Packets Lost in the Wild: An Analysis of Empirical Approaches to Measure Internet Censorship

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What is censorship?

- The **suppression** of **ideas**, words and images that are **offensive** *(American Civil Liberties Union)*

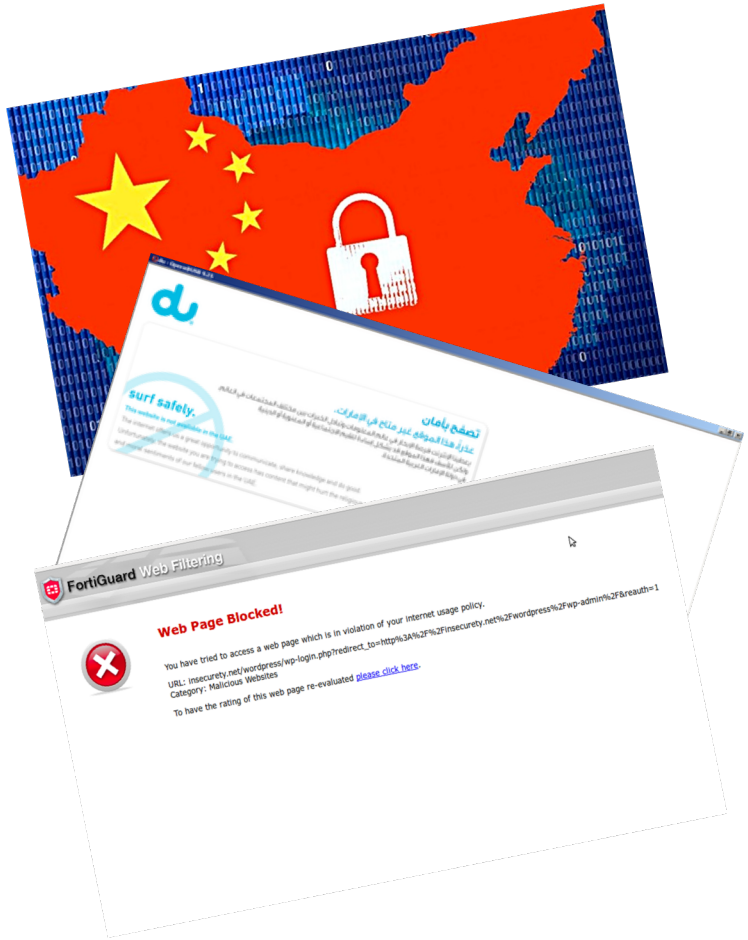
- Carried out authorities, institutions and media outlets

- The **motivations** can be religious, political, moral and even corporate

Censorship: History vs Today

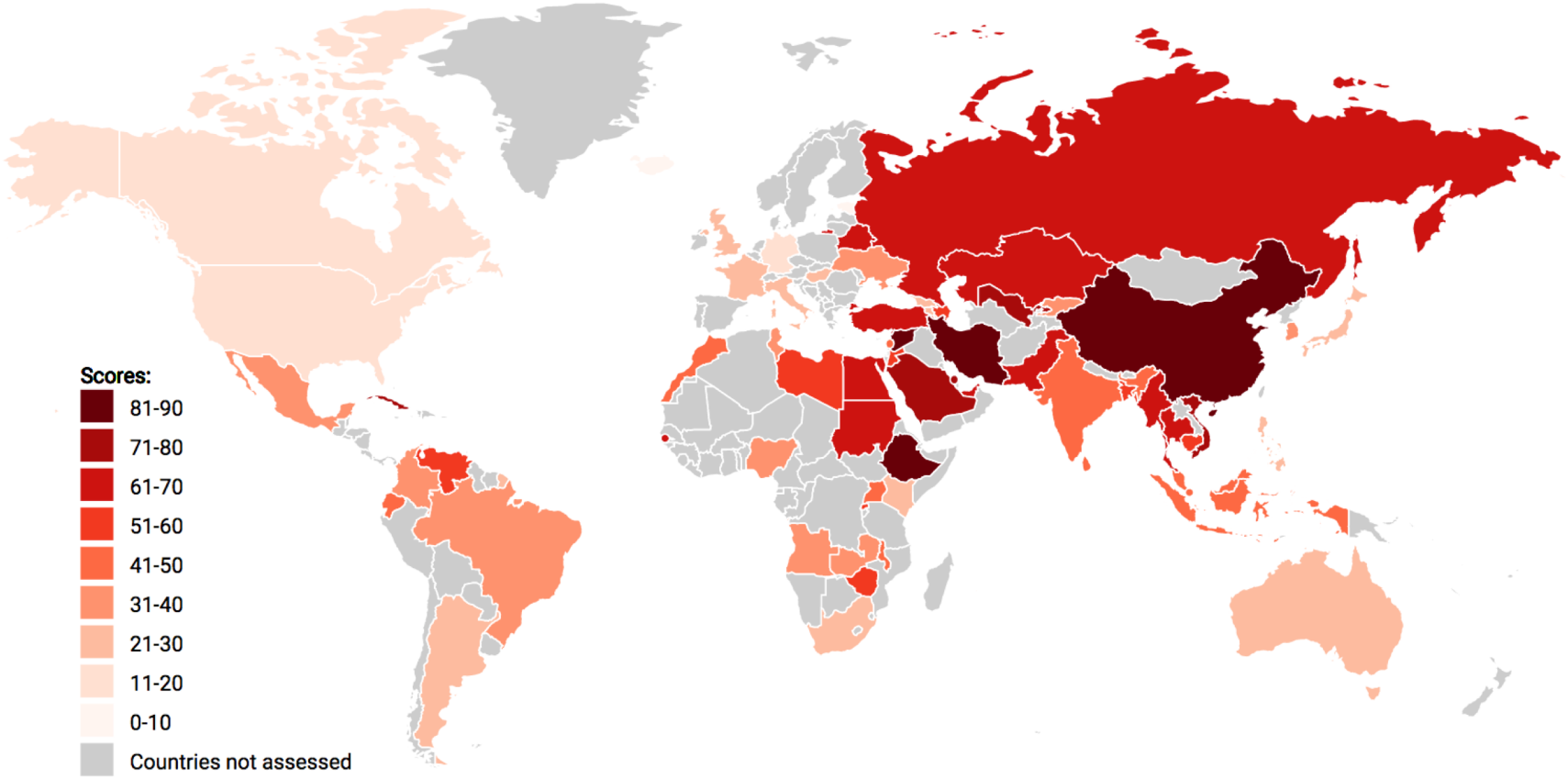
Pre-digital era

The age of the Internet



Global Internet censorship

- More than **66 countries** experience some form of Internet censorship



The Worst Part…

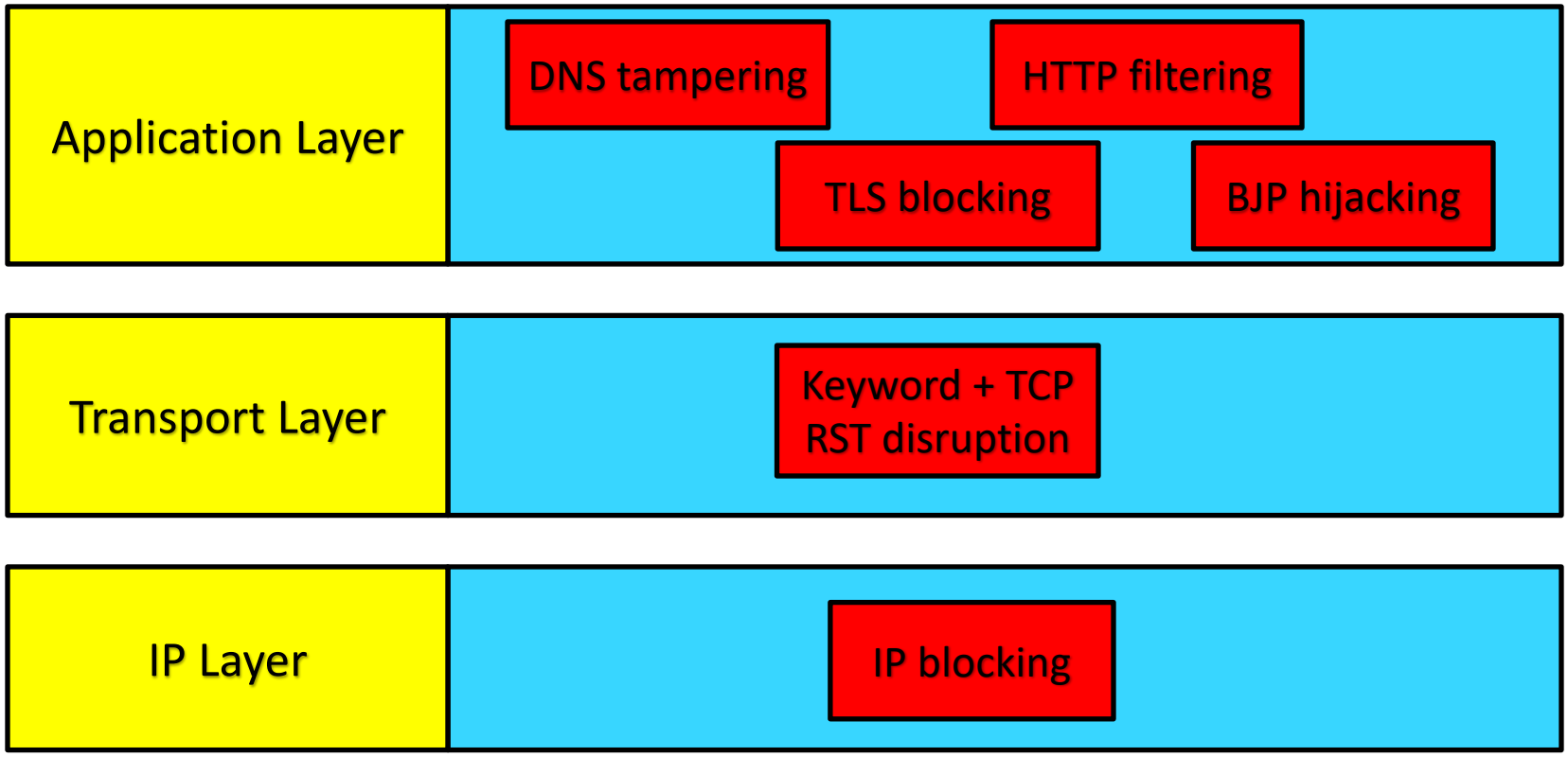
Measuring Internet censorship

- **Who?**
  - Individuals & organizations supporting the idea of the **open Internet**

- **To understand how censorship…**
  - Reduces availability of information
  - Hampers the growth of online communities
  - Impacts activists and civic groups
  - Disrupts economic growth

- To develop **circumvention** mechanisms

Implementation mechanisms



Measurement methodologies

- **Concept Doppler:** Keyword filtering in China
- **URL Filtering Products:** Detection and confirmation of URL filters for censorship
- **Censmon:** Distributed censorship measurements
- **Encore:** Browser based cross origin censorship measurements

1. Concept Doppler

- **Understand** and **quantify** the state of keyword filtering by the Great Firewall of China

- Keyword filtering is **granular**.

- Main **contributions**:
  - The **detection** and **mapping** of **filtering routers**
  - Development of an efficient keyword **extraction** and **probing** technique

Filtering device discovery

- Generate a list of **target servers** in China
  - Google query for domains ending in **.cn**

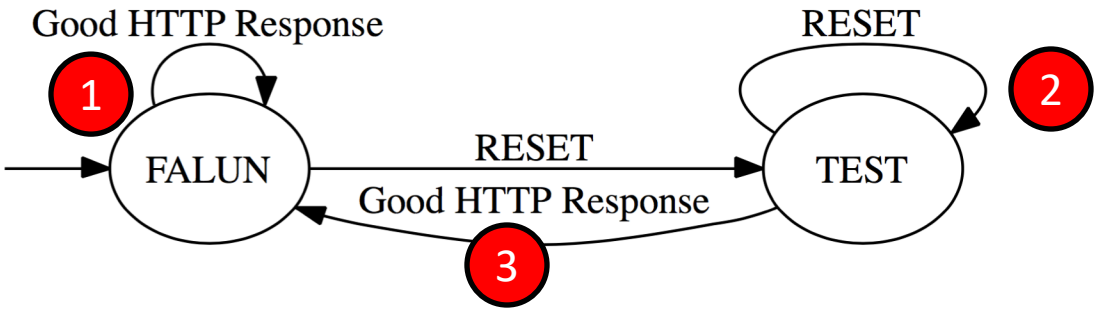
- TTL based ***firewall router*** discovery **algorithm**
  1. Establish a TCP connection
  2. Send a packet containing filtered keyword with increasing TTL values e.g. **TTL =0,1…**
  3. On receiving RST packet, identify location of the firewall routers using the last probe.
  4. Close connection to avoid idling

Discovering blacklist keywords

- Use **Latent semantic analysis (LSA)** to develop a comprehensive blacklist of keywords.

- Use 12 seed keywords to extract correlated keywords from Chinese language Wikipedia

- Probing ***search.yahoo.cn*** to test for plausible keywords:



Evaluation – Concept Doppler

- The firewall discovery algorithms assumes **identical packet routes**
- Current framework leverages **RST packets**
- The testing methodology is **Asymmetric**
- The LSA based technique uses **Gaussian distribution** of textual noise

2. Censorship via URL filters

- Third party URL products have a **dual use** for **censorship**

- ONI has documented several instances over the past 10 years

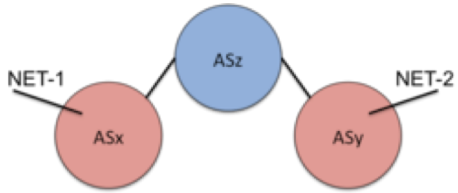
- Main **contributions**:
  - Identifying installations of URL filtering products
  - Confirming their use for Internet censorship

Identifying installations

- Searching the complete web space
  - Use **Shodan** to collect IP information and HTTP header metadata
  - Identify from keywords and country TLDs e.g. *proxysg, macafee, blockpage.cgi*

SHODAN

- Validating the installations:
  - WhatWeb proxy
  - IP to AS Mappings



Confirming use for censorship

- In-network testing
  - Measurement clients are setup in **suspected ASes**
  - **Control experiments** confirm the state of **blocking**
- Domain submission testing
  - Create domains containing **potentially objectionable content**
  - Submitted to **enterprises**

Evaluation – URL Filtering Detection

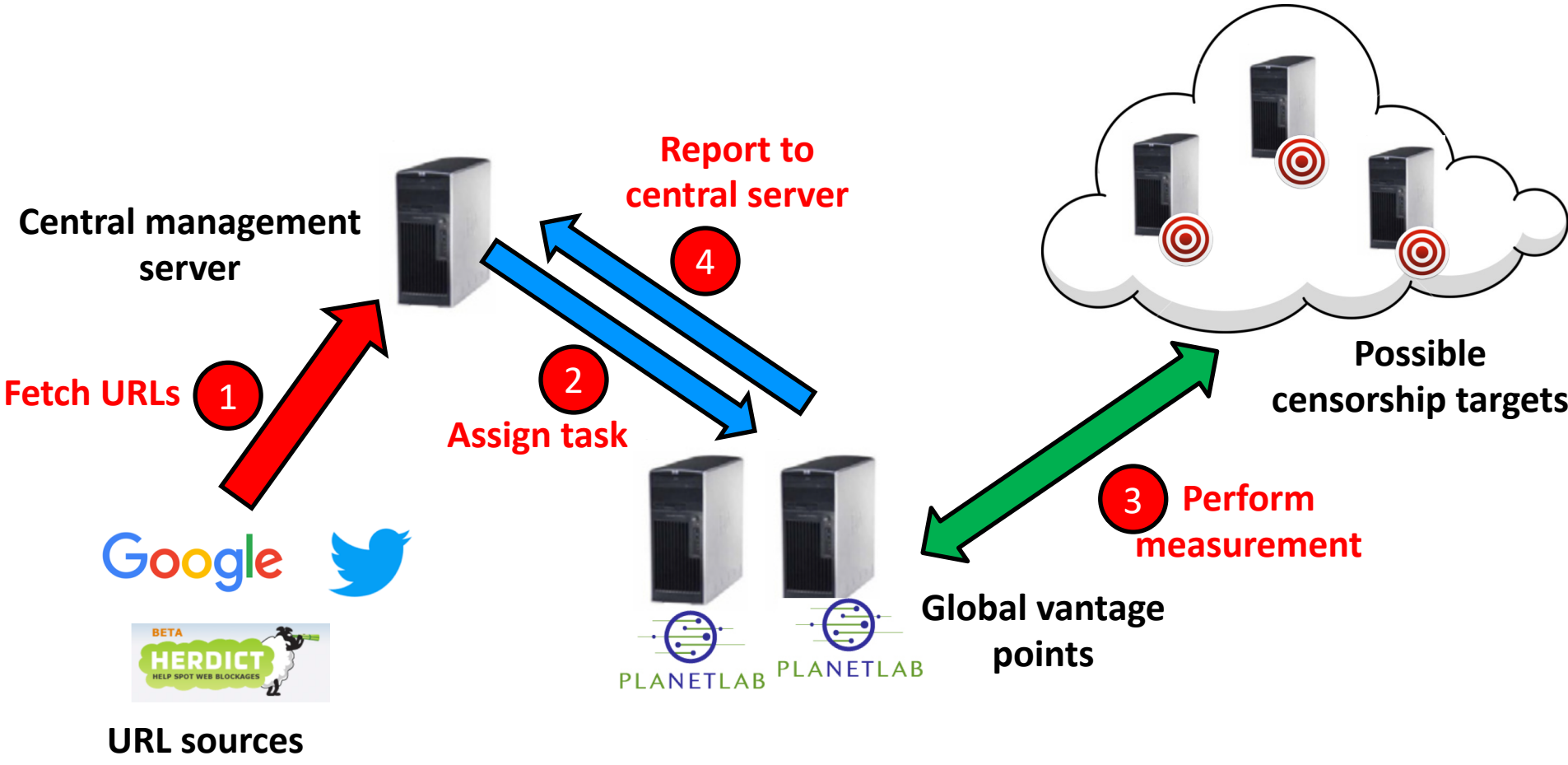
- Discovers installations that are **only globally visible**
- Scanning becomes **harder** with **newer technologies** like IPv6
- **Scalability** is an issue for **large scale measurements**
- Device vendors economically benefit and can collude make **installations undetectable**

3. Censmon

- **Censmon…**
  - Is a based on a client server model.
  - Collects automatic measurements

- **Salient features** of the design
  - Planet Lab Nodes
  - Multiple plugin feeds
  - Identify the filtering technique used

Censmon Design



Censmon Approach

Tasks at the node

1. Make a **DNS request** for domain resolution
2. Establish a **TCP connection** on port 80
3. Make request to **dummy server** and **target URL**

Tasks at the server

1. Repeat experiments due to **network failures**
2. **Match Whois** records with the DNS responses
3. Hashes HTML responses for **partial filtering**

Evaluation - Censmon

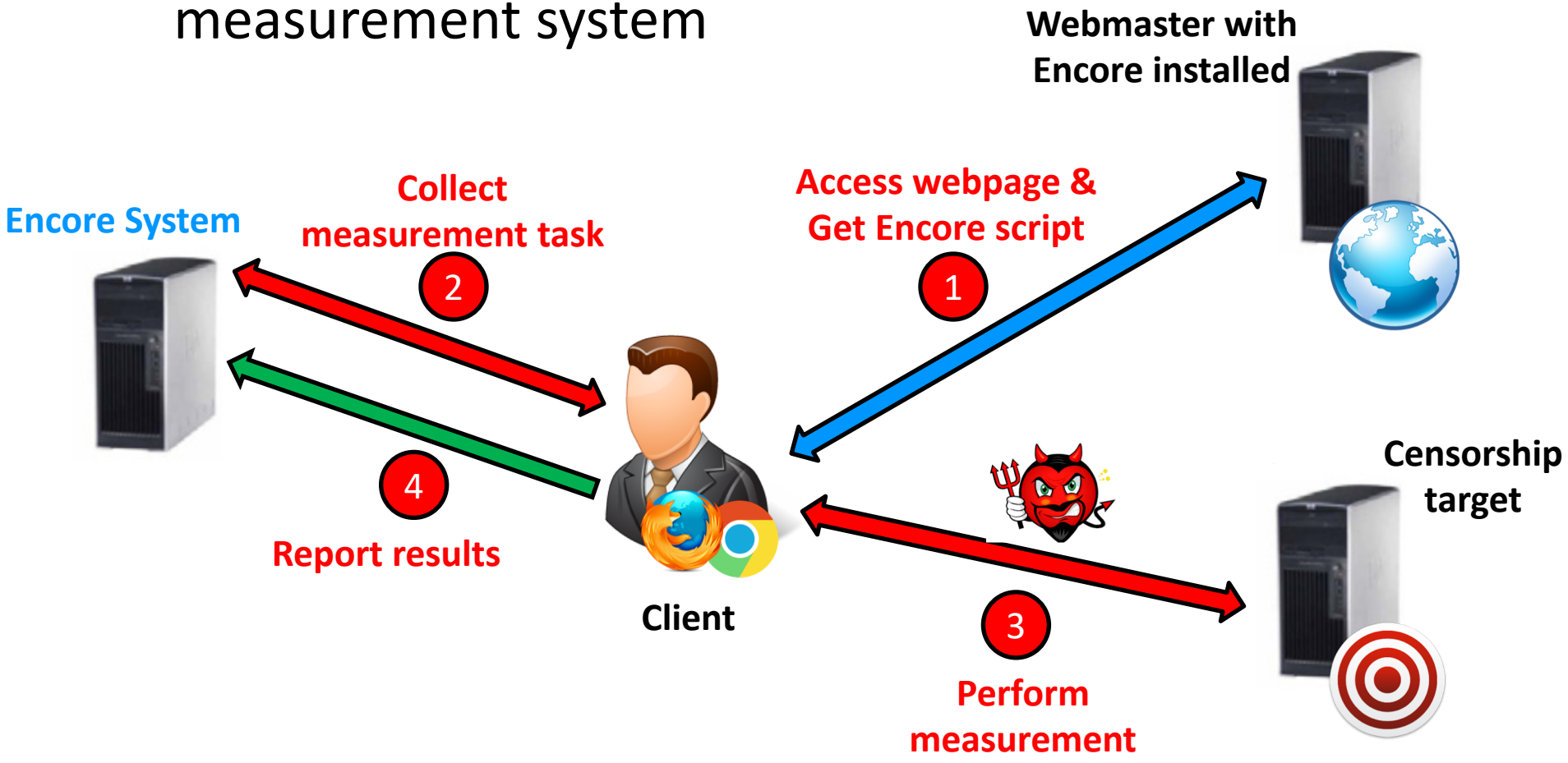
- Tested in 2500 domains, 193 **censored**.
- HTTP filtering (**48.5%**) DNS (**18.2%**) IP (**33.3%**)
- Planet lab nodes are **limited vantage points**
- **No validation** for HTML response filtering detected

4. Encore

- **Vantage points** are essential in measuring censorship
- Current systems achieve this by
  - Measurement clients
  - VPN services
  - Local crowdsourcing.
- These approaches incur an **overhead**
- **Encore** harnesses cross origin requests in browsers
- Current browsers allow cross origin requests for **images, stylesheets, iframes and scripts**

The design of Encore

- Encore requires webmasters to install the measurement system



Efficient measurement characteristics

- **Developing** intelligent measurement tasks
  - URL expansion
  - HTTP archives
  - Task selection
- Detection of domain vs URL filtering
  - **Complete domains:** multiple resources **blocked**
  - **Specific URLs:** iframe (timing information) & scripts
- **Control setup** to validate the measurements

Evaluation - Encore

- **Deployment**
  - 17 Webmasters
  - 141k measurements from 88K IP addresses
- Approach raises **ethical concerns**
- Encore **depends** on **reliable webmasters**
- Integration with more **secure browsers**

No silver bullet!!!

Takeaways…

- **Moving forward…**
  - Minimize user involvement
  - Globally diverse and safe vantage points
  - Collaboration of technologists and social scientists

- Create **a global repository** of measurement results

- Development of a product that provides **circumvention** and performs in a **measurement** decoupled manner

Conclusion

- Researchers have come up with various ways to measure censorship
- Measuring censorship is a **non-trivial** and **dynamic** problem.
- Active area of **research** and **development**

System	Region	Blocking Detection	Methodology
Concept Doppler	China	Keyword Filtering	External probing / LSA
URL Filtering	MENA	URL Filtering	External scans/ In-network testing
Censmon	Global	DNS, IP, URL Filtering	Overlay network (PlanetLab)
Encore	Global	Domain, URL Filtering	Cross origin browser requests

Thank You!

Questions?

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Latent Semantic Analysis