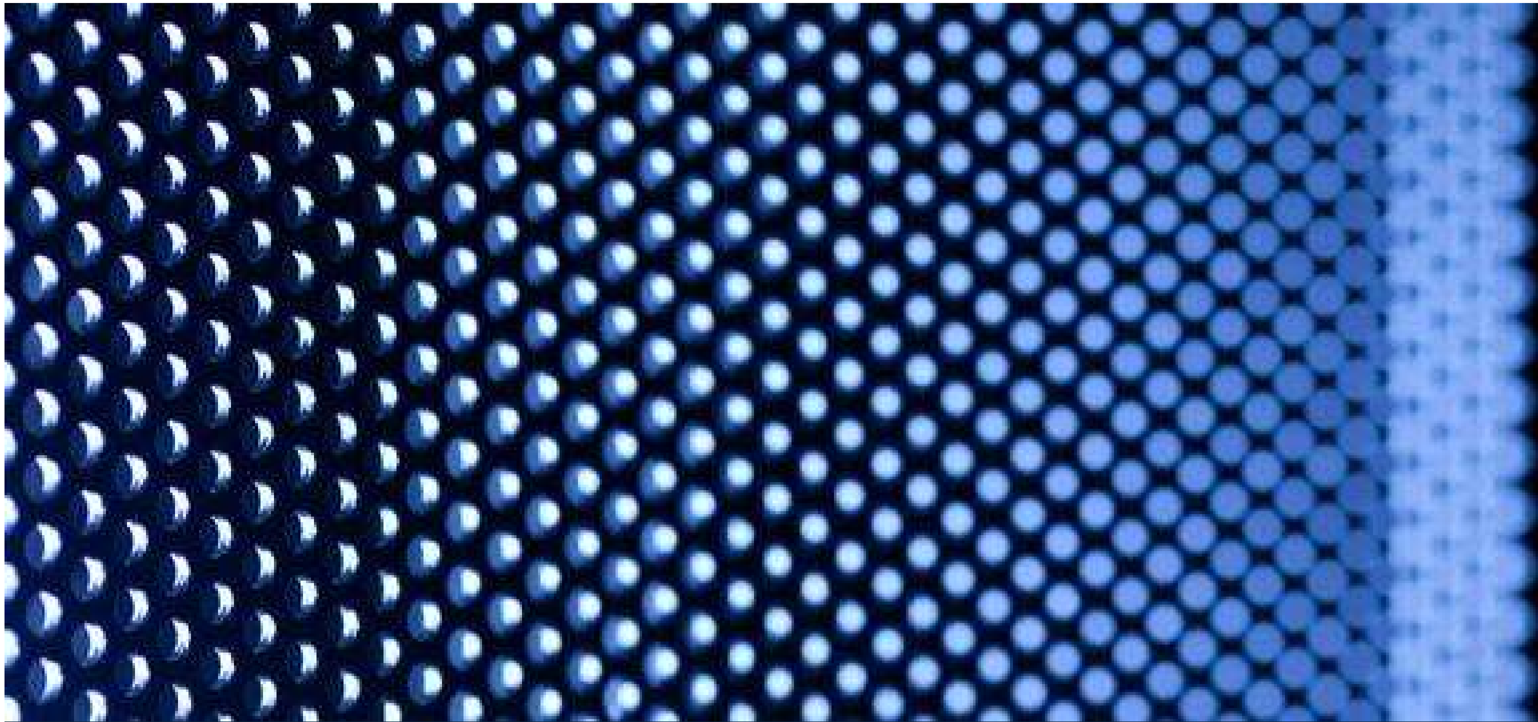


“What’s in a Name (collision)?” Modeling and Quantifying Collision Potential

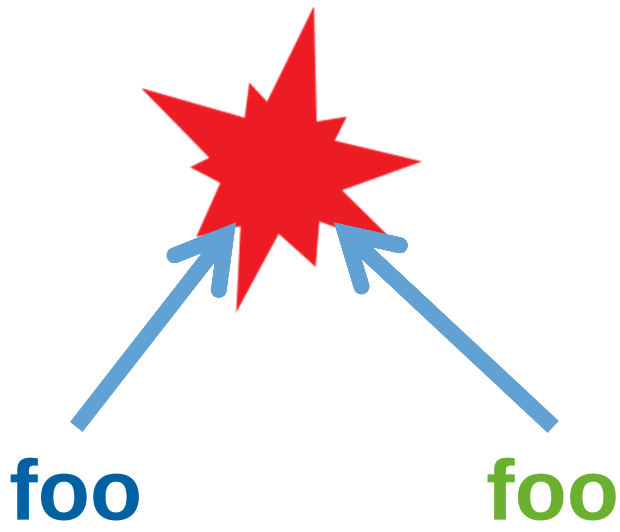
Casey Deccio, Verisign Labs

Workshop and Prize on Root Causes and Mitigation of Name Collisions (WPNC)

London, UK, March 10, 2014

Objectives

- Formalize a model of name resolution, based on current resolver library implementation.
- Define name collisions based on name resolution model.
- Define metrics to quantify probability and risk associated with name collision.
- Supply framework to apply model to network environments.



Motivation/Previous Work

- Previous work
  - "Name Collisions in the DNS", Interisle Consulting Group (commissioned by ICANN)
  - "New gTLD Security, Stability, Resiliency Update: Exploratory Consumer Impact Analysis", Verisign Labs
- "Outside in" perspective
  - Is data representative of current incidence and risk?
  - Can the risk be over- or under-estimated with outside data?
- New - "Inside out" perspective
  - What does data look like on the inside?
  - What is the risk potential?

"Amagase Dam and reservoir", ccfarmer
http://commons.wikimedia.org/wiki/File:Amagase_Dam.jpg

Creating a Model of Name Resolution

- Benefits
  - Creates consistent reference.
  - Facilitates definition of resolution behavior, such as name collision.
  - Facilitates definition of metrics for quantification.
  - Naturally leads to implementation.
- Requirements
  - Understand behaviors of resolver implementations.
  - Model individual components and their dynamics.
  - Represent as simply as is possible, and no more.

Resolver Library Behavior

- Suffix search list processing varies:
  - Across OS.
  - Depending on whether name is single- or multi-label.
- A series of names are queried to the DNS:
  - In specified order, built from search list.
  - Until positive response is returned from the DNS or list is exhausted.

name + search list + behavior ➔ DNS query list

Example

Name: "www"

Suffix search list: ["foo.example"]

Behavior: Windows XP; **Query list:** ["www.foo.example"]

Behavior: Linux; **Query list:** ["www.foo.example", "www"]

Modeling Resolver Library Behavior

n = name queried of resolver library	c = resolver behavior	S = search list

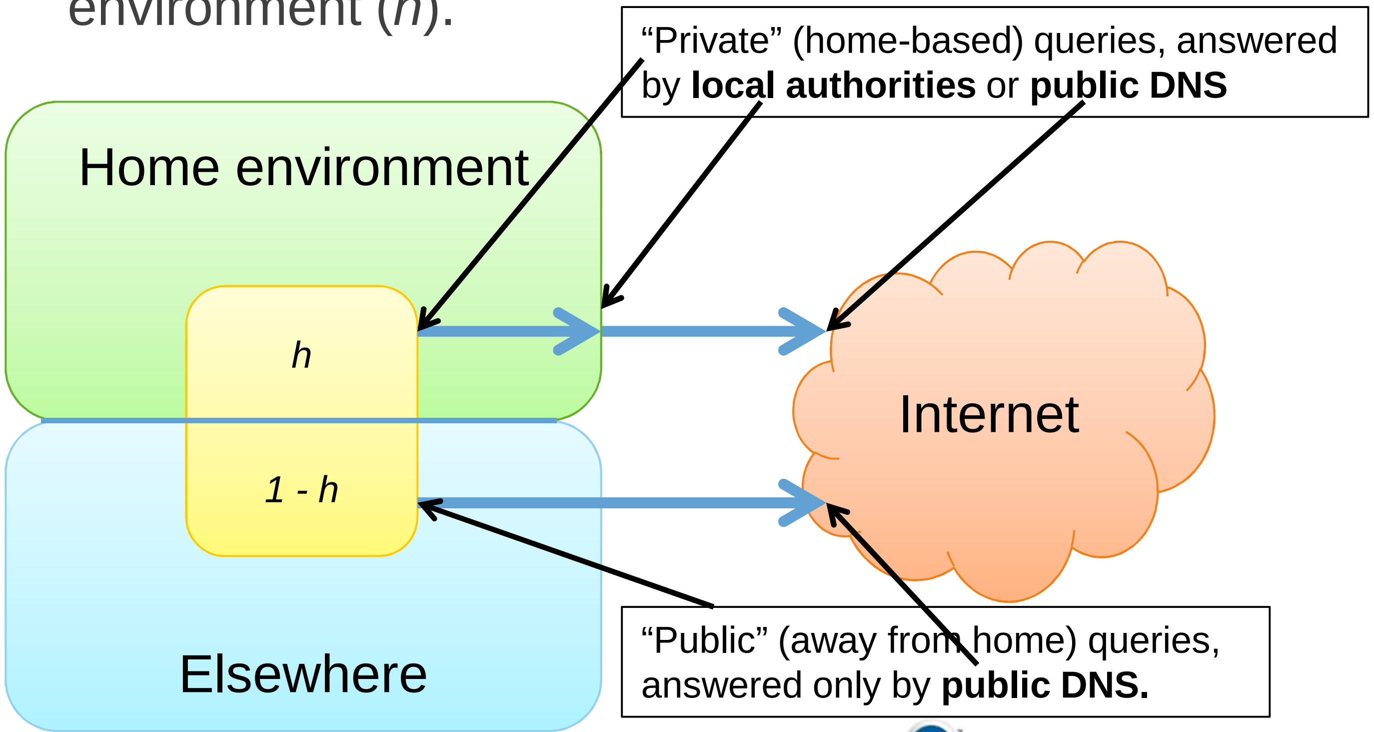
$$Q_{(c,S)}(n) = [n_1, n_2, \ldots, n_m]$$

Sequence of DNS names recursively queried to produce the intended answer for *n.*

- $n_1 \ldots n_{m-1}$ result in negative responses.
- n_m produces the end result (positive or negative).

Modeling Mobility

- **"Home" environment** – network environment corresponding to resolver configuration
  - Suffix search list (*S*).
  - Locally administered DNS namespaces (*LA*).
- **Locality** – percentage of time clients operate within "home" environment (*h*).



Name Collision – A definition

A **name collision** results from one or both of the following conditions:

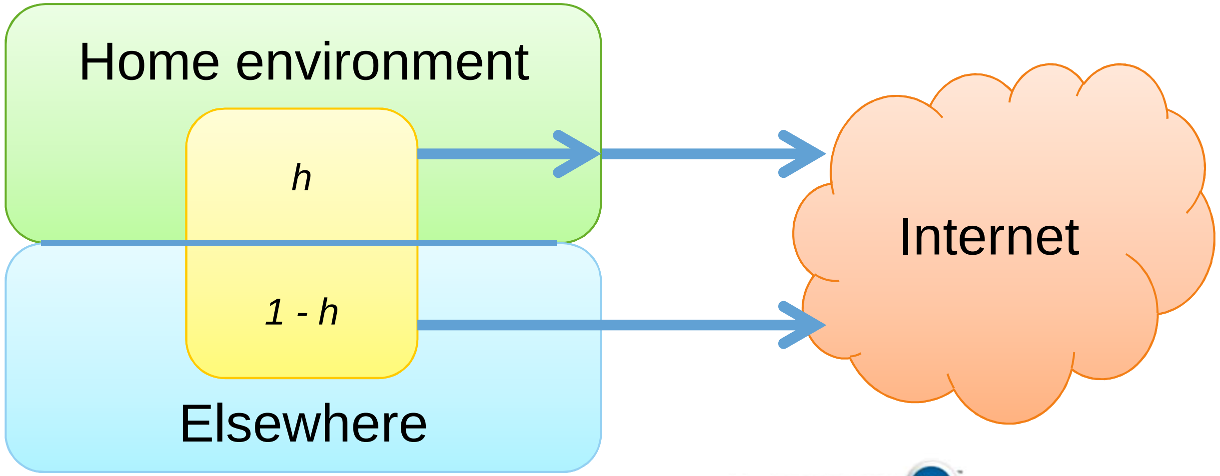
A DNS query for any name, $n_i \in [n_1, n_2, \ldots, n_{m-j}]$ $j \in [0, 1]$ yields a **positive result**.
(*j* is 0 if *n* should return negative response; otherwise *j* is 1).

There is at least one name, $n_i \in Q_{(c,S)}(n)$, such that the namespace for n_i is **locally administered** but the response to a DNS query for n_i is received the responded by by the **public DNS**.

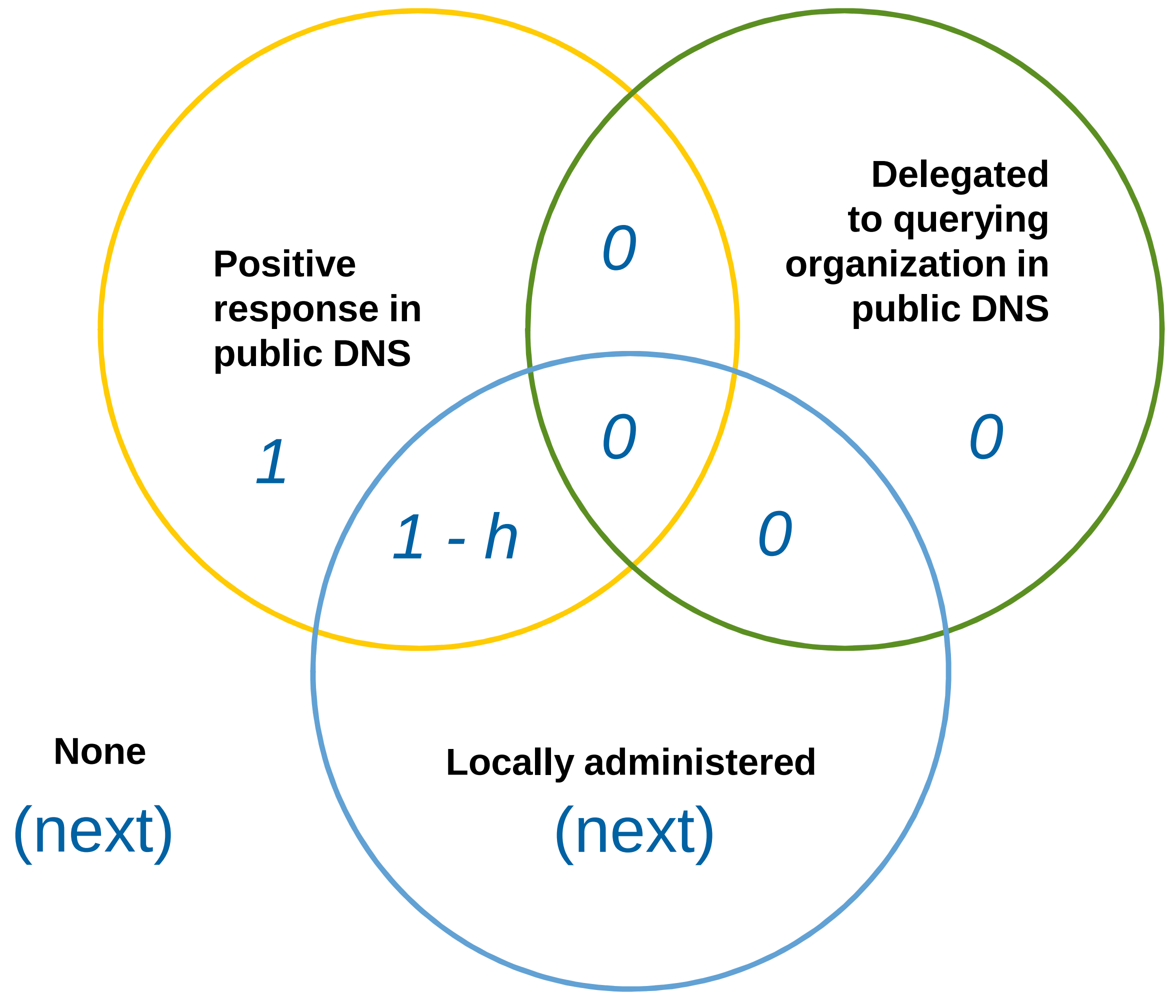
Passive name collision – no difference in ultimate response.
Active name collision – difference in ultimate response.

Collision Probability

- *localAnswerFromPublic*
  - *1 - h*: if there is a locally administered name in query list, $Q_{(c,S)}(n)$
  - *0*: otherwise
- *falsePosProb* 🡐 *0*
  - If name in query list yields positive response from “public” query, then add *h* to *falsePosProb.*
  - If name in query list yields positive response from “private” query, then add *1 - h* to *falsePosProb.*
- *collisionProbability* 🡐 *max(localAnswerFromPublic, falsePosProb)*



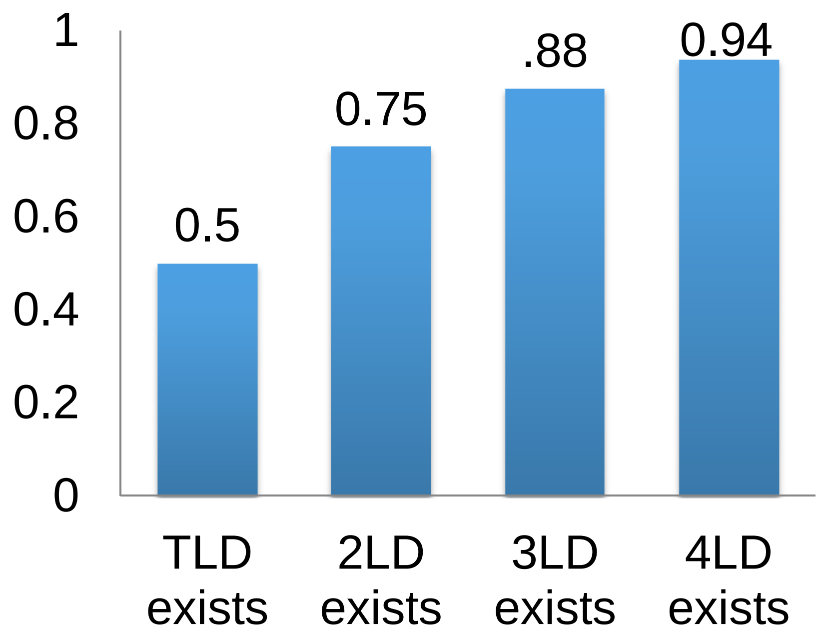
Third-party False Positive Risk



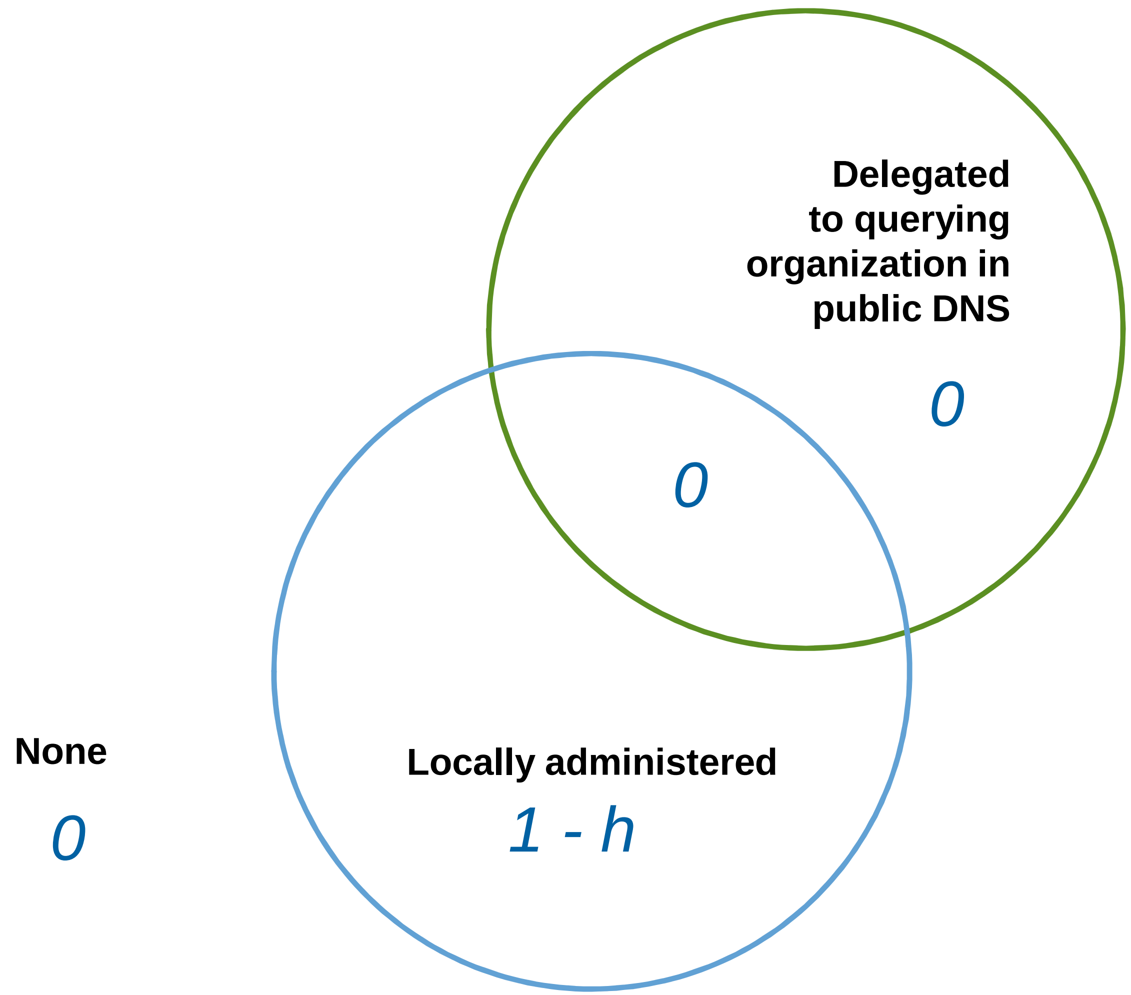
Third-party False Positive Risk (cont'd)

- Remaining characteristics:
  - Name results in negative response from public DNS.
  - Name is not delegated to querying organization in public DNS.
- Consider each label in name, sorted hierarchically from top: $L_n = [l_1, l_2, \ldots, l_q]$

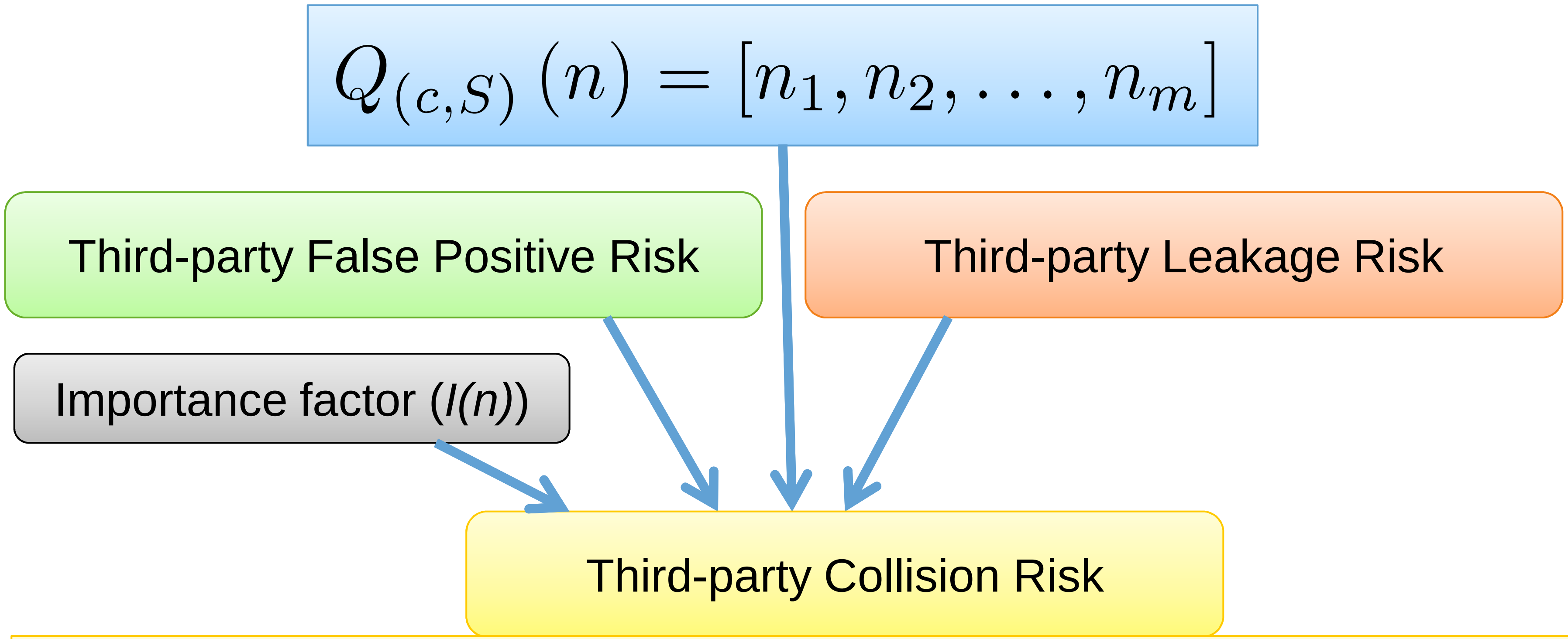
$risk \leftarrow 0$;
foreach $l_i \in L_n$ **do**
  if $YX(l_i)$ **then**
    if $l_i \in LA$ **then**
      $risk \leftarrow risk + (1 - h) \times \frac{0.5}{i}$
    else
      $risk \leftarrow risk + \frac{0.5}{i}$
    end
  end
end



Third-party Leakage Risk



Third-party Collision Risk

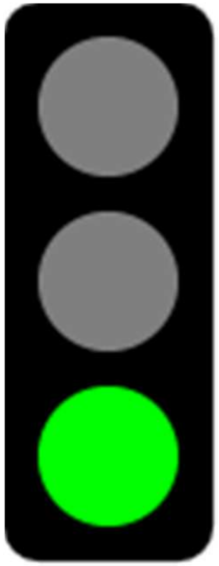


$$I(n) \times \left(1 - \left(\prod_{n_i \in [n_1, n_2, \ldots, n_{m-j}]} 1 - \texttt{thirdPartyFalsePosRisk}(n_i)\right) \times (1 - \texttt{thirdPartyLeakageRisk}(n_m))\right)$$

Aggregated like probabilities of independent events.

Case Studies

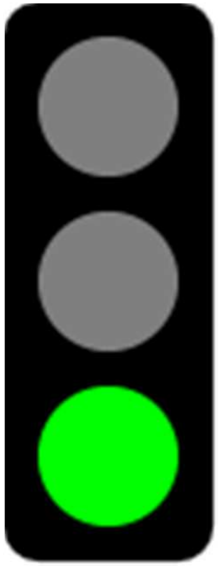
- Case 1 – simple
  - Configuration
    - Search list: empty
    - Locally administered namespace: none
  - Query name: “foo.example”
    - DNS query names: [foo.example]
    - Result expected: positive or negative
  - Collision probability: *0*
  - Third-party collision risk: *0*



“Traffic lights 4 states 3” by SteffenB
http://commons.wikimedia.org/wiki/File:Traffic_lights_4_states_3.png

Case Studies

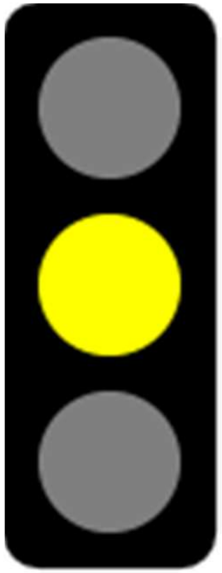
- Case 2 – simple search list
  - Configuration
    - Search list: **[foo.example]**
    - Locally administered namespace: none
  - Query name: **“www”**
    - DNS query names: **[www.foo.example]**
    - Result expected: positive
  - Collision probability: *0*
  - Third-party collision risk: *0*



powered by VERISIGN
“Traffic lights 4 states 3” by SteffenB
http://commons.wikimedia.org/wiki/File:Traffic_lights_4_states_3.png

Case Studies

- Case 3
  - Configuration
    - Search list: [foo.example]
    - Locally administered namespace: **foo.example**
      - foo.example delegated to third party
  - Query name: “www”
    - DNS query names: [www.foo.example]
    - Result expected: positive
  - Collision probability: ***1 - h***
  - Third-party collision risk: ***1 - h***

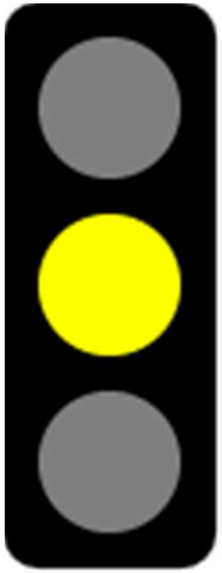


powered by VERISIGN

“Traffic lights 4 states 4” by SteffenB
http://commons.wikimedia.org/wiki/File:Traffic_lights_4_states_4.png

Case Studies

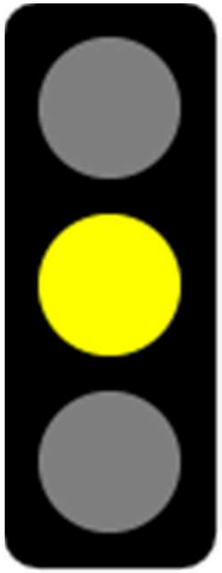
- Case 4
  - Configuration
    - Search list: [foo.example]
    - Locally administered namespace: foo.example
      - foo.example delegated to third party
  - Query name: “www”
    - DNS query names (depends on OS):
      - [www.foo.example]; or
      - **[www.foo.example, www]**
    - Result expected: **negative**
  - Collision probability: *1 - h*
  - Third-party collision risk: *1 - h*



“Traffic lights 4 states 4” by SteffenB
http://commons.wikimedia.org/wiki/File:Traffic_lights_4_states_4.png

Case Studies

- Case 5
  - Configuration
    - Search list: [foo.example]
    - Locally administered namespace: foo.example
      - foo.example delegated to third party
  - Query name: “www”
    - DNS query names (depends on OS):
      - [www.foo.example]; or
      - [www.foo.example, www]
    - Result expected: negative
    - “www” **delegated** in public DNS (but returns negative response)
  - Collision probability: ***1***
  - Third-party collision risk: $1-(1-(1-h))(1-0.5)(1-h)=1-0.5h^2$

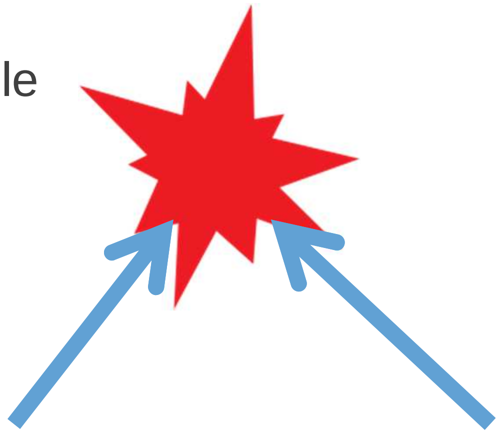


powered by VERISIGN

“Traffic lights 4 states 4” by SteffenB
http://commons.wikimedia.org/wiki/File:Traffic_lights_4_states_4.png

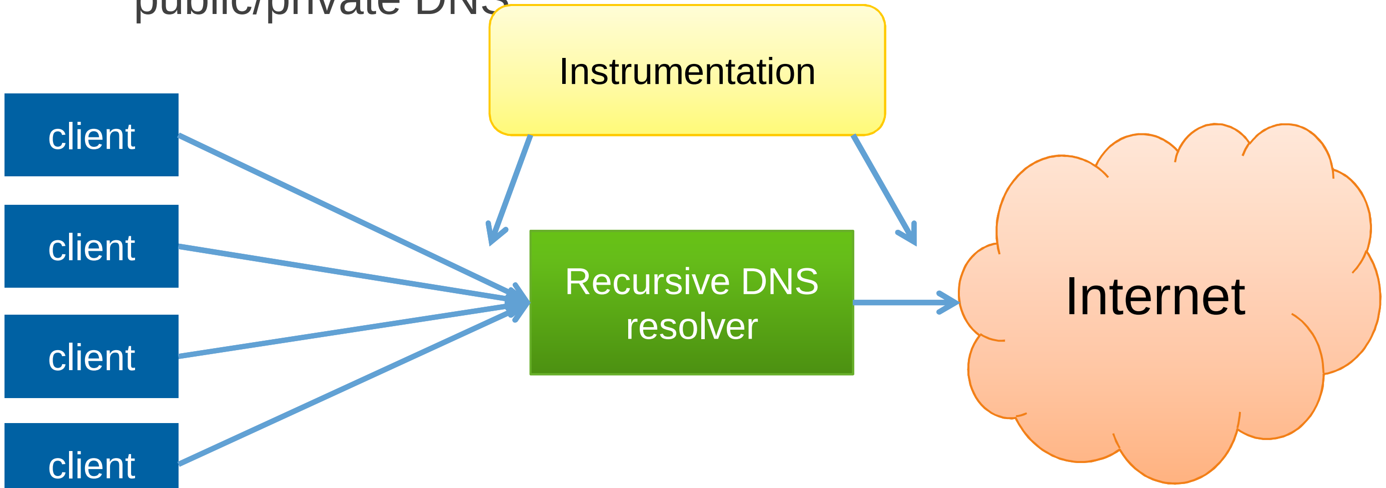
Case Studies

- Case 6
  - Configuration
    - Search list: [foo.example]
    - Locally administered namespace: foo.example
      - foo.example delegated to third party
  - Query name: “www”
    - DNS query names (depends on OS):
      - [www.foo.example]; or
      - [www.foo.example, www]
    - Result expected: negative
    - “www” delegated in public DNS **and has positive response**
  - Collision probability: *1*
  - Third-party collision risk: ***1***



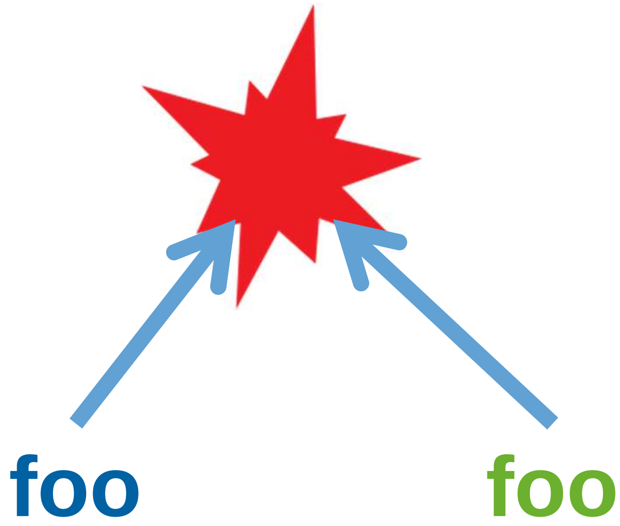
Model Application

- Required:
  - Suffix search list
  - Locally administered zones
- Derived from measurement/monitoring framework:
  - Queried names/results
  - Resolver configurations
  - Existence of names in public/private DNS
- Variable:
  - Locality
  - Existence of names in public DNS (e.g., in anticipation of future delegations)
- Computed:
  - Risk/potential



Summary

- Accurately quantifying name collision risk involves accurate modeling of resolver behavior “inside out”.
- Modeling provides foundation for metrics.
- Modeling leads to application.



powered by

VERISIGN™

© 2013 VeriSign, Inc. All rights reserved. VERISIGN and other trademarks, service marks, and designs are registered or unregistered trademarks of VeriSign, Inc. and its subsidiaries in the United States and in foreign countries. All other trademarks are property of their respective owners.