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The Internet edge is exploding

34% of global population uses the Internet
5x growth in the past 12 years

% Penetration

Number of countries

0 10 20 30 40 50 60 70 80 90 100

Fixed broadband countries

Fixed broadband penetration
The view from the edge

Many of our systems run at the edge

Lack platforms to experiment at or even characterize the edge
The view from the edge

```
Control

Scale
```
The view from the edge
The view from the edge
The view from the edge

Control

Scale

PLANETLAB

DASU

DIMES
The view from the edge

A flexible experimentation platform hosted by end users
Our work

Hosted by end users, at scale …

Guarantees safety of participants

Controls impact of experiments on underlying network and systems

Shares platform resources among concurrent experiments
Dasu

A platform prototype

Software-based (BitTorrent ext., for now)

Hosted at the network’s edge

Broadband characterization as incentive for adoption
Dasu

Two purposes by design

– Characterize users’ broadband services
– Support experimentation from the edge

Aligns objectives of end-users and experimenters
Dasu

Two purposes by design
– Characterize users’ broadband services
– Support experimentation from the edge

Aligns objectives of end-users and experimenters

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End-user based platform – Challenges

No dedicated resources
  – We cannot run arbitrary experiments
  – Safety of volunteer nodes is key

Large-scale platform $\Rightarrow$ large-scale *impact*

Highly volatile nodes
  – We cannot run at arbitrary times
  – We cannot run at arbitrary locations
Roadmap

Motivation

Design and implementation

Challenges

A unique perspective
Dasu: Current status

An extension to BitTorrent
- Soon standalone and in a DNS resolver

Could be hosted by other long-running networked app. (e.g. Skype, IPTV)

Over 90,000 users (>150 countries)
with almost no advertisement
Guiding goals...

Programmable platform
  – To run general measurement experiments

Reduce effort needed to develop/deploy large-scale measurements
Design: System components

- Experiment Administration
- Configuration
- Experiment Task
- Registration
- Experiment Lease
- Coordination
- Measurement Activity
- Data Service
- Experiment Report
Design: Experiment specification

package package-name
Imports
variable declaration
- global
- local
functions
rules

dialect "java"
package edu.northwestern.dasu.drools
import edu.northwestern.dasu.drools.*;
global FactHalt halt;
declare TestResult
    taskId : String
    todoList : List
    pingList : List
end

function void ping(String ip, int taskId)
{
    AMCoordinator.addProbeTask(
        taskId, ip, ProbeType.PING);
}

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Design: Experiment specification

package package-name
Imports
variable declaration
- global
- local
functions
rule "name"
  when
  ...
  then
  ...
end

rule "Process Probes"
  when
    $tr : TestResult();
    $ping : FactProbePingResult();
  then
    $tr.getPingList().add($ping);
    retract($ping);
    if($tr.getTodoList().size() == 0) {
      AMCoordinator.commitResult("Experiment Name", $tr);
      halt.setHalt(true);
    } else {
      ping($tr.getTodoList().remove(0), $tr.getTaskId());
    }
end
Design: Rule-based programming

Experiment as a combination of rules

Rules drive execution and flow of experiments

Benefits of a declarative model

– Clear and concise
– Easy to check
– Easy to extend
Design: Dasu client

Experiment

Rule Engine

Working Memory

Coordinator

Probe Modules

Results

Traceroute

Ping

NDT

…
Challenges: No dedicated resources

Protecting volunteer nodes

- Sandboxed
  - Import restrictions avoid arbitrary code execution
  - Resource profiler / watchdog timer

- Secure communication of configuration and experiments
Challenges: No dedicated resources

Limit resource consumption

Minimize impact on user’s performance:

– Pre-defined probe rates
– Restrict aggregate bandwidth consumption
– Limit probes to low-utilization periods
Challenges: Impact

Scaling measurement coordination across participants
– Experiment leases
– Elastic budgets
Challenges: Availability and churn

![Graph showing CCDF vs. Number of hours online]
Challenges: Availability and churn

Median session time \( \sim 3 \) hours
Challenges: Availability and churn

Median session time $\sim 3$ hours

50% PlanetLab slices $< 3$ hours
Challenges: Availability and churn

![Graph showing the average fraction of peers online per hour over the day. The graph indicates a general decrease in the fraction of peers online from 47% to 23% throughout the day, with some fluctuations.](image_url)
Challenges: Availability and churn

Peers online per hour

39-43% of day’s total
Challenges: Availability and churn

39-43% of day’s total
52-63% of day’s ASes
Challenges: Load-control on experiments

Delayed probes per peer

- 80% download utilization
- 80% upload utilization
Challenges: Load-control on experiments

For 85% of peers, scheduled probes can be launched immediately.
Illustrating its unique perspective

Revisiting past experiments: Routing asymmetry, King

Questioning old assumptions: AS-level connectivity

Performing novel experiments: Evaluating a recently-proposed DNS extension
CDNs and DNS-based localization
CDNs and DNS-based localization
CDNs and DNS-based localization

- CDN Replica
- Content Origin
- End Host
- CDN Replica
- Google DNS
- CDNs and DNS-based localization
CDNs and DNS-based localization

- CDN Replica
- Content Origin
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- Google DNS
- CDN Replica
DNS extension approach

Idea: Avoid impact of remote DNS usage by directly providing client location

A EDNS0 extension “edns-client-subnet”

Resolver adds client’s IP prefix to request

Is it effective?
Understanding performance benefits

Access to large set of vantage points

Vantage points located around the world

Interrelated measurement probes

Flexible
Evaluating EDNS

Higher savings in North America
Evaluating EDNS

- Higher savings in North America
- ECS savings in Oceania 70–90%

Latency savings with ECS (%) vs. HTTP latency without ECS (ms)
Dasu’s first child  namehelp

… more than just better CDN performance

– Faster lookups with proactive caching
– Automatic, personalized server selection
– Graceful handling of DNS outages …

As of this morning – 52,800 users over 147 countries!

http://aqualab.cs.northwestern.edu/projects/namehelp
Summary

Experimental platform for the network edge

Relies on a direct incentive model for adoption
  – Rather than relying on the kindness of strangers

Participants collectively offer
  – Broad network coverage
  – High availability
  – Fine-grained control

Contact us to play with it