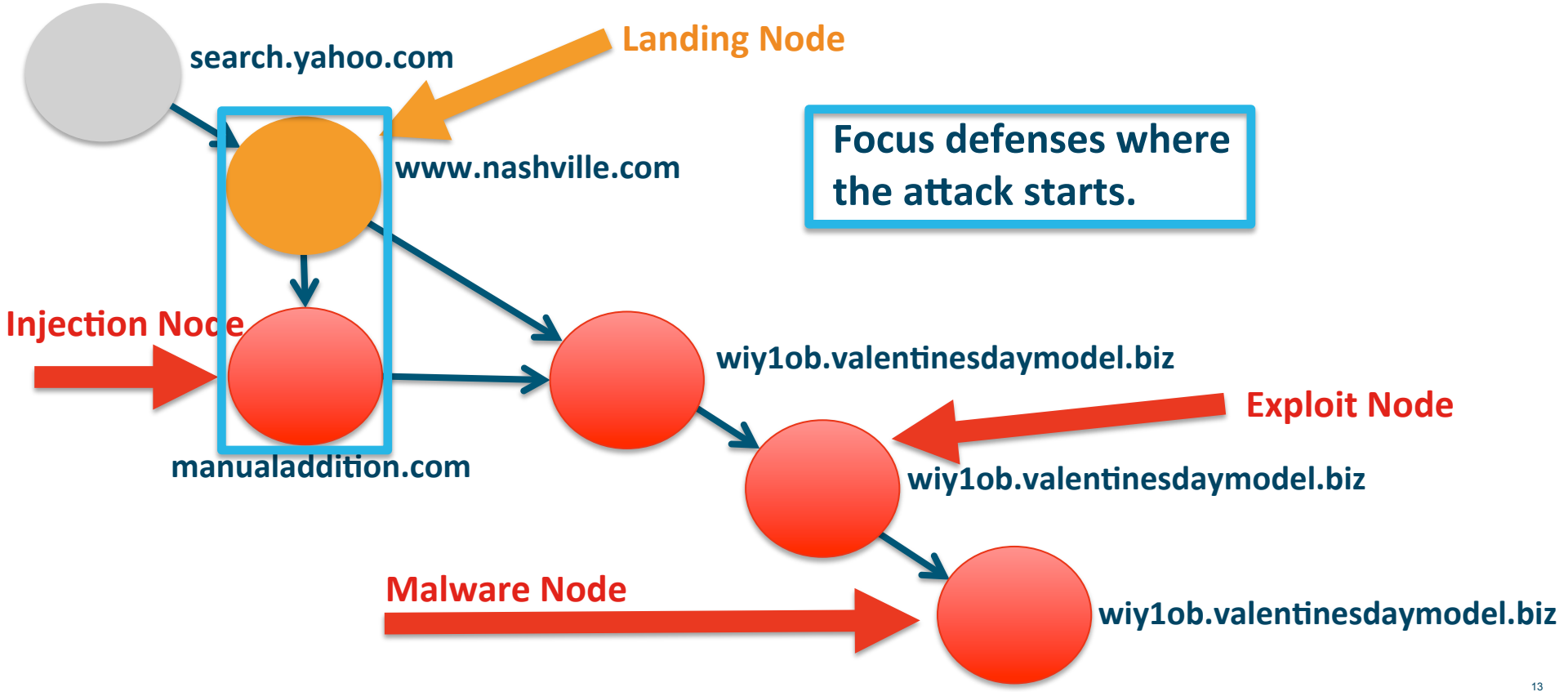


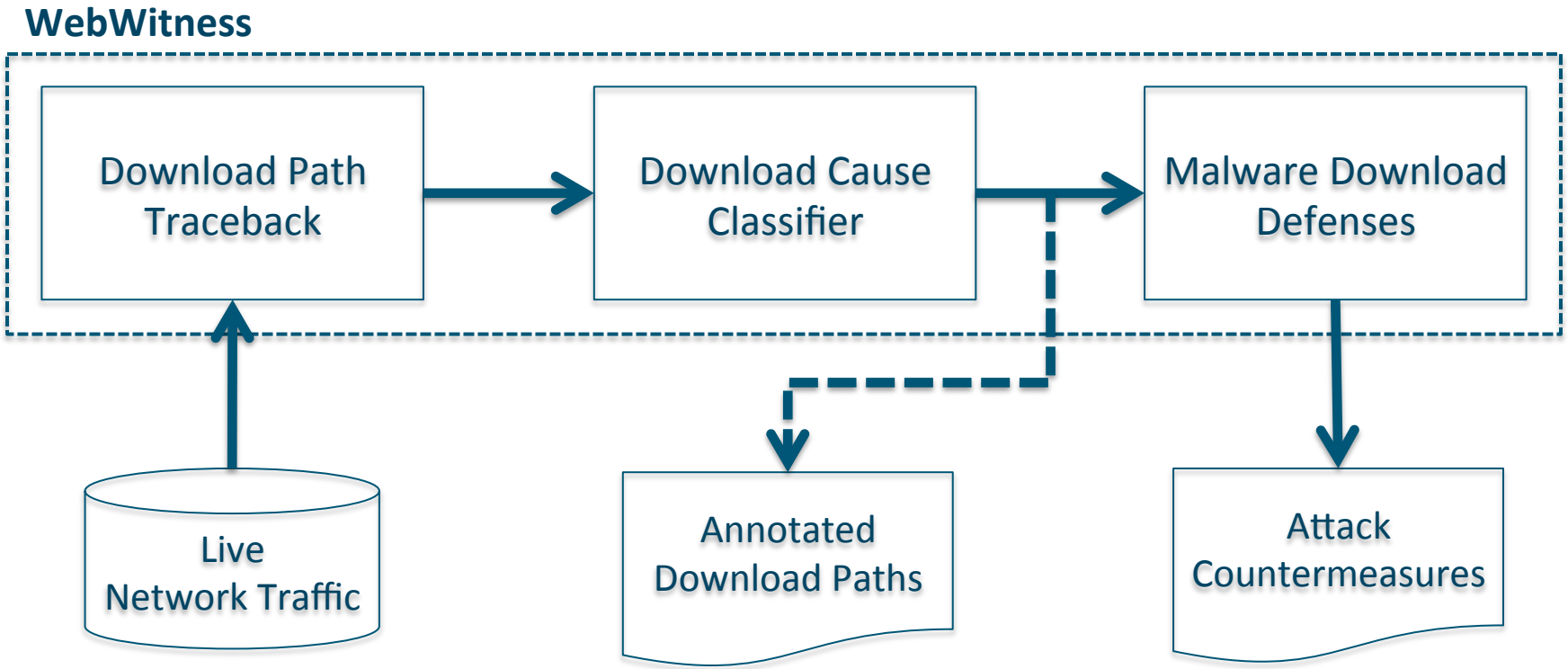
In-The-Wild Malware Study

- Collection agent deployed on large academic network for a period of six months.
- A total of 533 malware downloads due to drive-by, social engineering and update.
- Extensive manual analysis of malicious downloads.
  - Reverse engineer content.
  - Deobfuscate java script.

In-The-Wild Malware Study Results

- Download path trace back is difficult.
  - Cannot only rely on Referrer and Location headers.
- Labeling the role of nodes extremely challenging.
  - Semantic gap between network and browser.

WebWitness System



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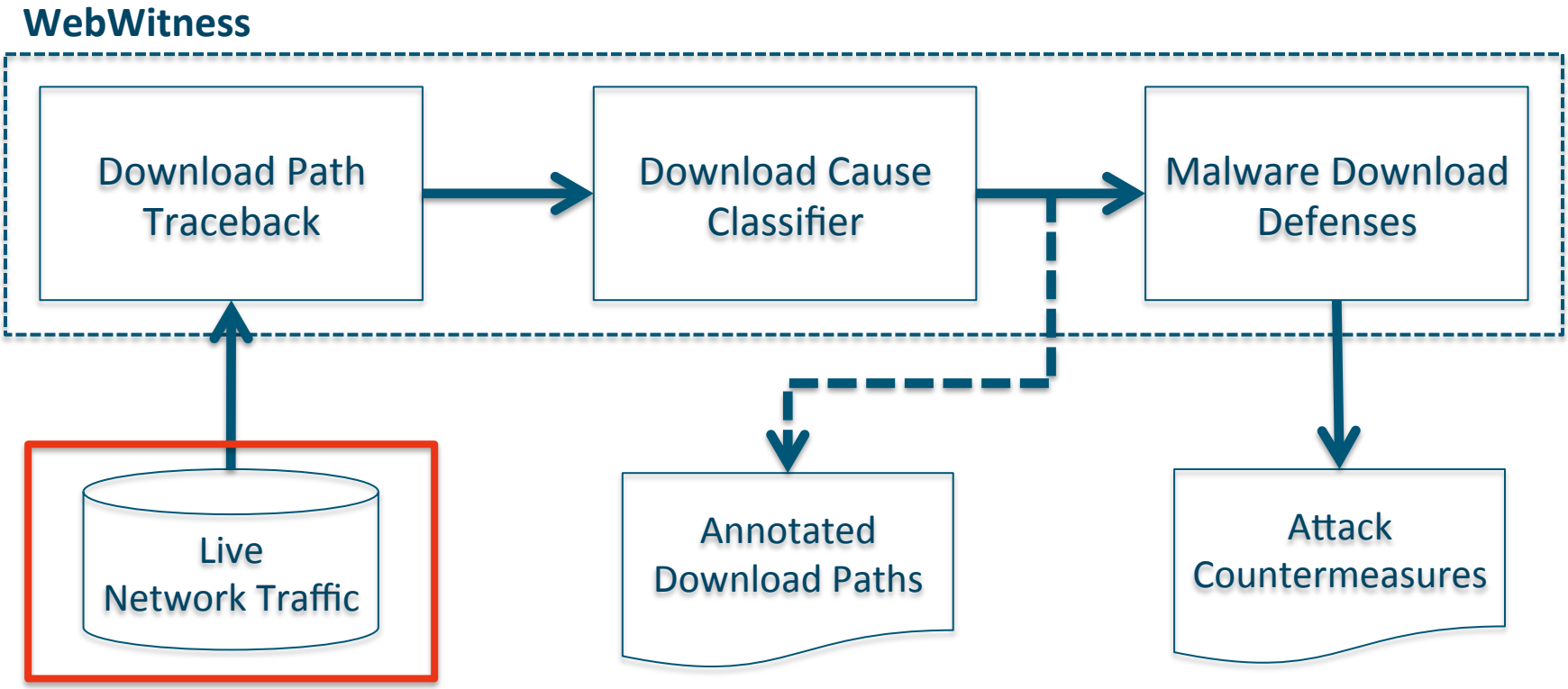

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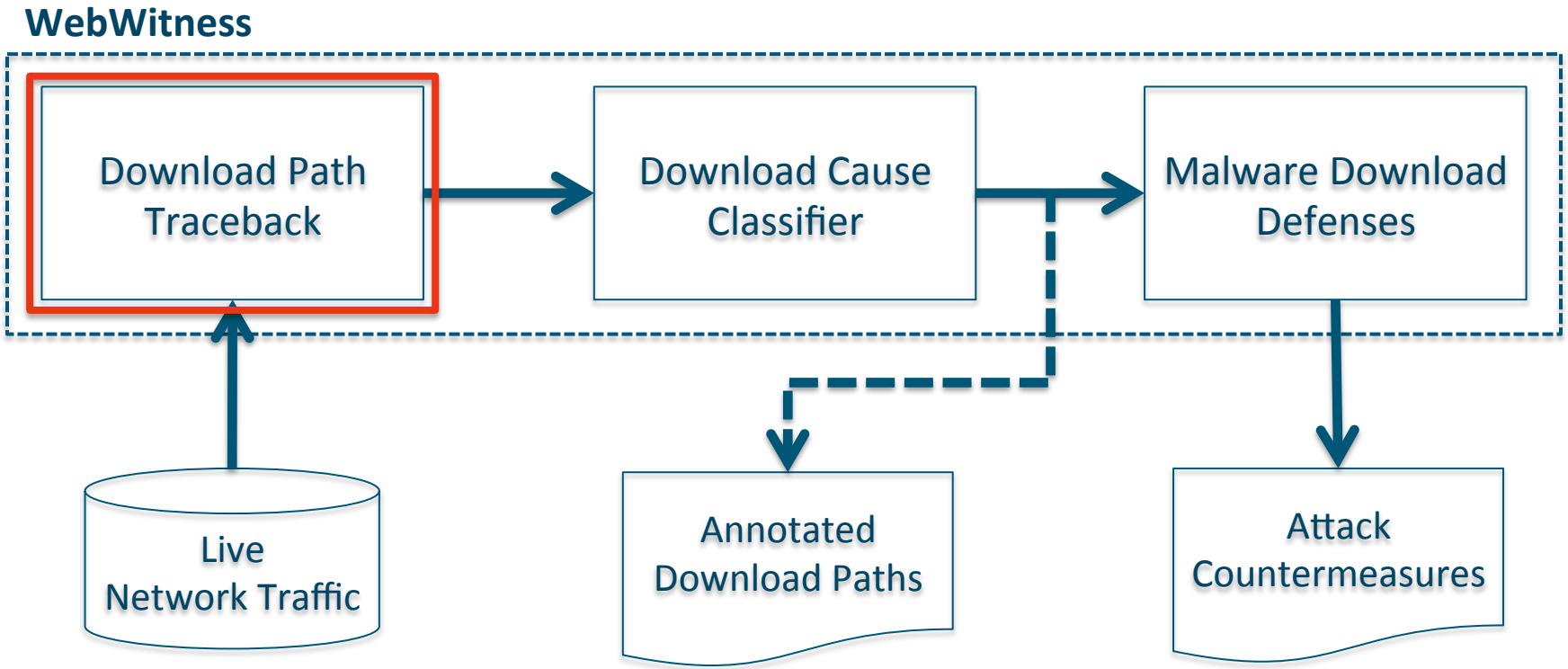

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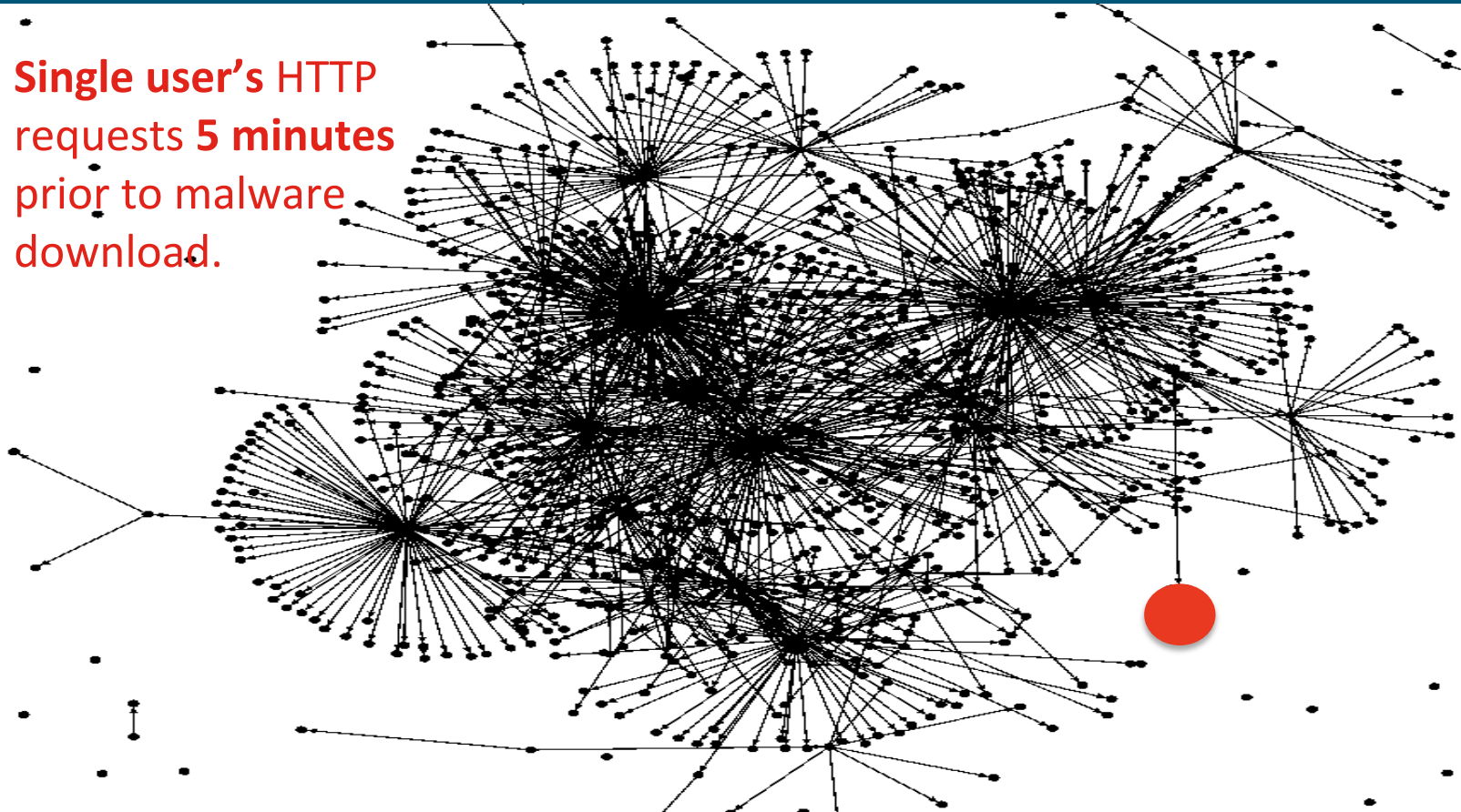


Referrer & Location Header Only

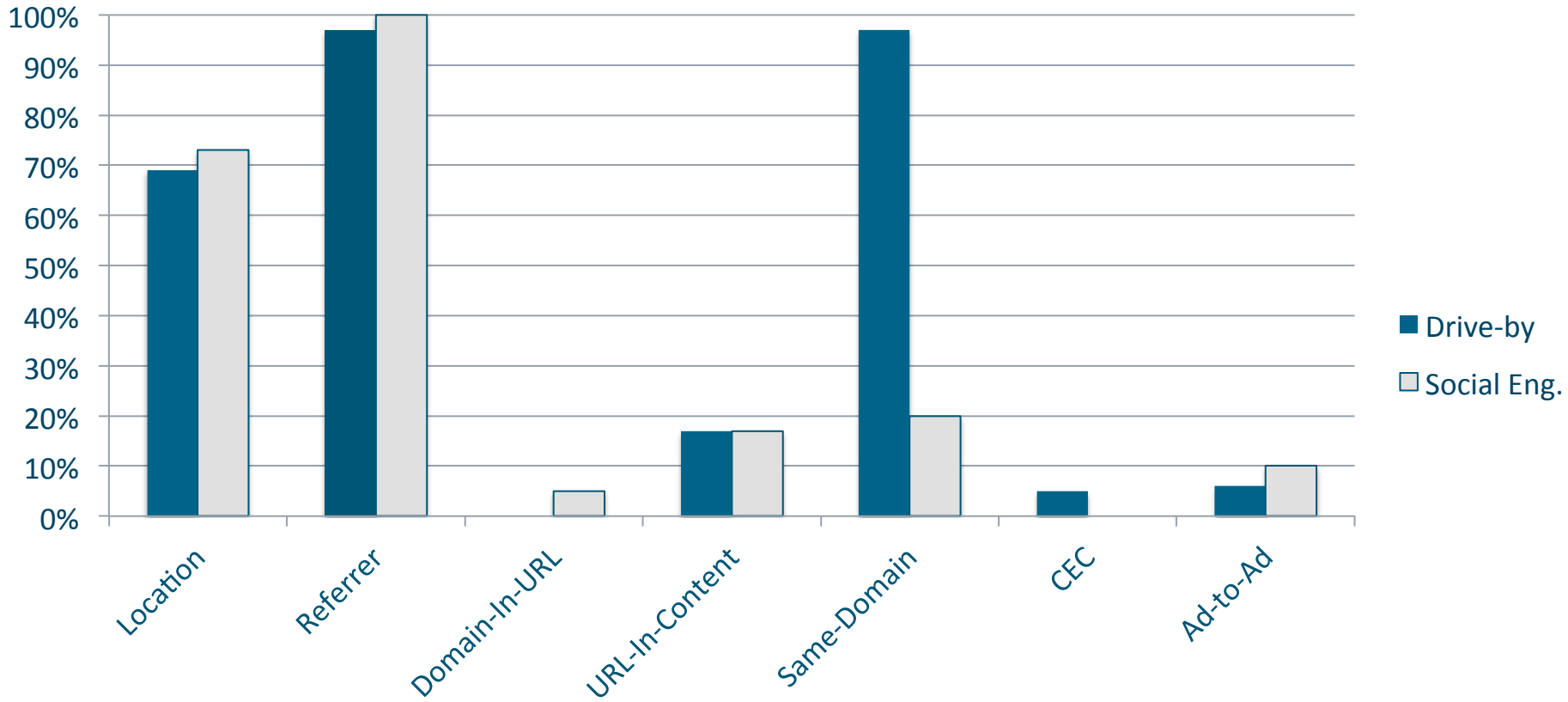
Drive-by

0%

Social Eng.

53%

Web Graph “Source-of” Relationships



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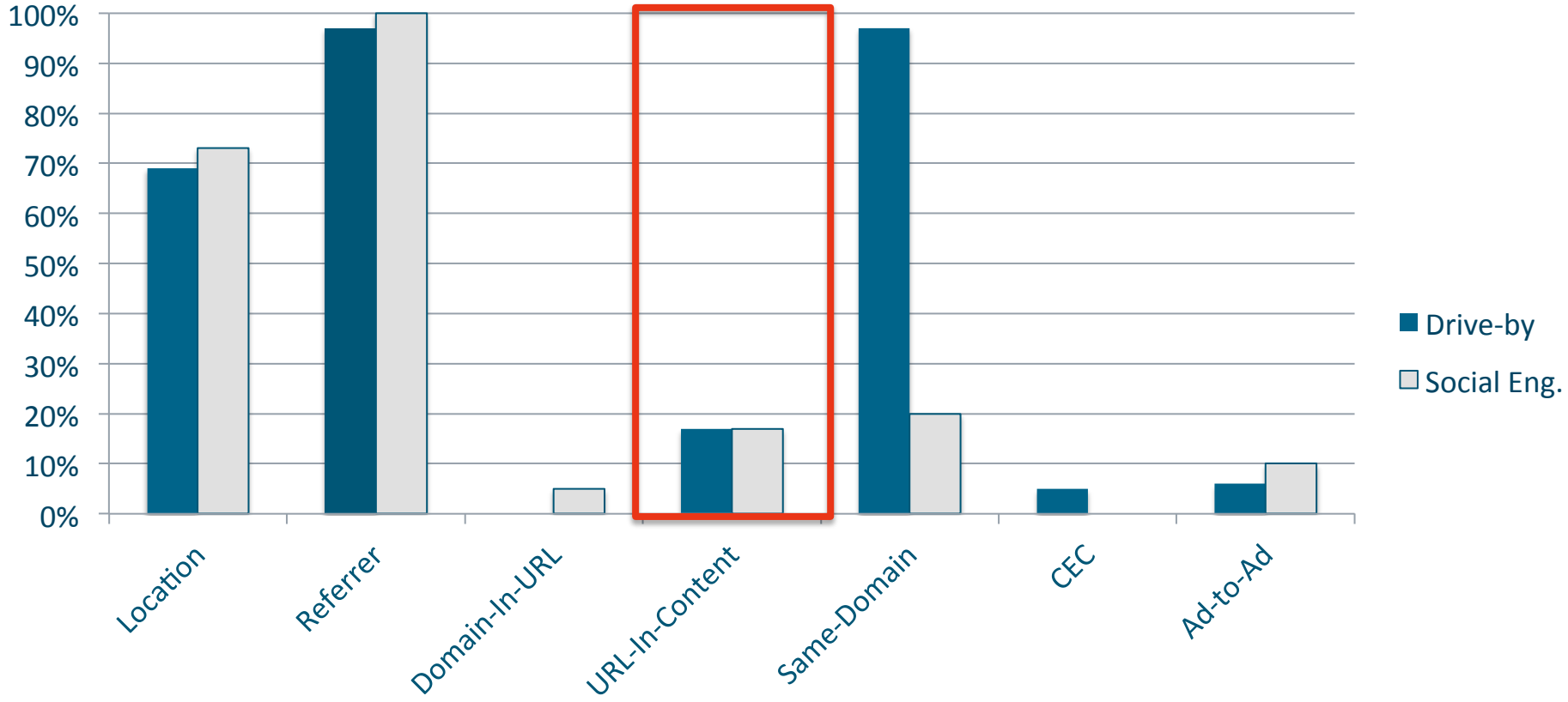


Improvement using all “source-of” features

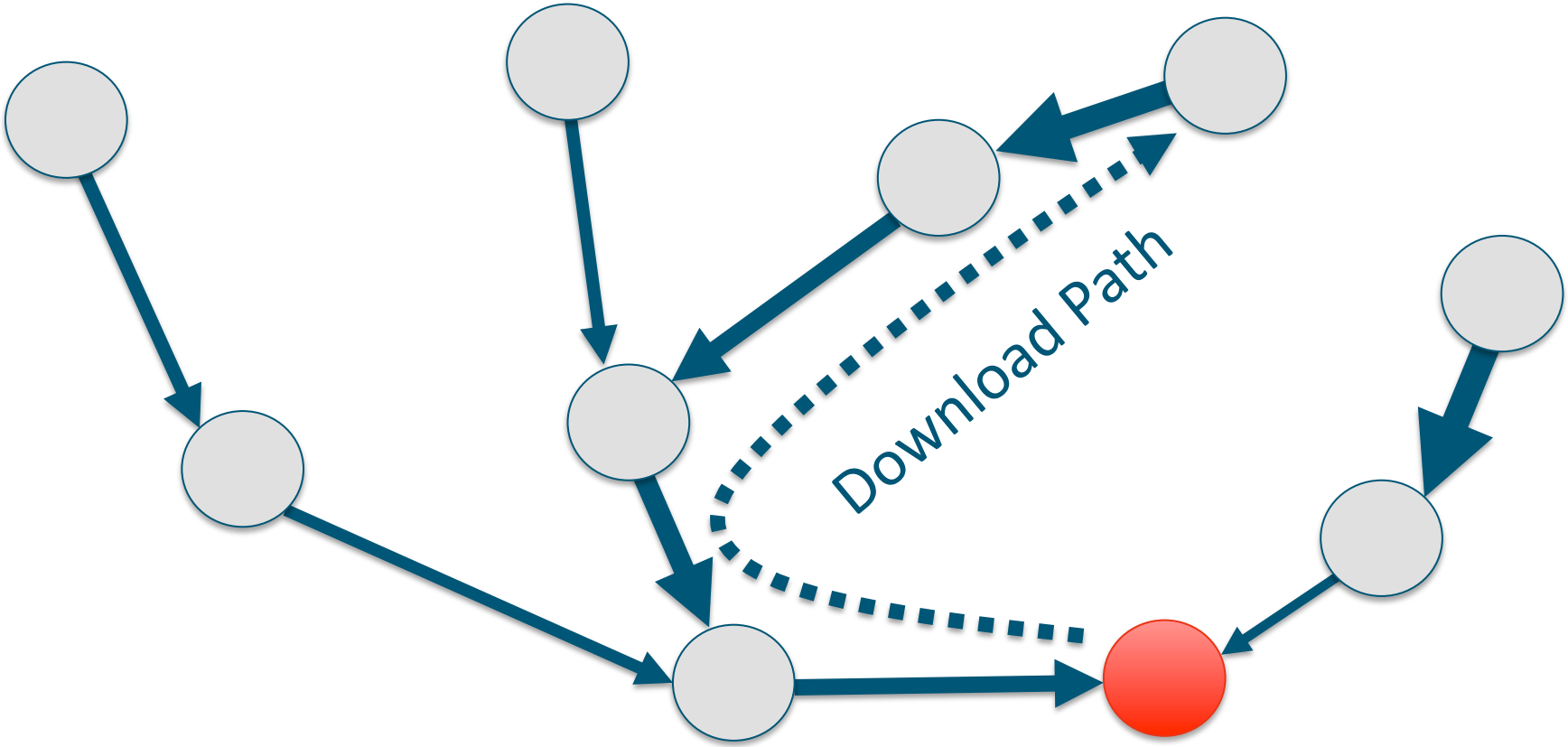
Drive-by

0% → **96%**

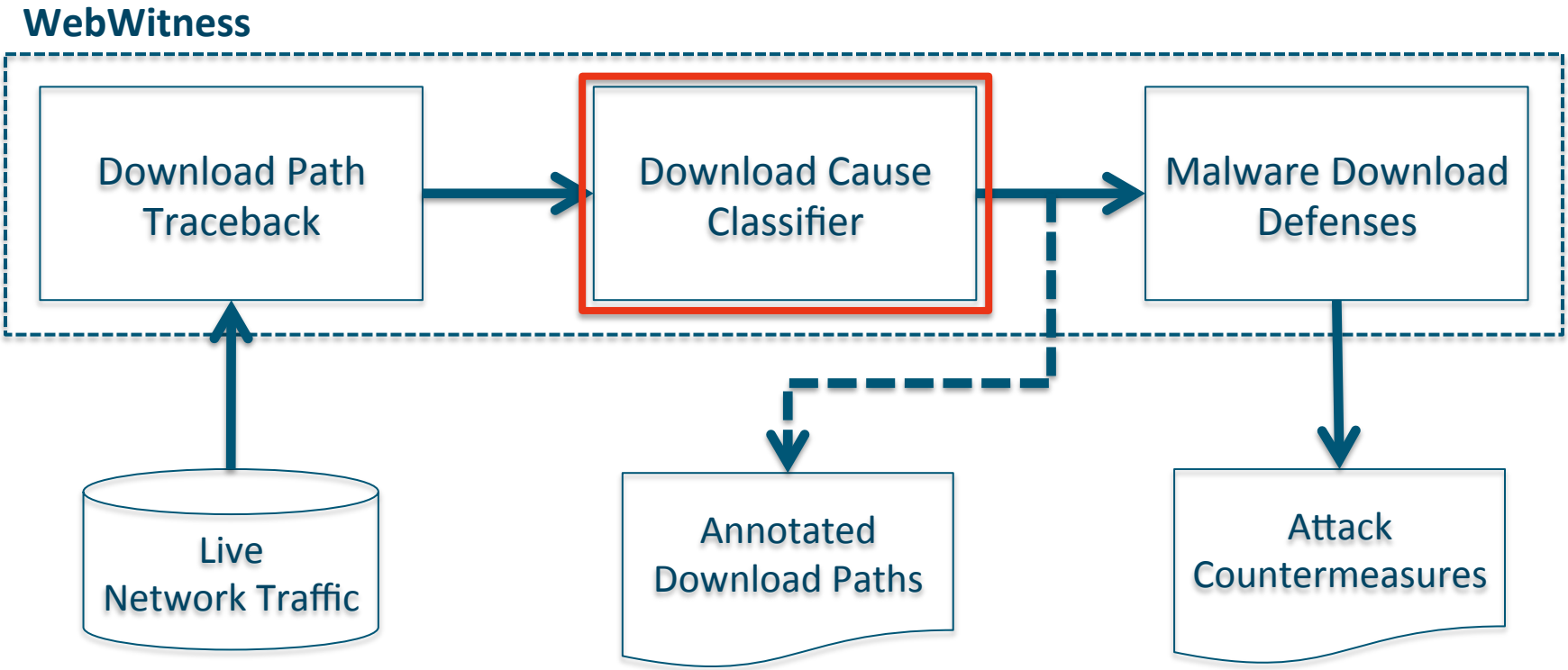
Social Eng.

53% → **95%**

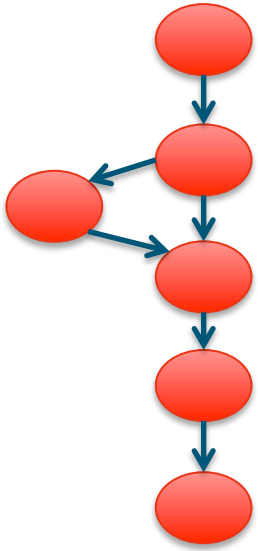
Download Path Traceback

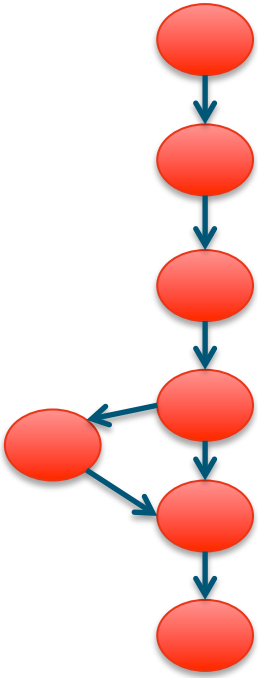


WebWitness System

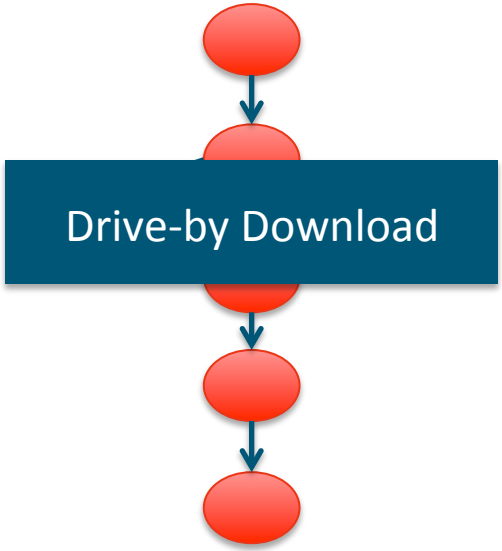


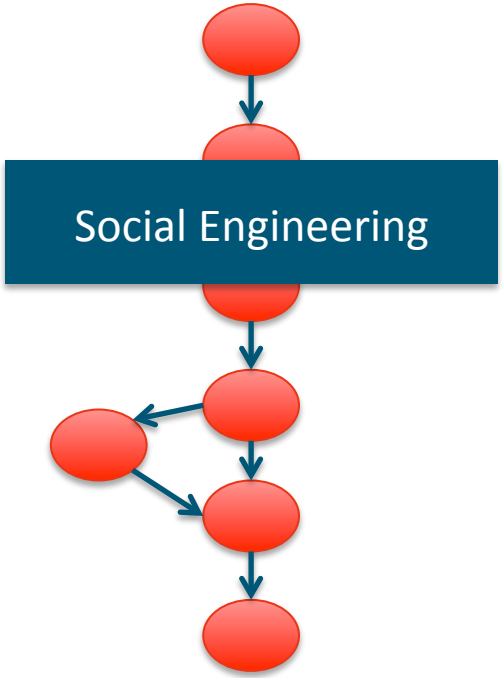
Download Paths





Download Path Classification



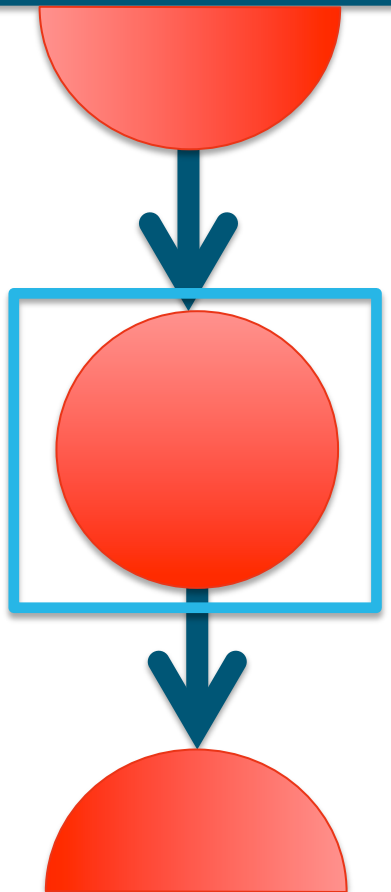


Cause Classifier Features

6 Features

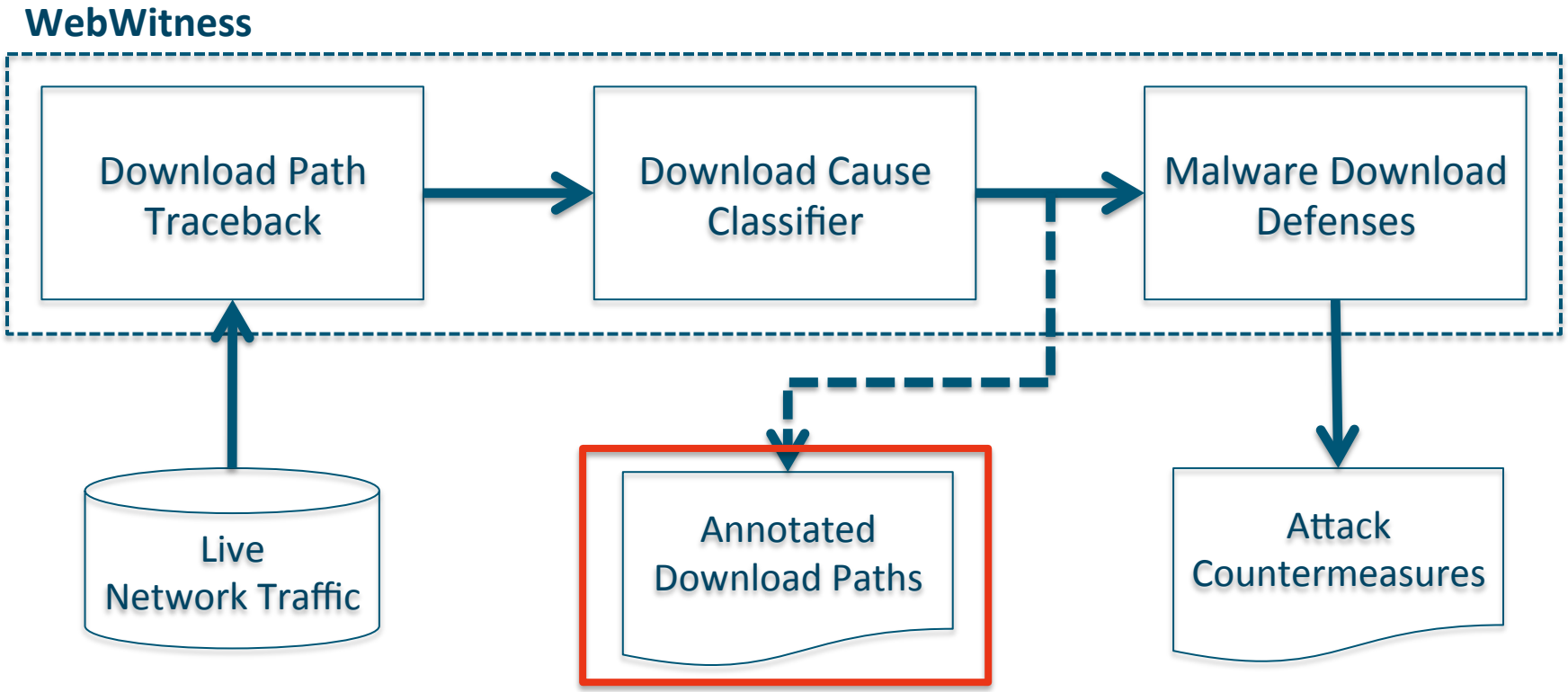
- Candidate Exploit Domain Age.
- Drive-by URL Similarity.
- Download Domain Recurrence.
- Download Referrer.
- Download Path Length.
- User-Agent Popularity.

Candidate Exploit Domain Age

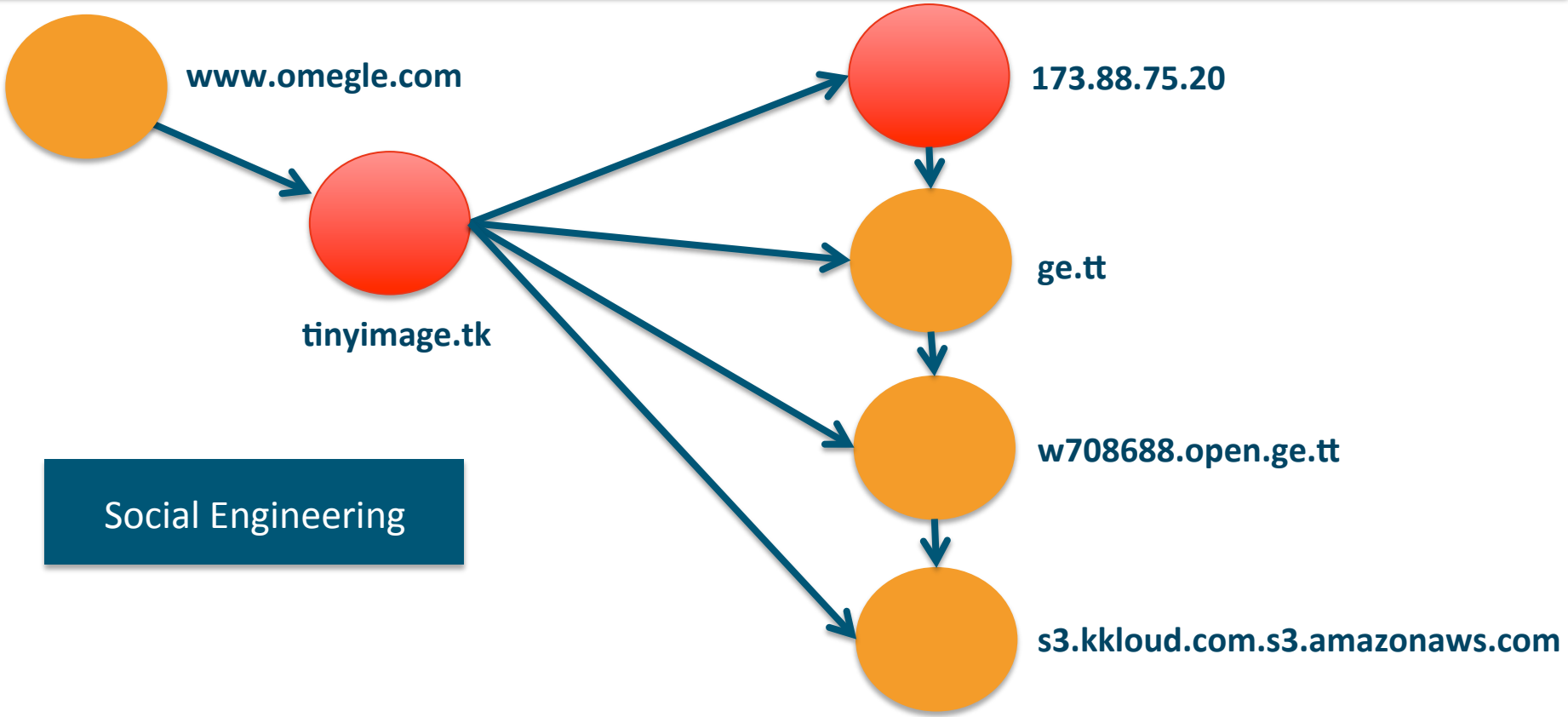


- “Commonly Exploitable” Content
  - Java
  - Flash
  - PDF
- Domain Age
  - First resolved
  - Exploit median age 0-days

WebWitness System



Annotated Social Engineering Path



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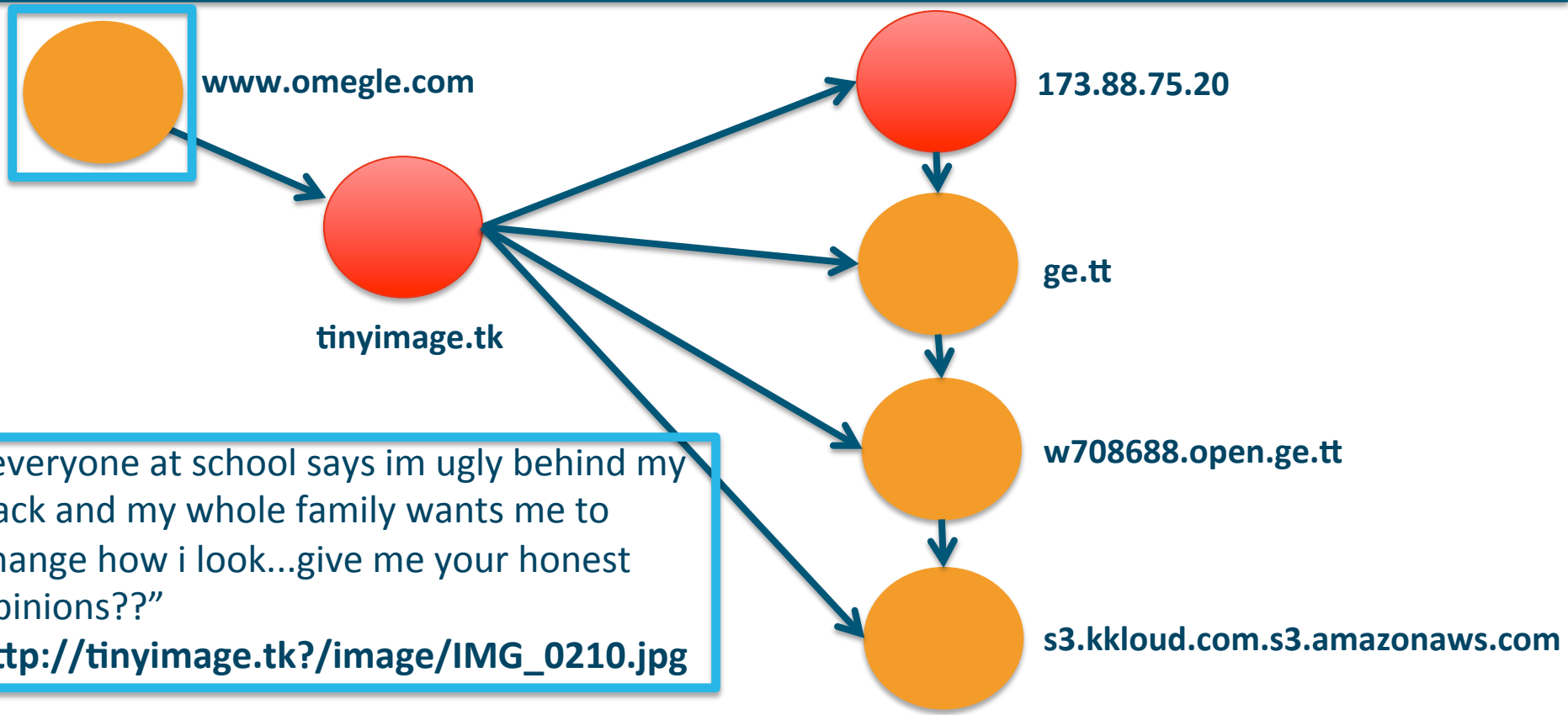

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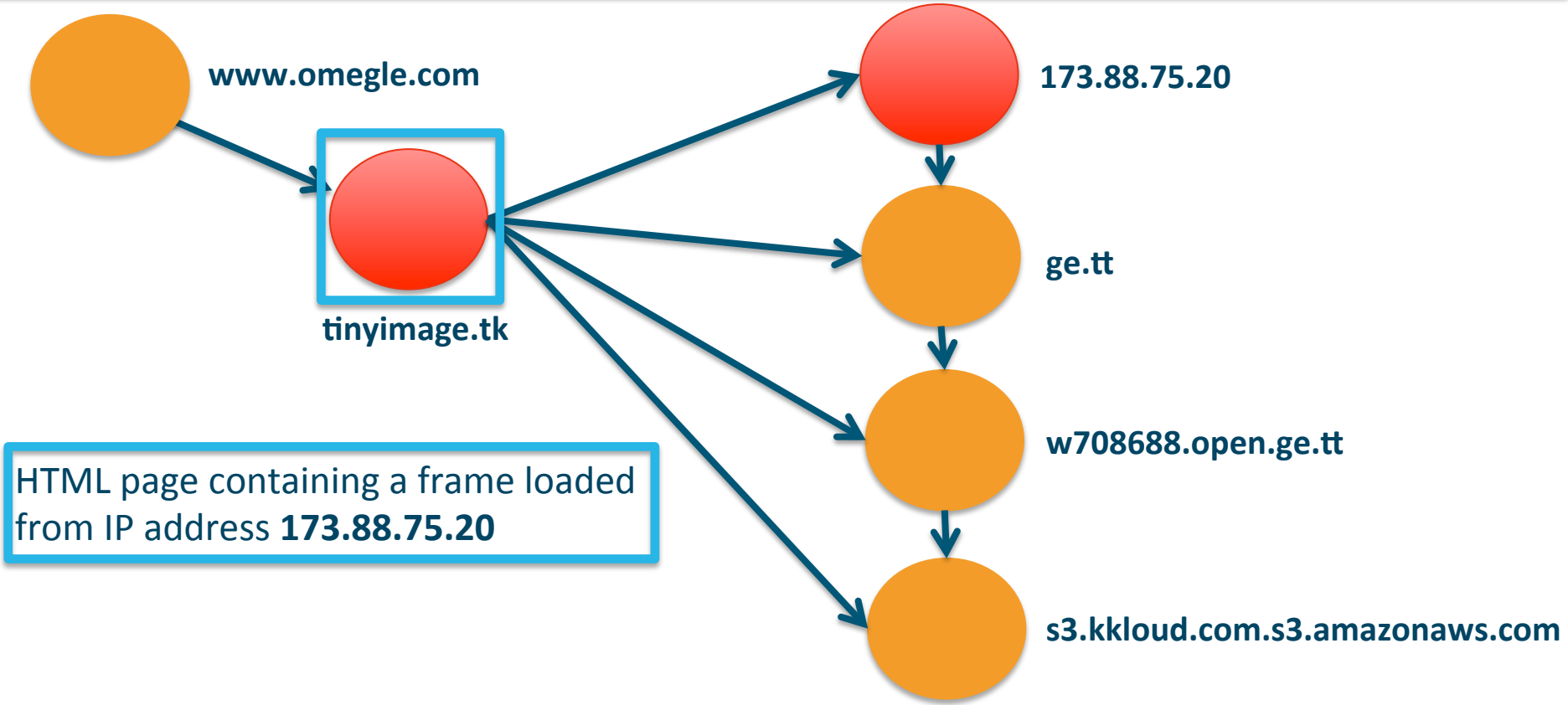

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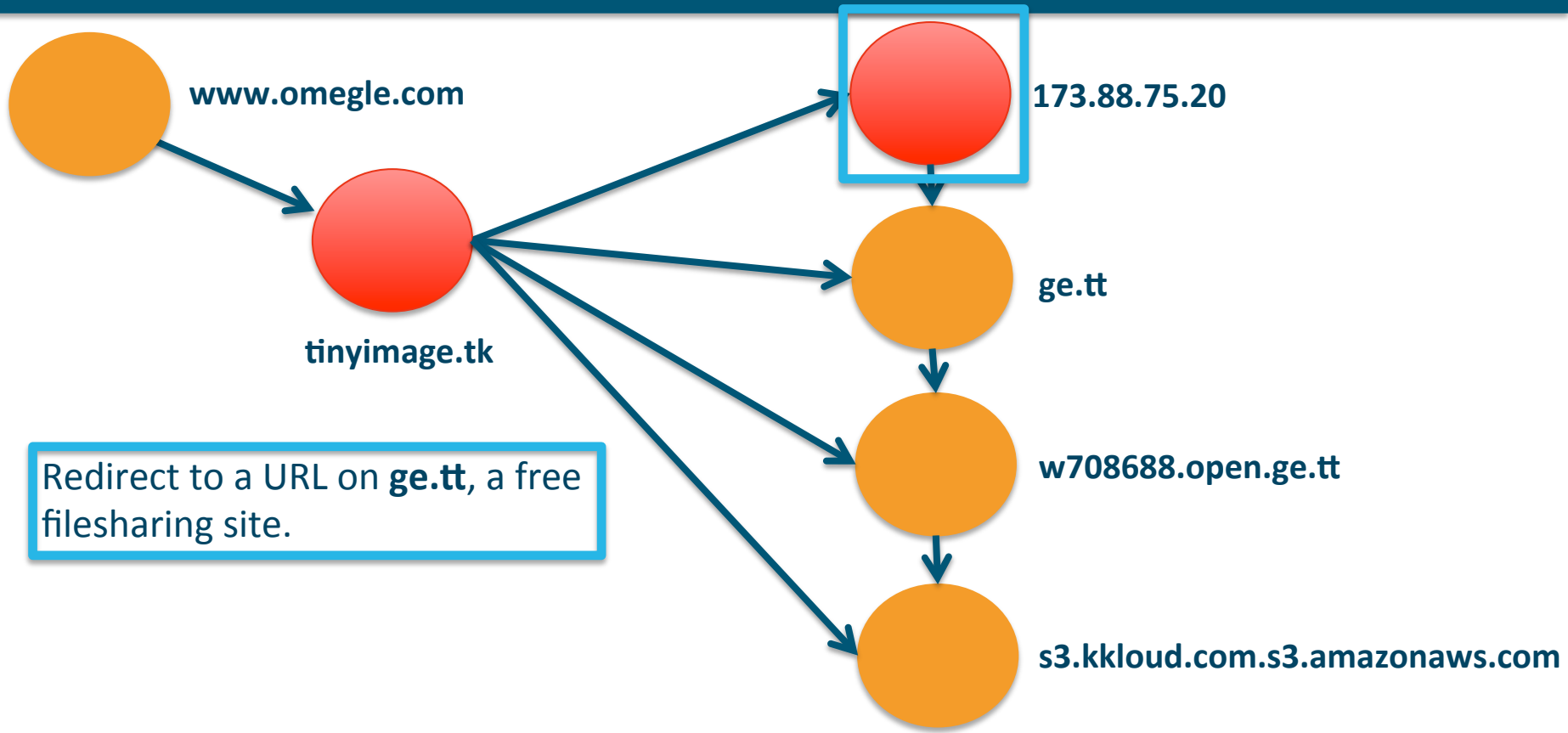

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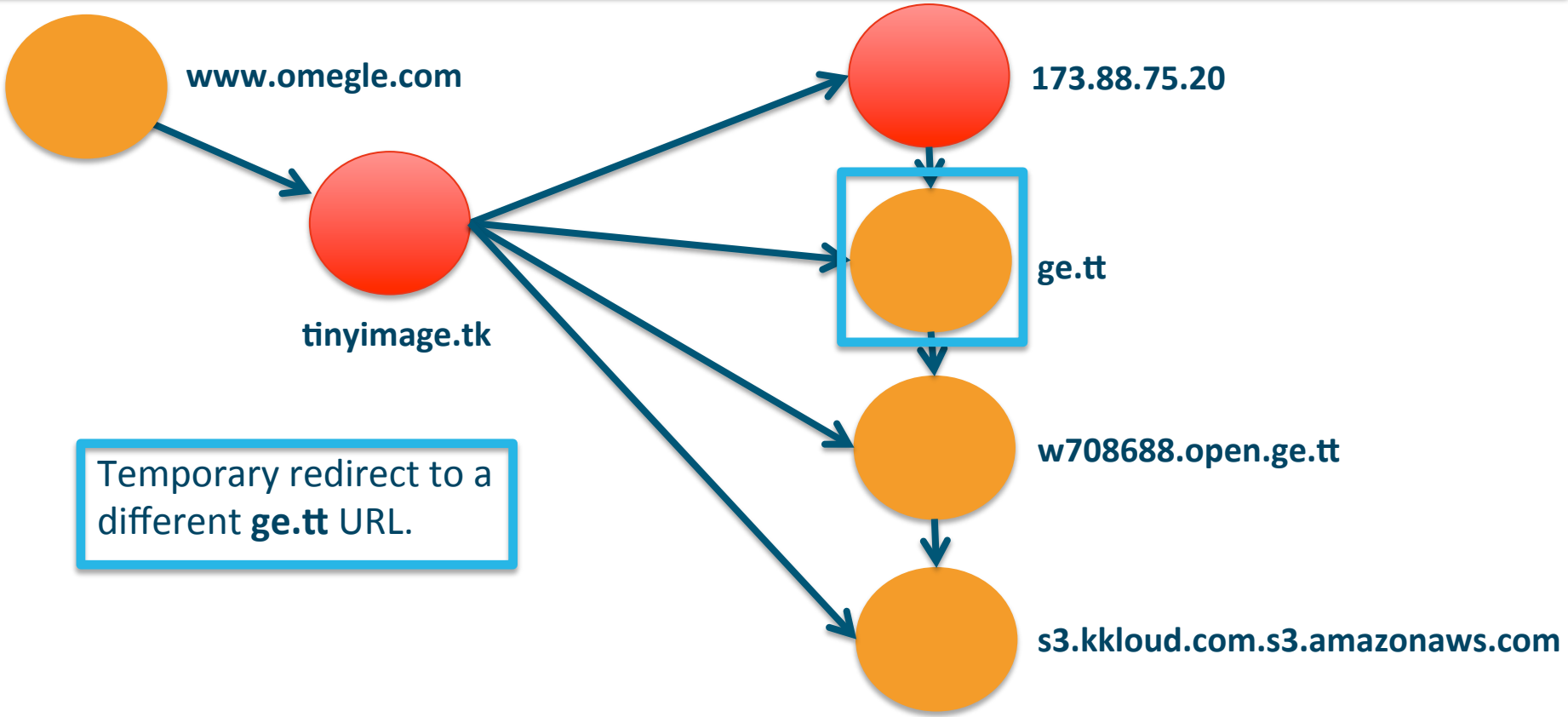

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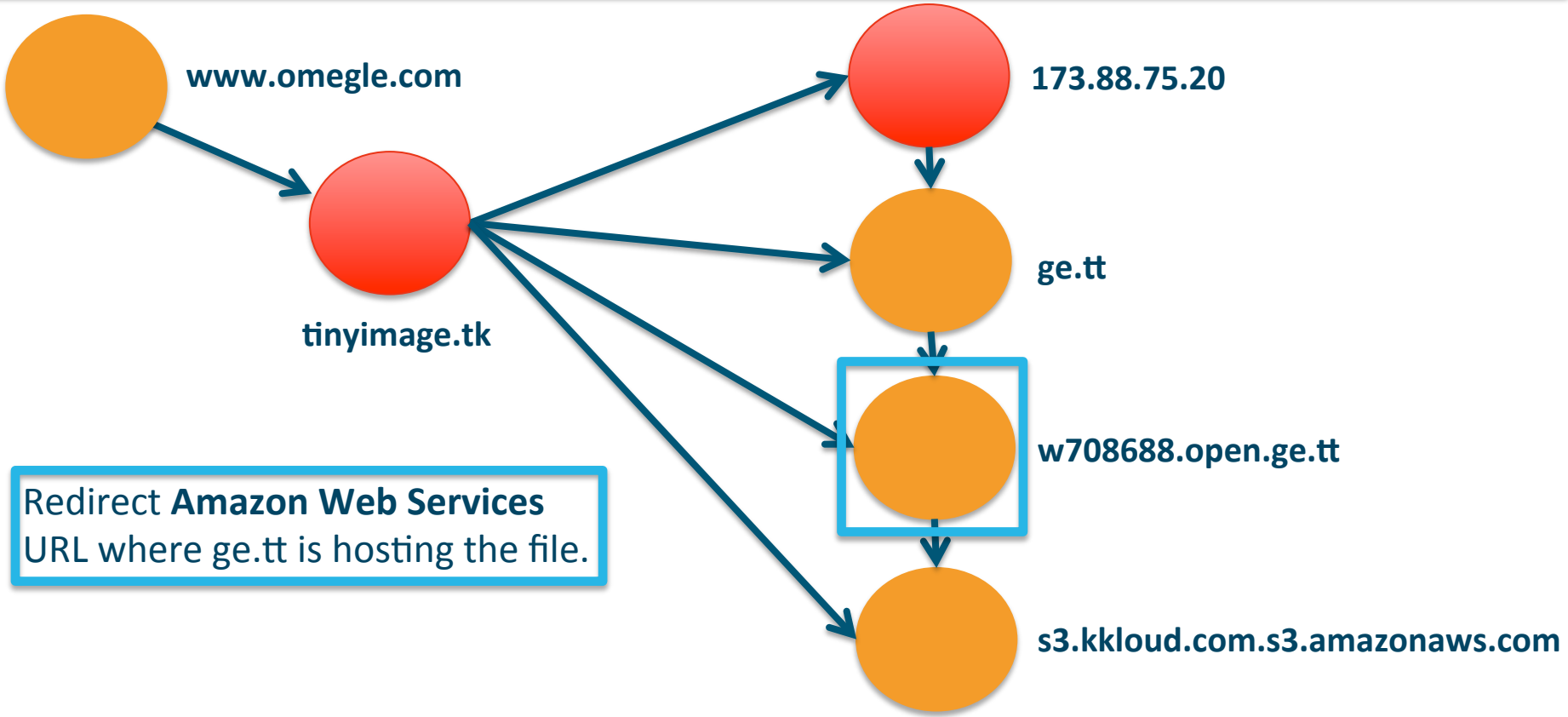

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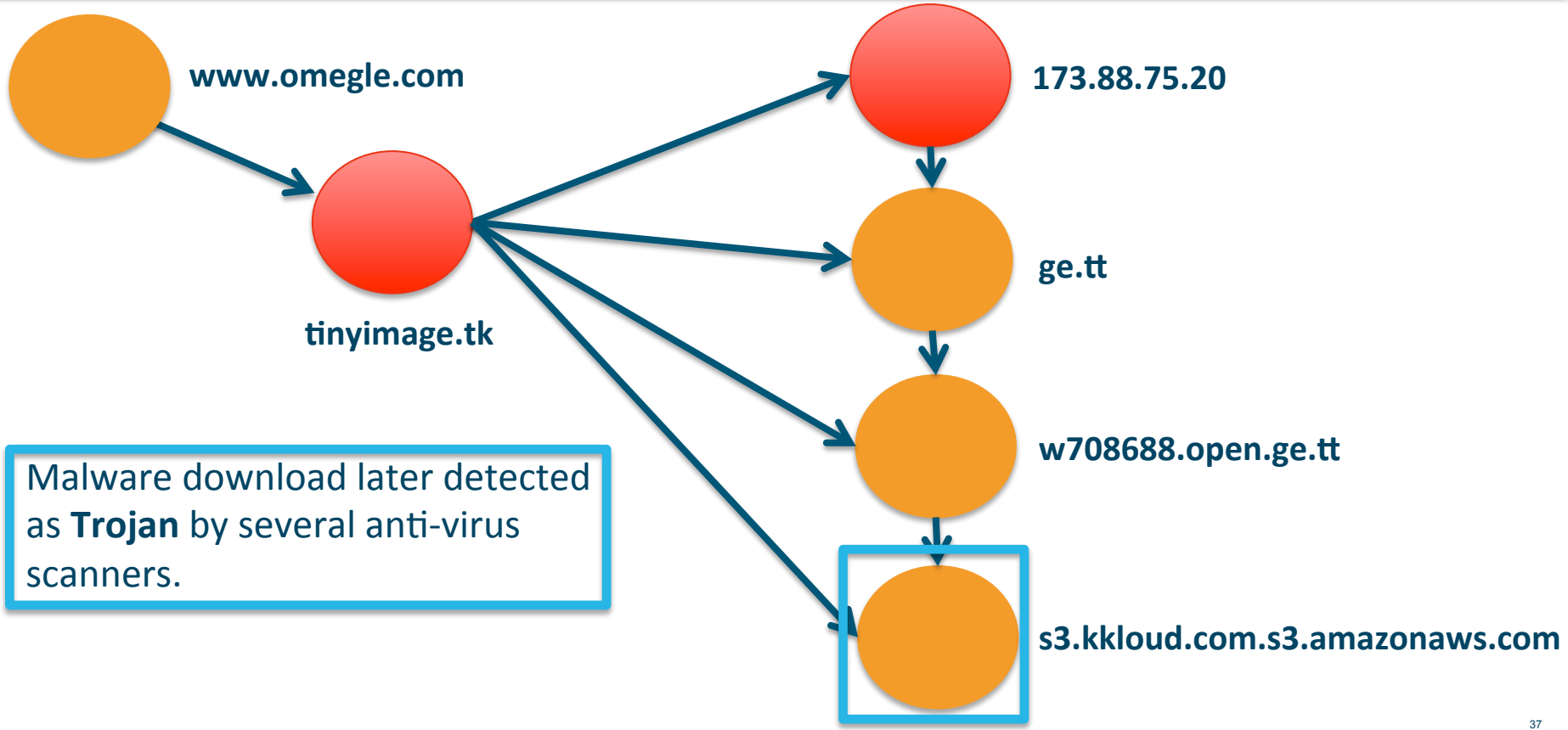
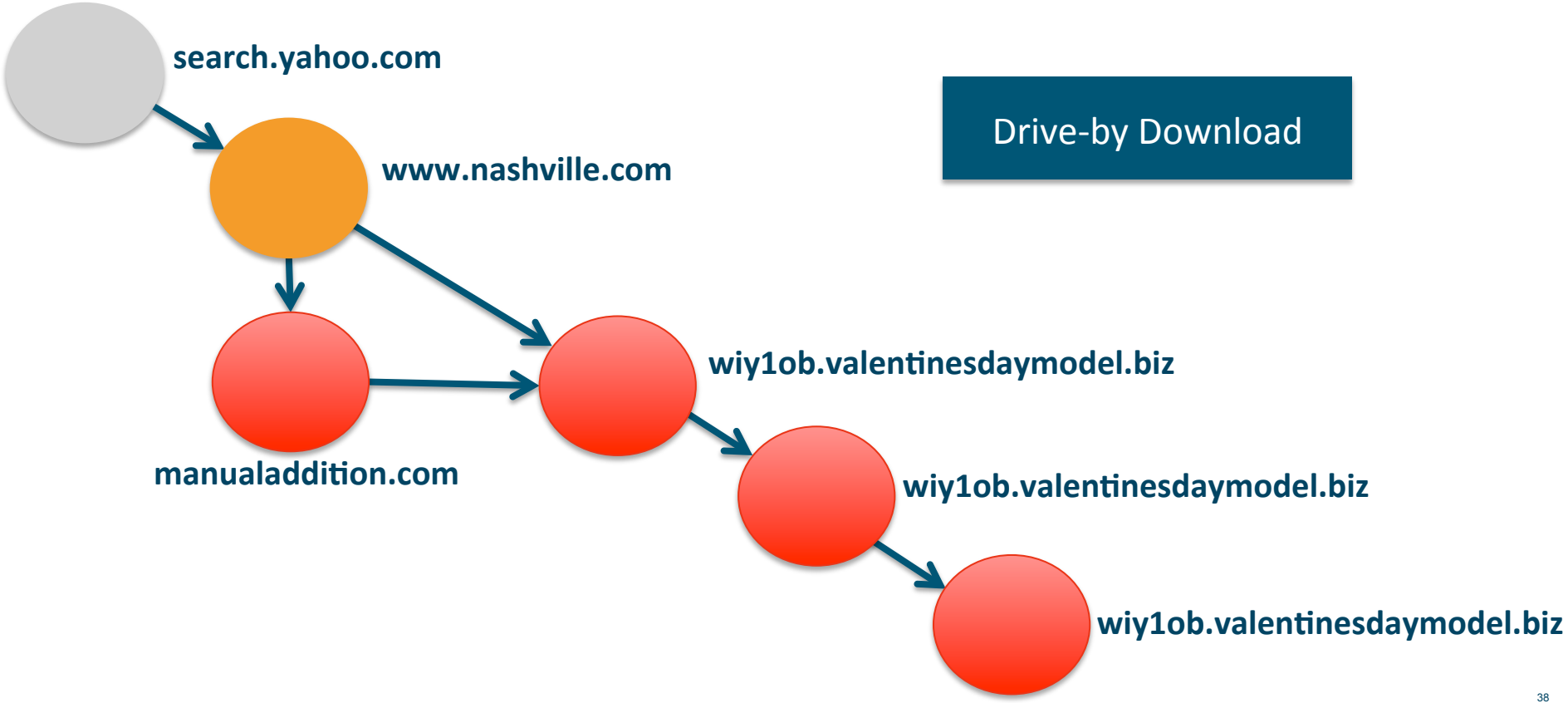


Annotated Drive-by Download Path



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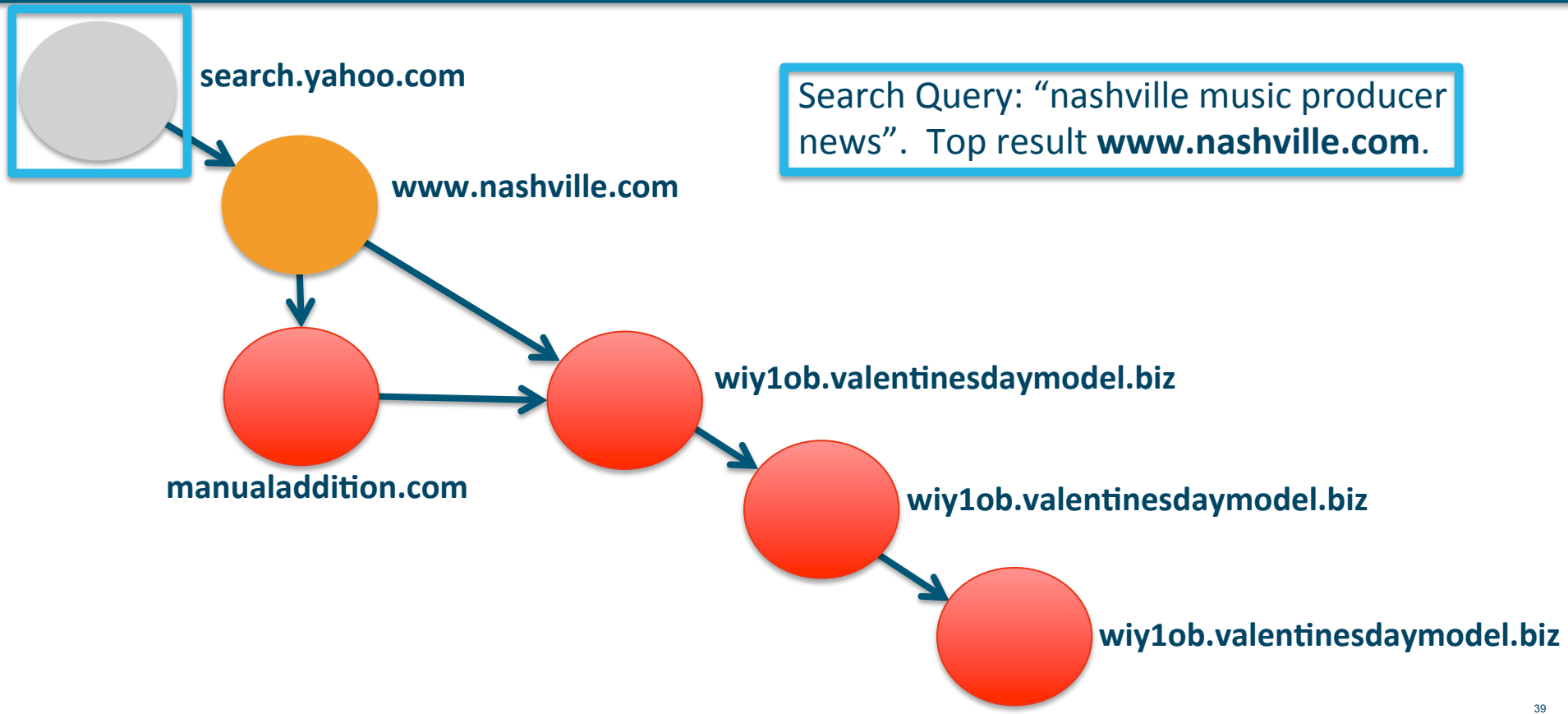

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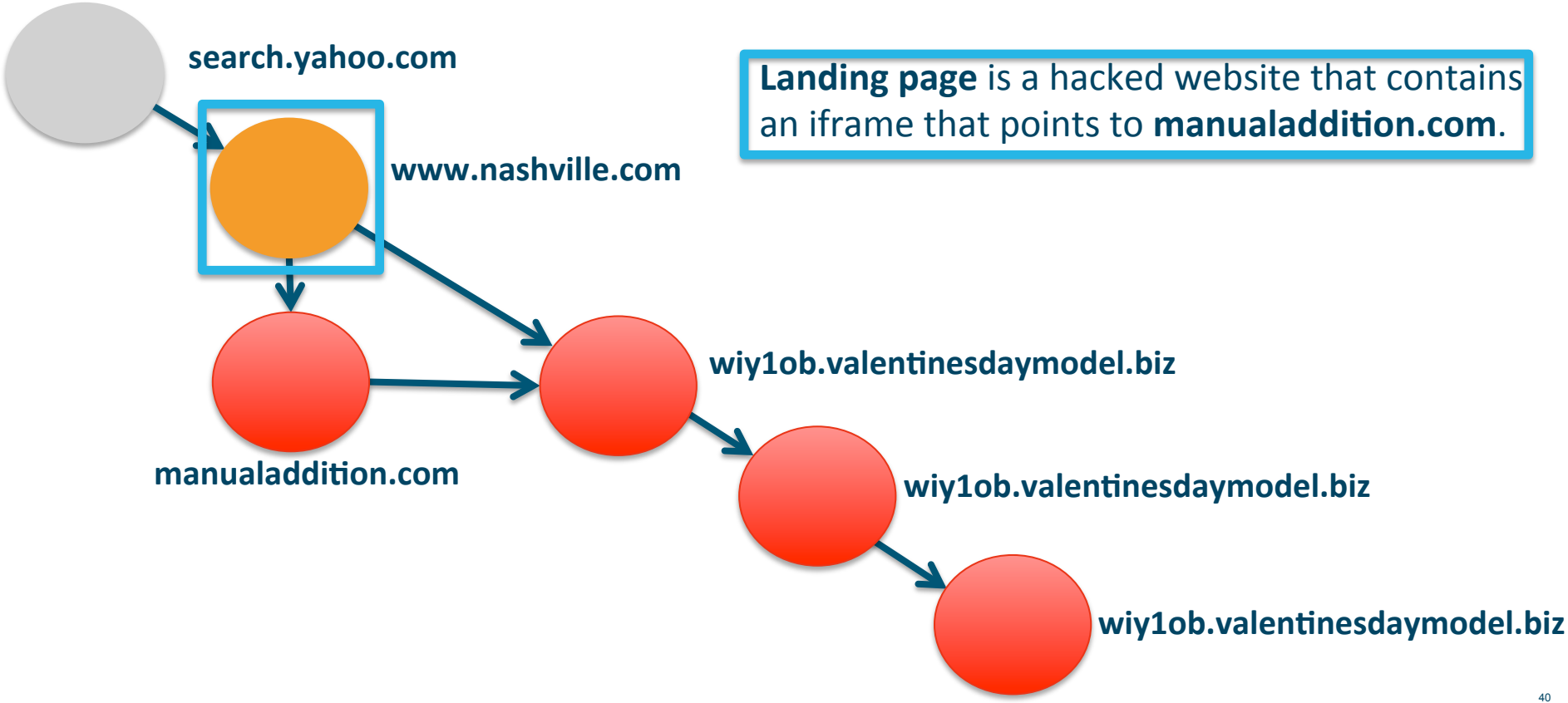

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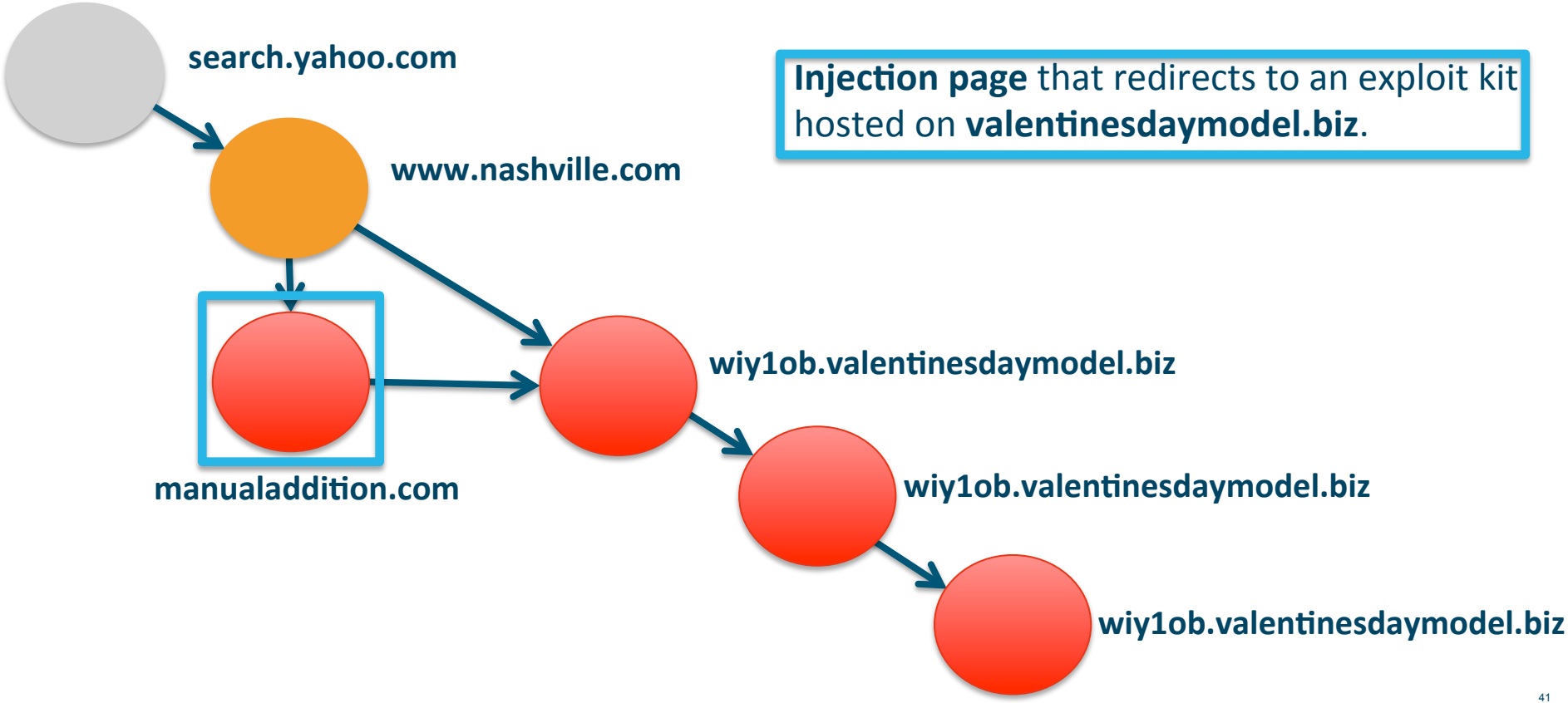

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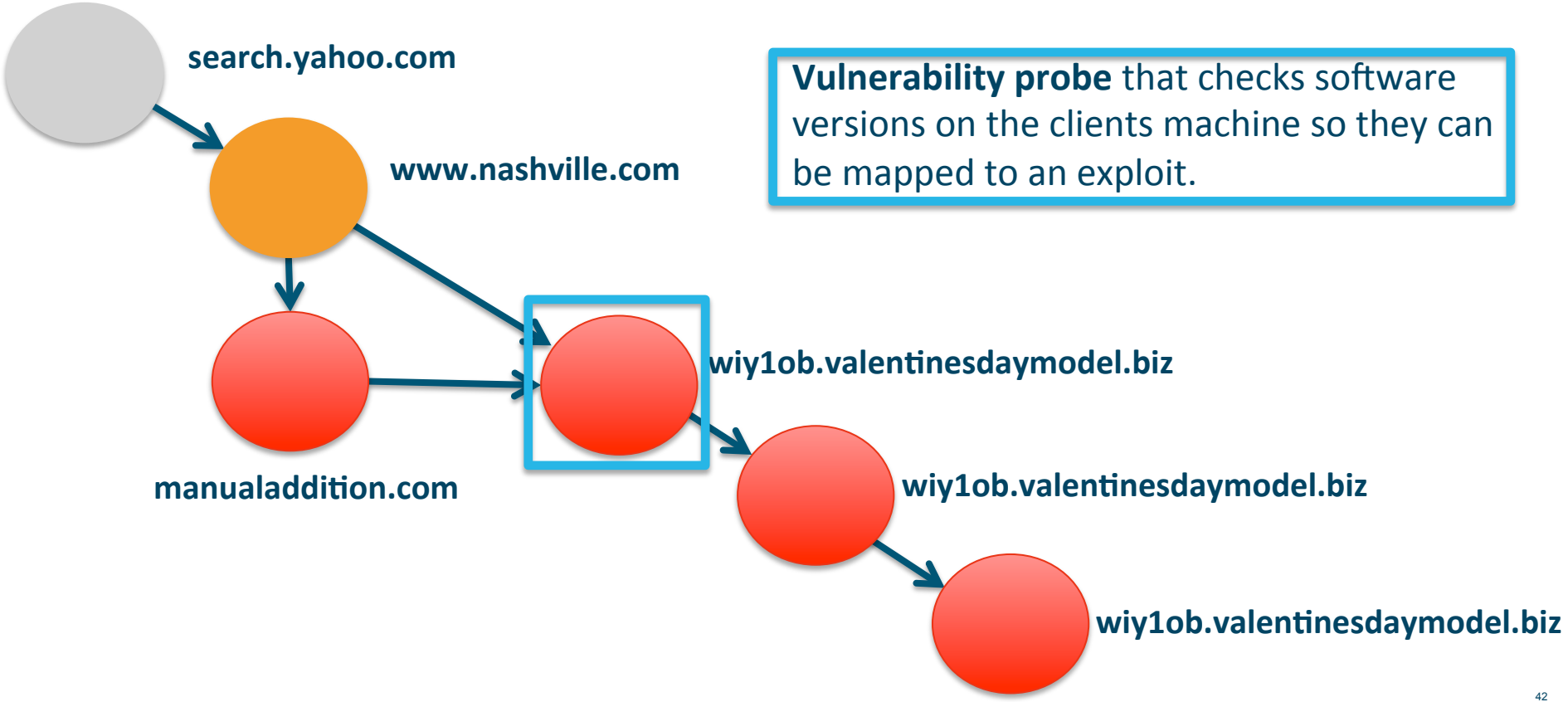

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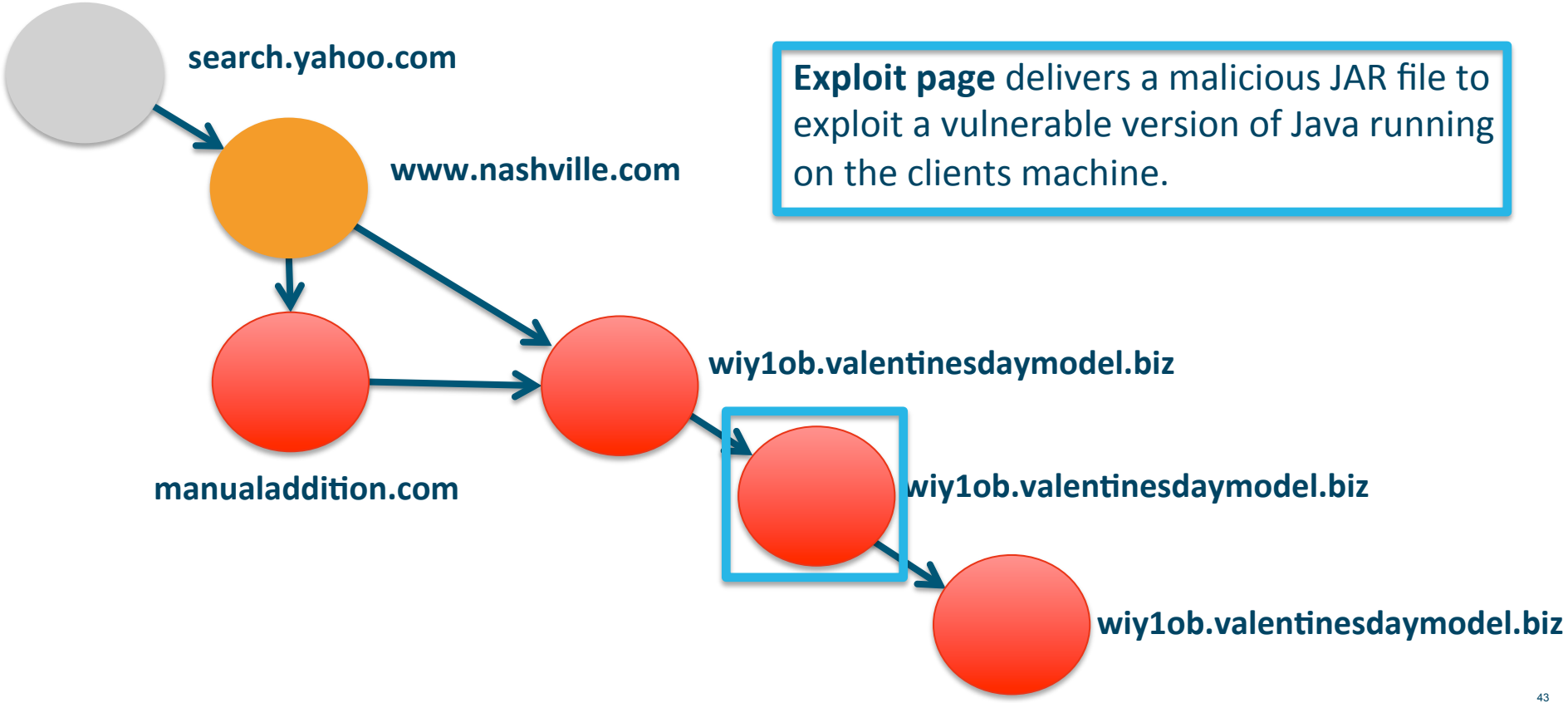

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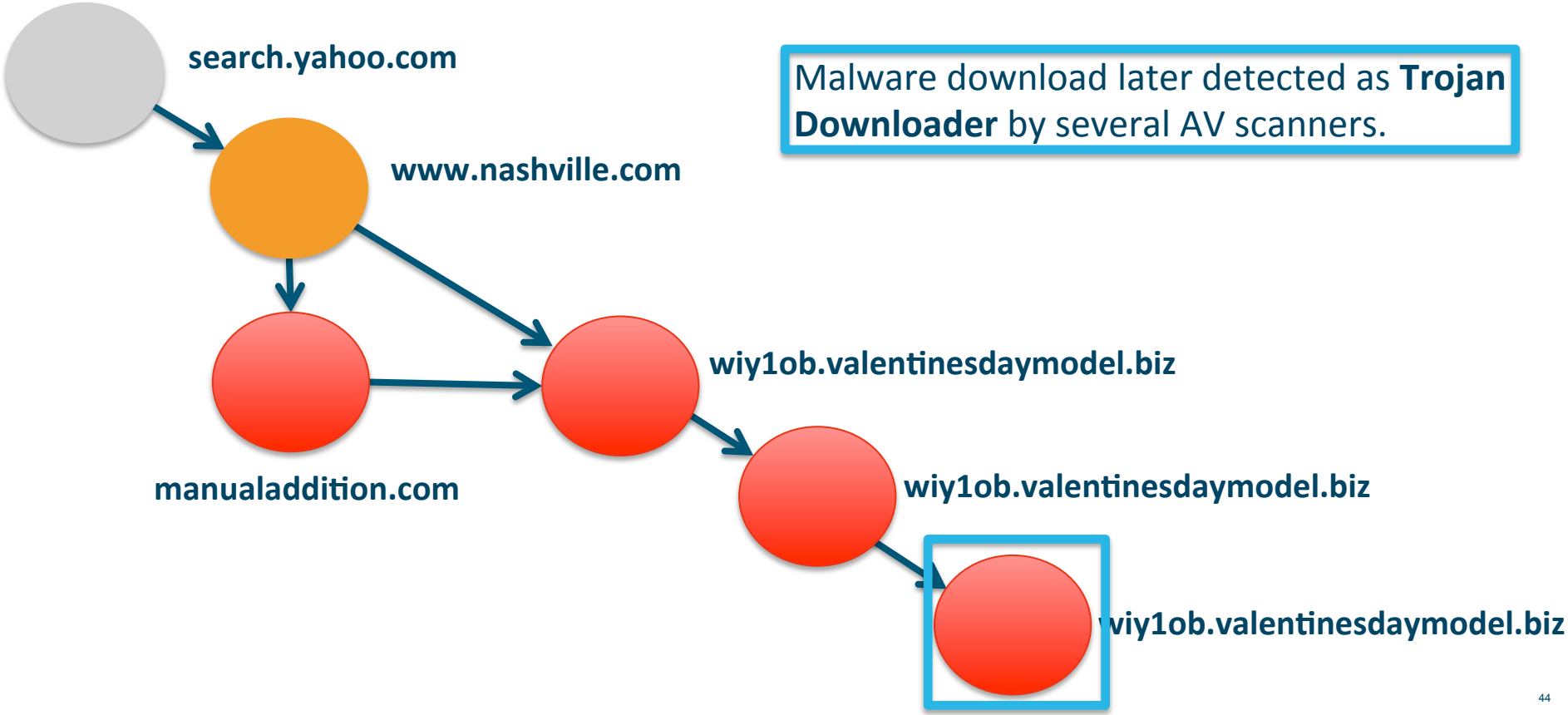
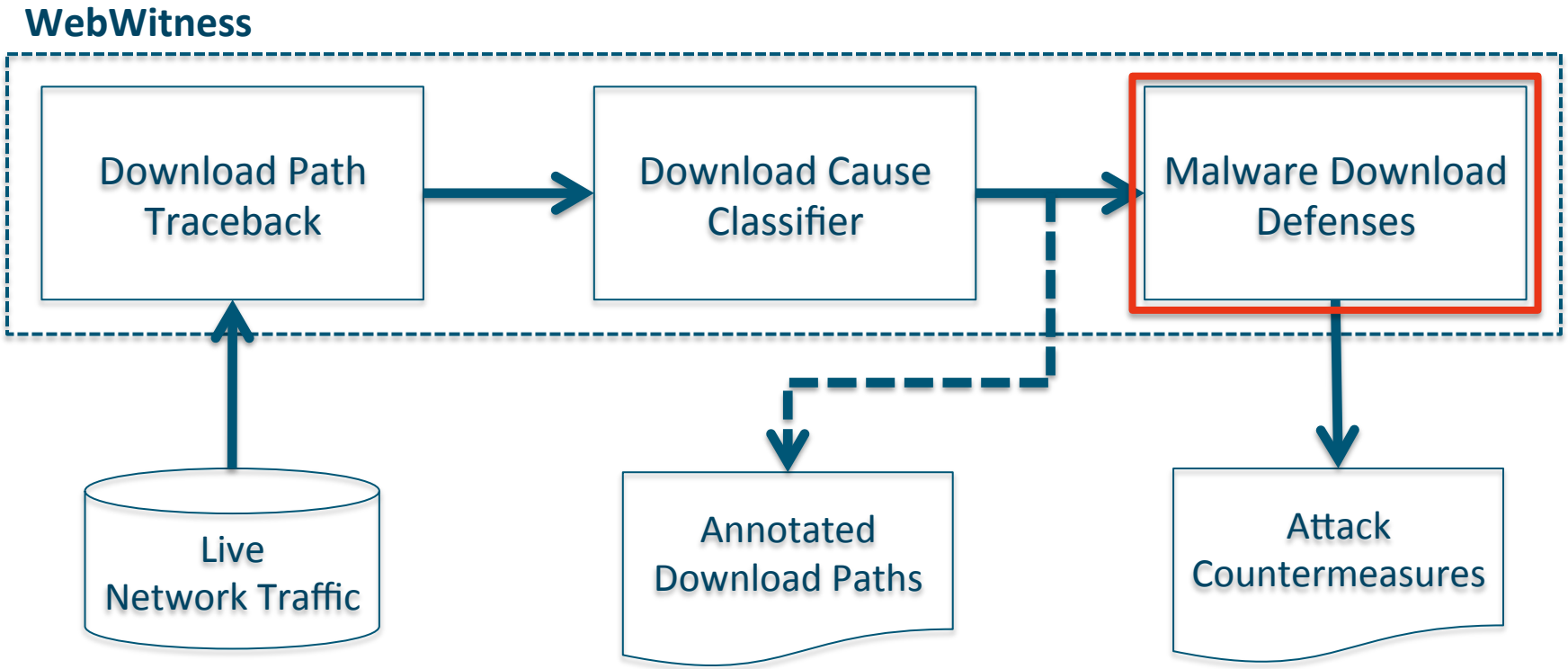
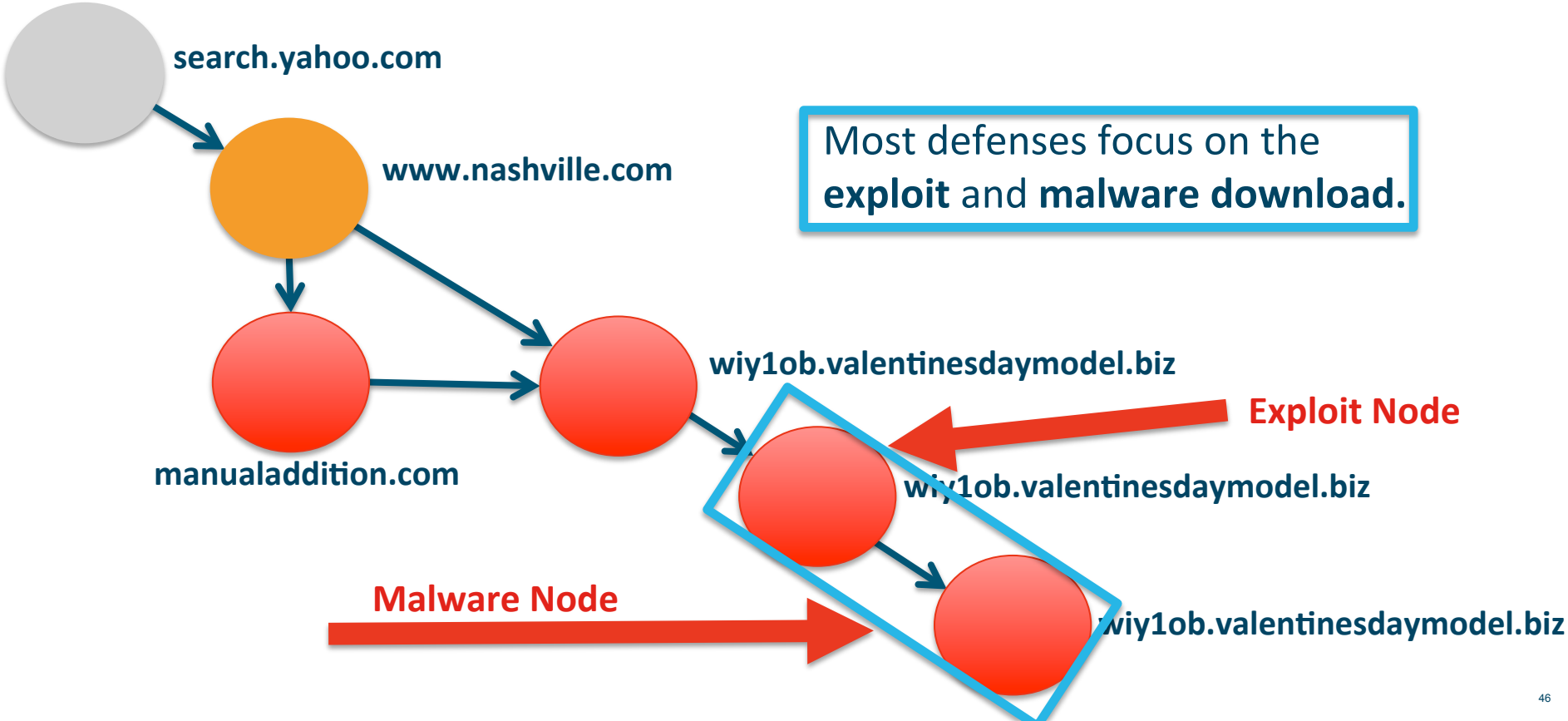


WebWitness System



Drive-by Download Defense



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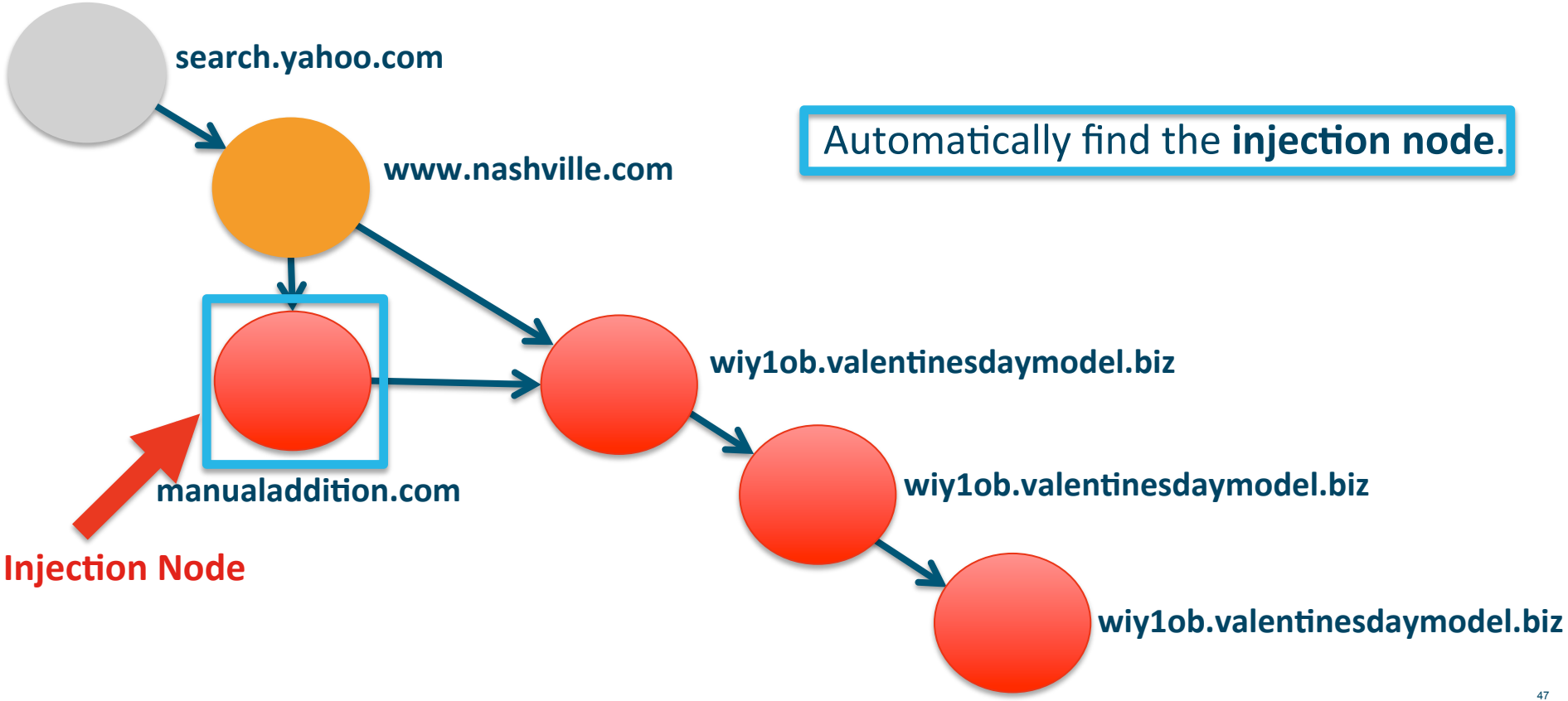

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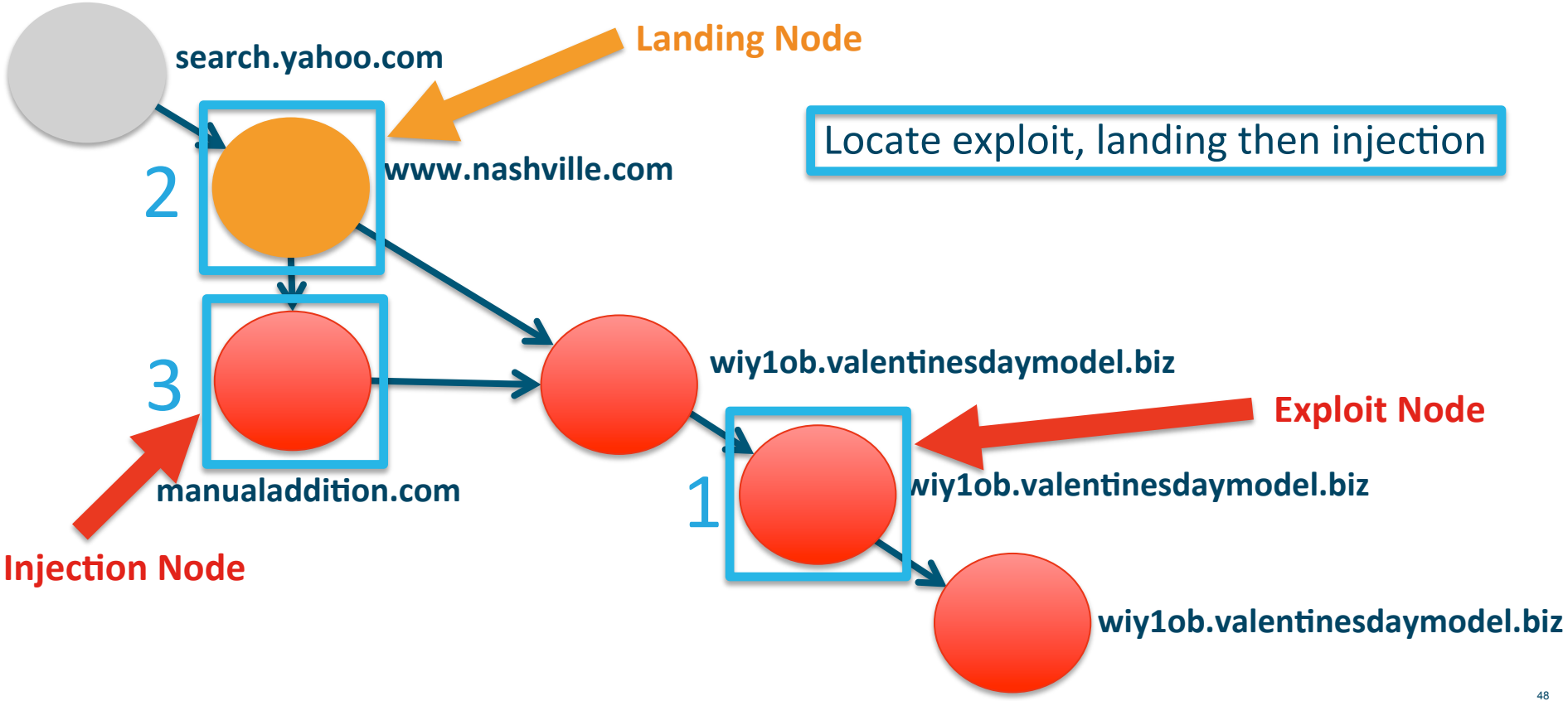
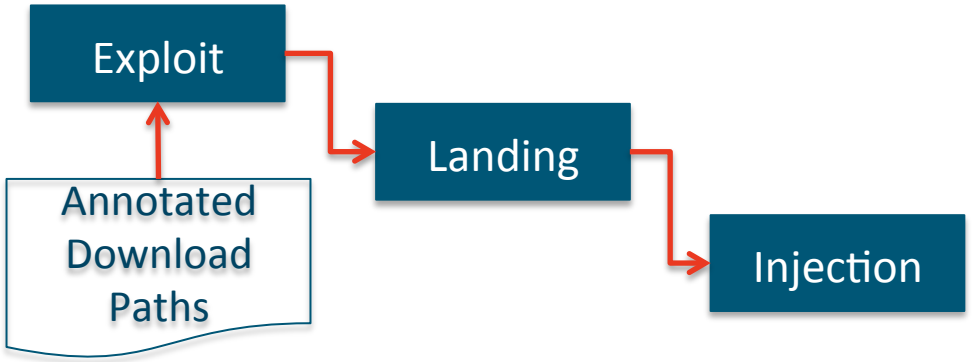


Node Classification Features

- **Exploit**
  - Hops to download page.
  - Commonly exploitable content.
  - Domain age.
  - Same domain.
- **Landing**
  - Hops to exploit page.
  - Domain age.
  - Same domain.
- **Injection**
  - On path.
  - Advertisement.
  - Domain age.
  - Successors.
  - Same domain.



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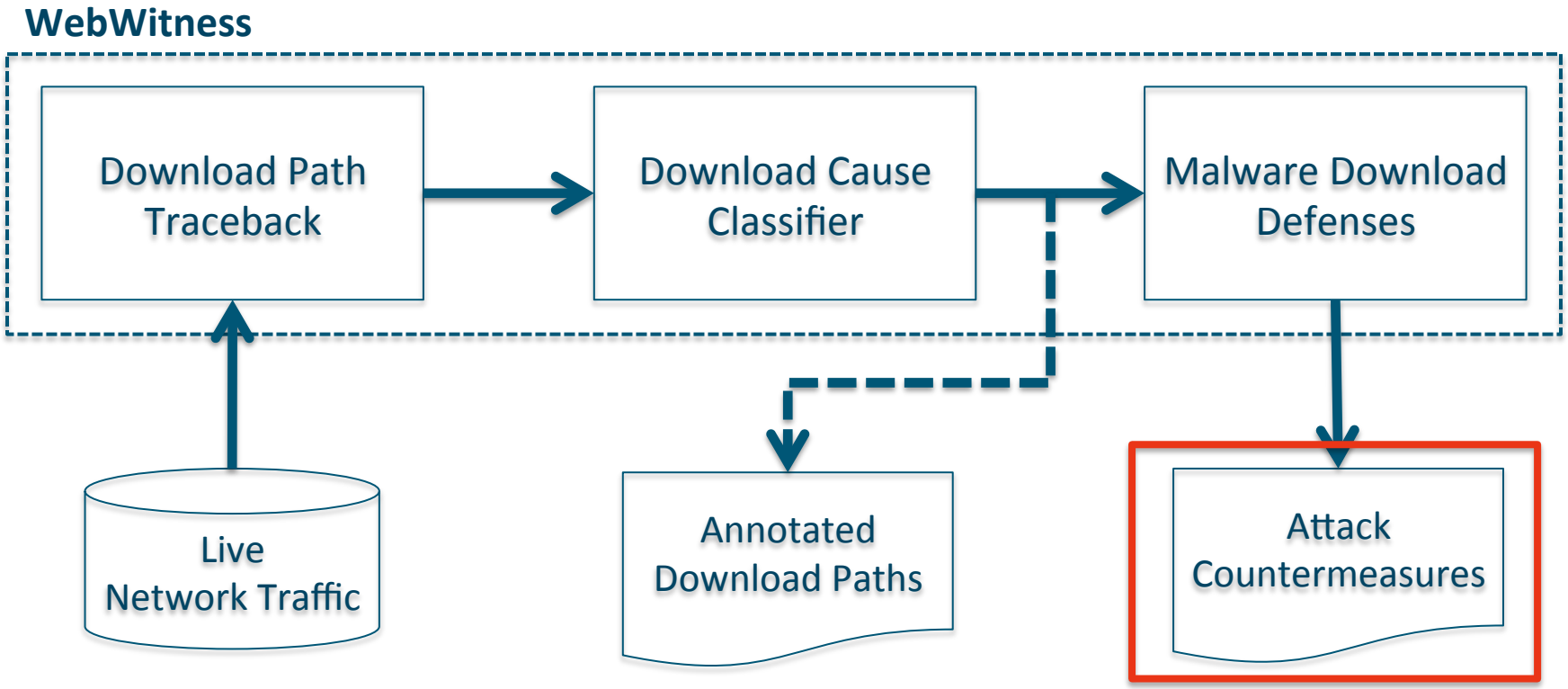
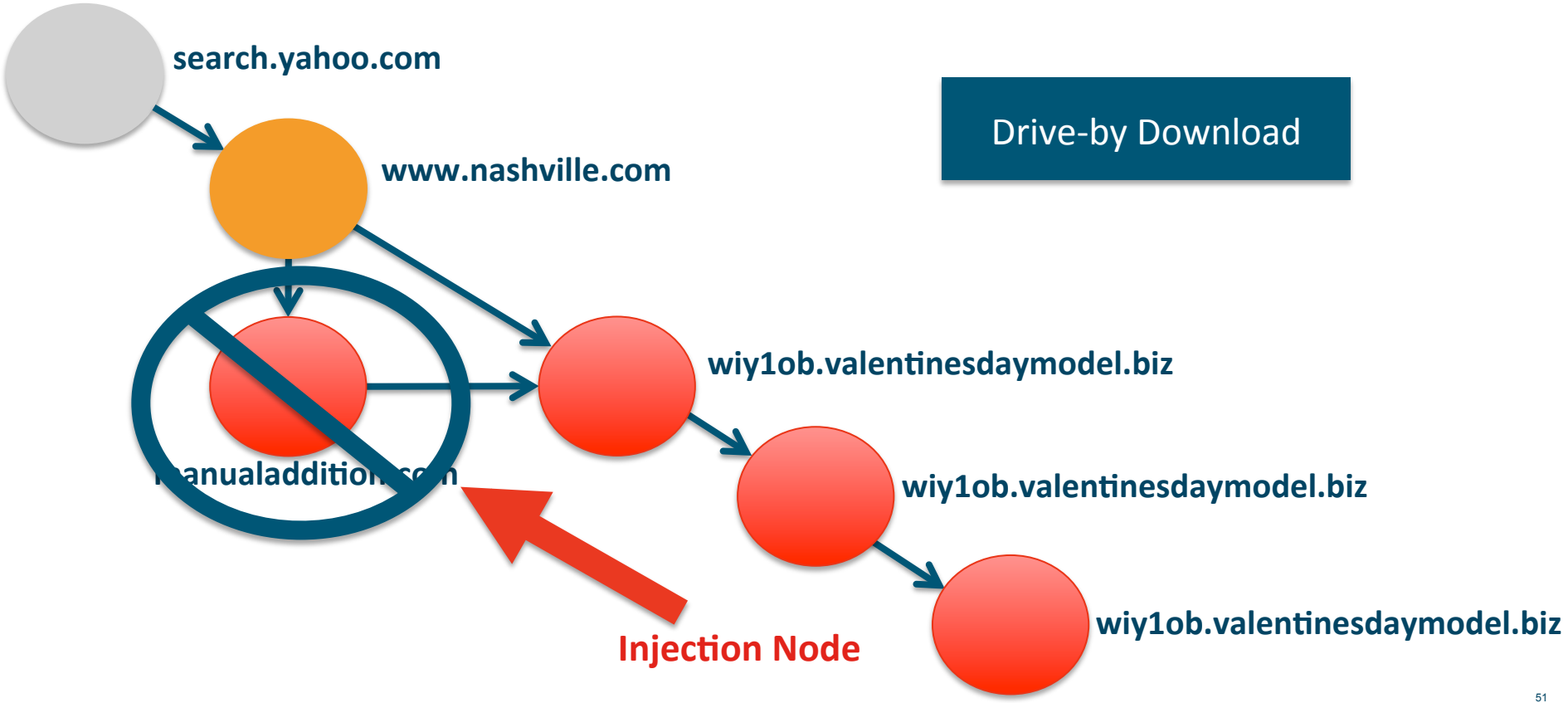
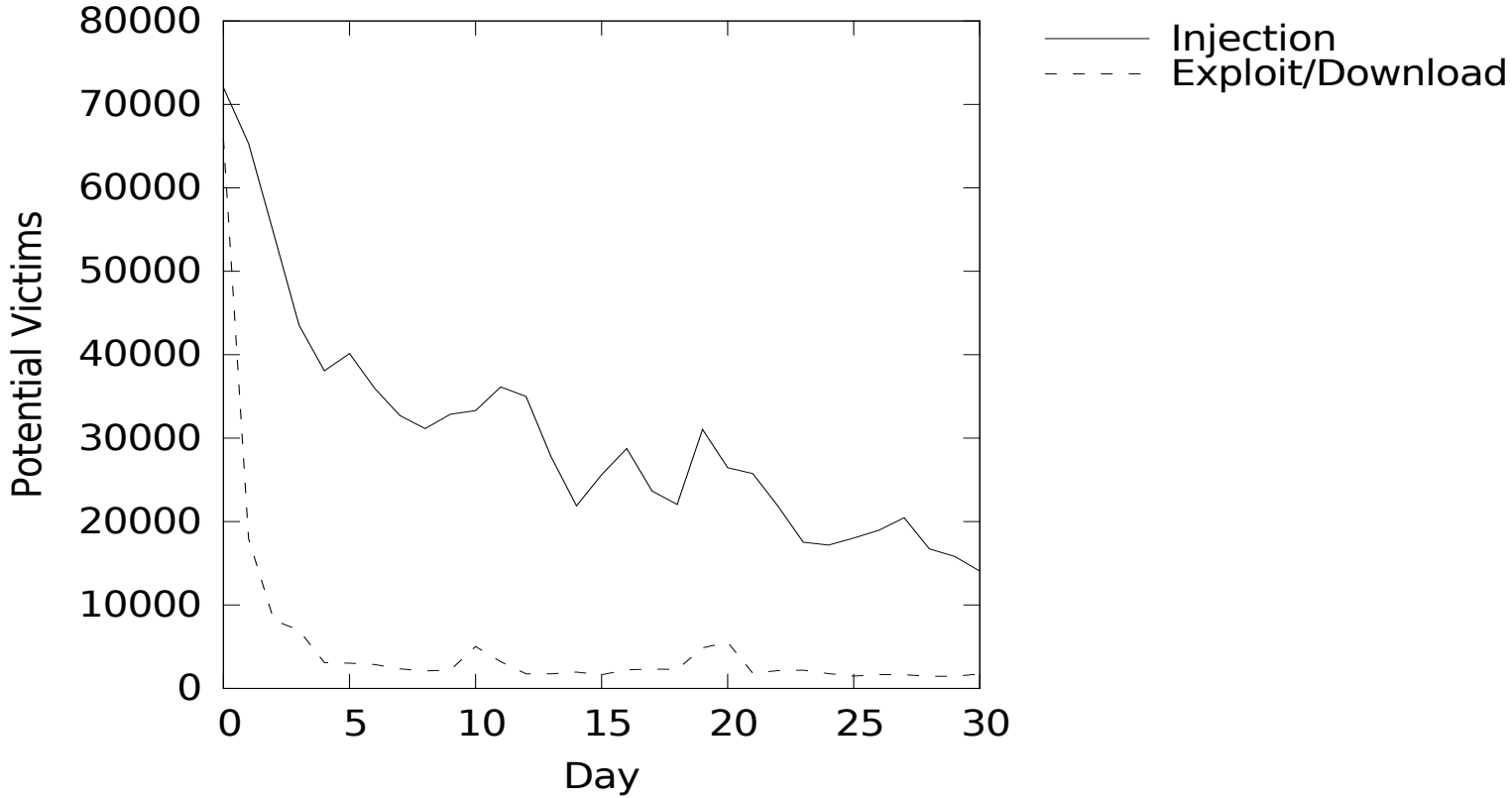


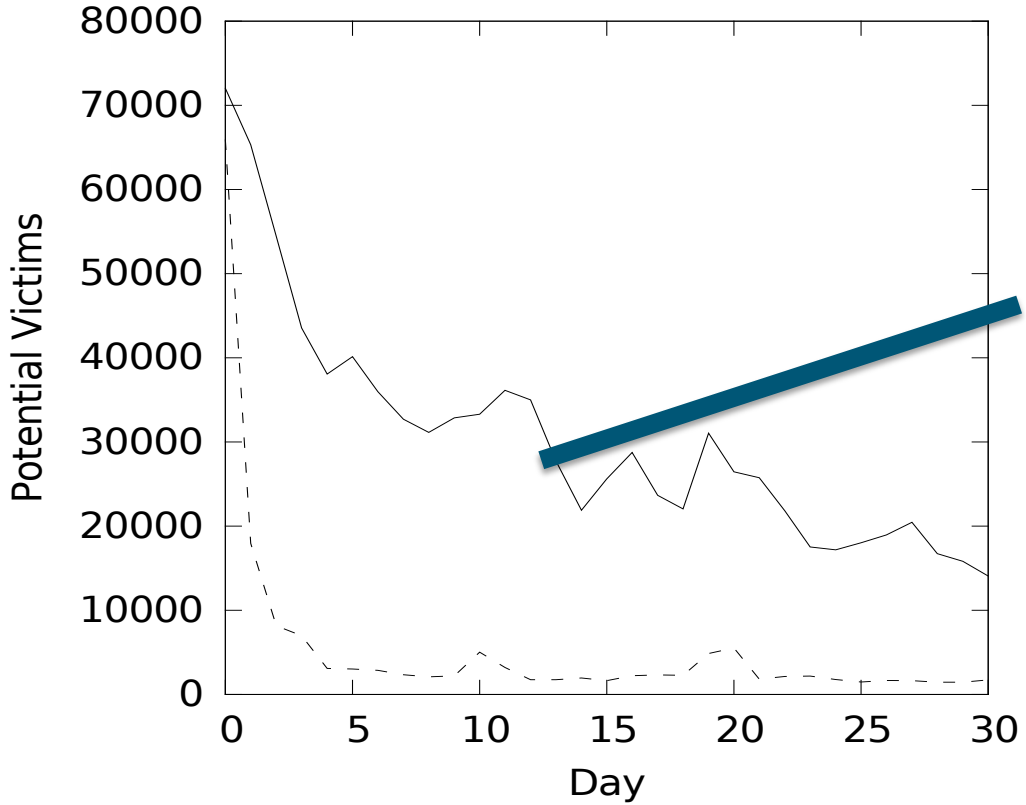
Block Injection Domain



Saved Victims – Blocking Injection Domain

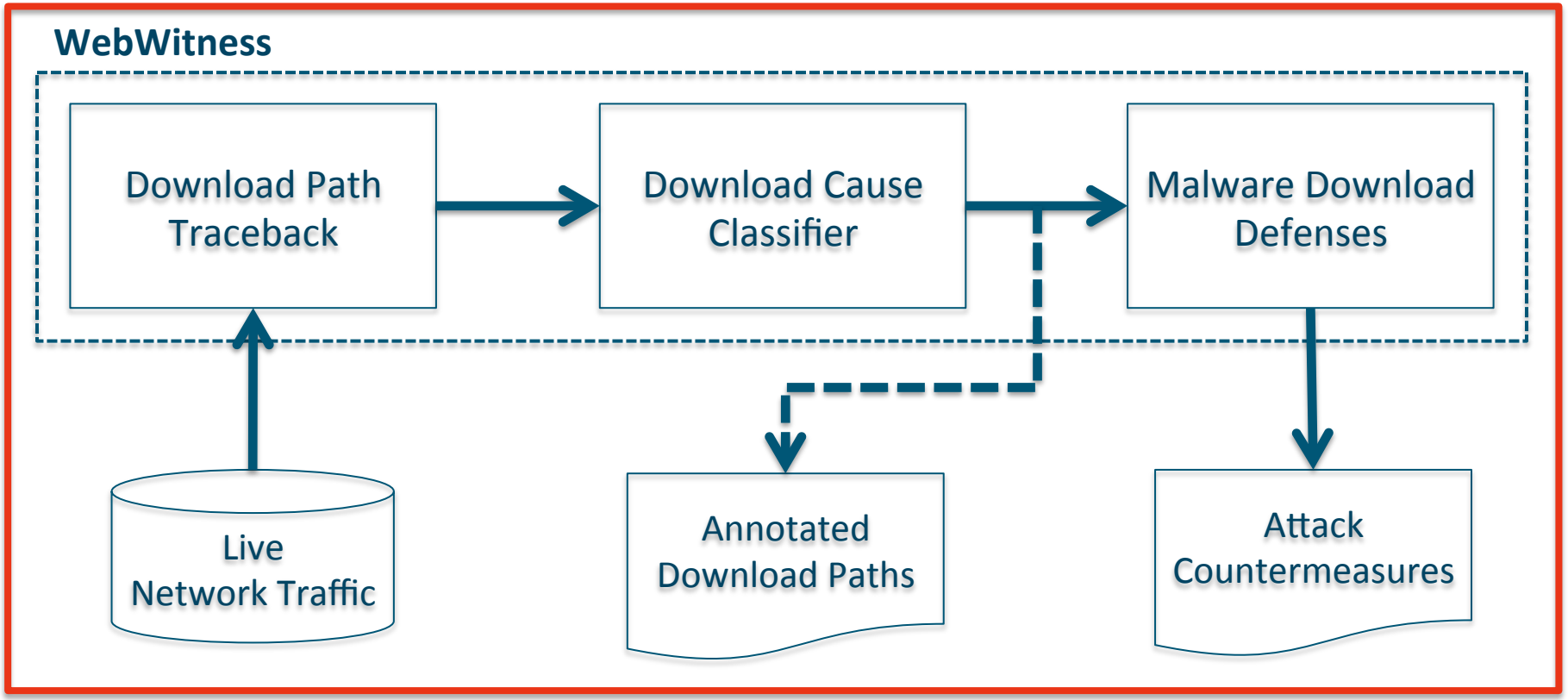


Saved Victims – Blocking Injection Domain



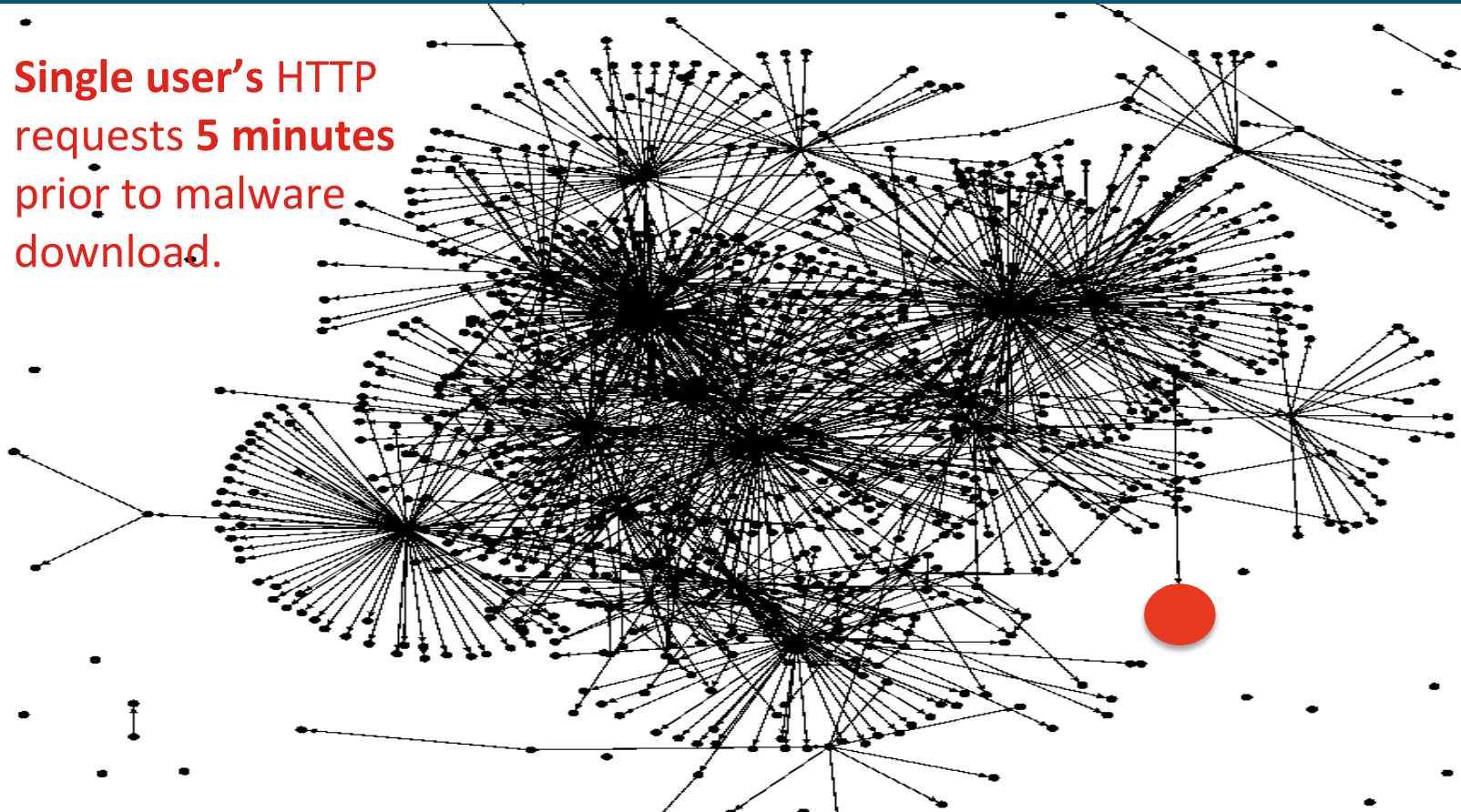
6 *times* more saved victims!

Conclusion

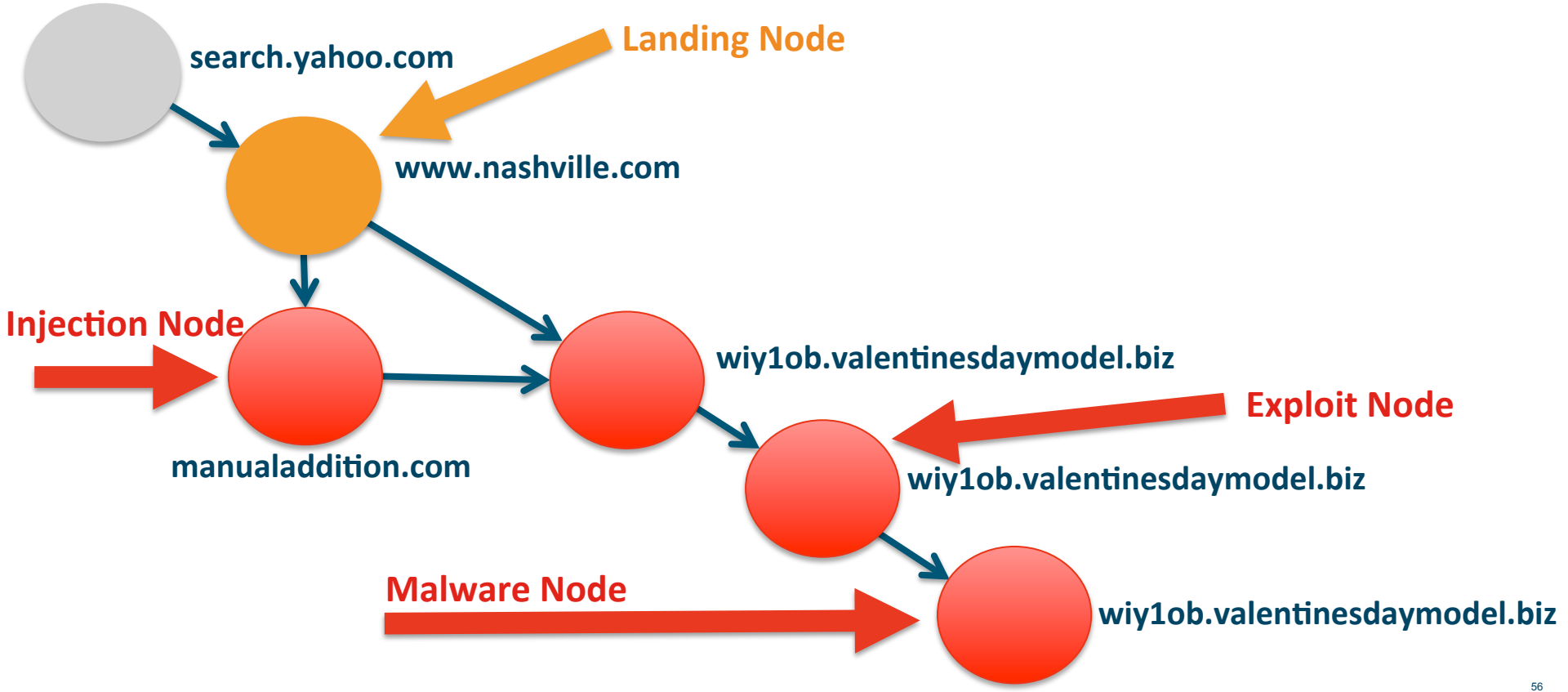

WebWitness
Download Path Traceback
Download Cause Classifier
Malware Download Defenses
Live Network Traffic
Annotated Download Paths
Attack Countermeasures

Web Traffic Graph

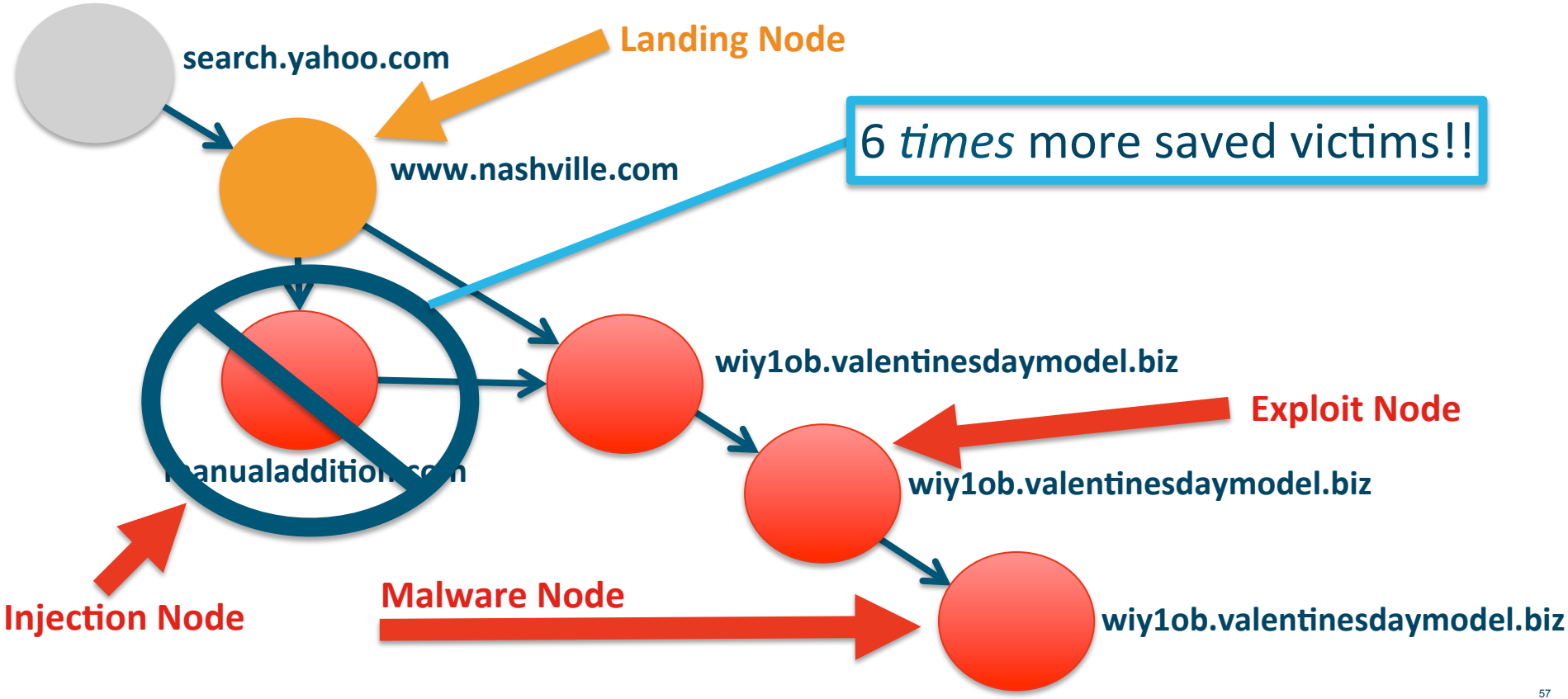
Single user's HTTP requests **5 minutes** prior to malware download.



Annotated Drive-by Download Path



Drive-by Download Defense



Questions?

WebWitness: Investigating, Categorizing, and Mitigating Malware Download Paths

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