A lightweight measurement platform for home Internet monitoring

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***Abstract*—CheesePi is a lightweight measurement platform with the goal of performing active measurements directly from within users' homes. As an always on device, it provides better context on the network state, than those available from browser interaction (Speedtest, etc.)**

In this demonstration, we will show the frontend of CheesePi and how we incorporate data from several sources around Sweden into a dashboard. A testbed of CheesePi nodes has been deployed, where we have conducted several tests.

The presentation will highlight how to make unbiased and neutral measurements of the telecommunications infrastructure (Table III). Measurements are of sufficient quality to be useful by an operator, plus requirements mandated by academia [3], regulatory bodies [1] and the IETF [4].

I. CheesePi in a nutshell

Home-based: We deemed networking characterisation requires continuous monitoring of connections, an external device satisfies this requirement. Furthermore, in a home setting, non-technical requirements on the installation, configuration and presentation of data are important requirements. By measuring from the home, we must consider devices that are quiet, cheap, non-obtrusive, and media-capable. ***Community measurements:*** Continuous measurements are needed for correlating with other measurement devices. Measurements that rendezvous are essential to draw some inference from poor quality streaming seen at different locations. Inference of Internet paths using a collaborative strategy is needed to detect shared Internet infrastructure, a secondary topic for our READY project.

Goal	Solution
Trivial install & use	Commodity HW+Community SW
Unbiased/neutral measurement	Enroll regulator & TLD provider
Popular event monitoring	Coors. & distrib. measurements
QoE metrics & shared infrast.	Research issues [2]

TABLE I: CheesePi goals and proposed solutions.

Solution	Implementation
Commodity HW/Community SW	Pi + pip install + dashboard
Enroll regulator & top level domain	Existing data[1] sources
Coordinated measurements	Always on device + CheesePi
QoE metrics / shared infrastructure	Engineering sol. + ML

TABLE II: Solutions and our chosen implementations.

Unbiased, neutral measurements: Our central tenant is a representative unbiased neutral sample of home connection quality within Sweden. We wanted to ensure, that not only are individual measurement points constrained to a budget, or share thereof, but also each ISP receives a fair share of the measurement budget. This is really at the behest of the regulator for obvious reasons of neutrality. Table III shows options for *how* to perform active measurements over several ISPs or operators. ***Country specificity:*** Although not constrained by the software per se, we expect CheesePi to be used within a country. This is because some contact with the regulator is useful within a country. We have hinted at a deployment of measurement nodes, to be inline with the regulators' needs. E.g. a deployment should include an appropriate proportion of DSL/fiber, rural/urban, geography, age, and so on. ***QoE-metrics:*** measure the quantities necessary to derive usable quality measures. To quantify the frustration associated with video stalls, we measure the current video rate, coding format, available capacity, receiver buffer lengths to ascertain the most important factors. We link measurable quantities to the frequency of playout stalls, however, do not include users in the loop to automate the QoE "process". ***What CheesePi is not:*** Our objective is not a large scale deployment of measurement nodes. Rather, we want to deploy the minimum number of nodes to collate sufficient statistics for our regulator. Furthermore, we are aware that measurement efforts can generate large amounts of data, and wherever possible we would like to **avoid** processing by judicious choice of node placements and measurement metrics.

Measurement type	Description	Comments
Data fair	Identical amount of traffic sent per ISP	Simplest form of fairness (as DASU [5])
Scaled-data-fair	Identical amount of traffic per ISP scaled by #users/lines	Proportioned measurements taking into consideration the size of the ISP.
Time-fair	Measure over the same period of time	If on intersecting paths measurement traffic will interact
Rate fair	Over a time period the rates over each operator should be identical	Allows different rates and packet sizes over shorter periods.
Period fair	Over a set period, the same amount of data transferred	Time and data fair
Random fair	Send at different periods/rates, the total time and data sent the same across all operators.	Fair over a period only.

TABLE III: Fair measurement categories.

A. Data presentation

Technical dashboard: home users monitoring their home connections, we display as Figure 2. It shows some tasks: the ICMP delay, the HTTP delay to a Alexa selected site, a Speedtest to the nearest Ookla site, a retrieval of a YouTube

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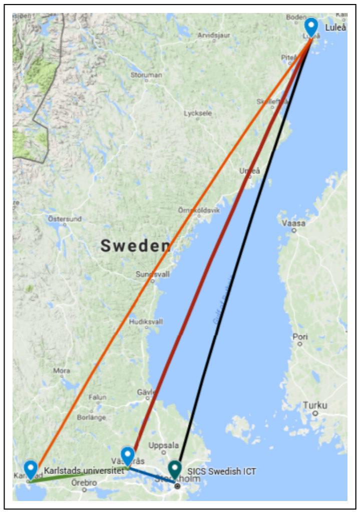

Fig. 1: Swedish CheesePi nodes.

clip[2], packet loss %, DNS lookup time, the WiFi AP seen and local information. *Non-technical dashboard:* Since we envisage CheesePi being used in a variety of homes, we designed some different dashboard. Figure 2 shows a Javascript representation of the download speed and latency "flowing" into a home. The mean rates are represented by the height, and the swell represents the variance of the throughput.

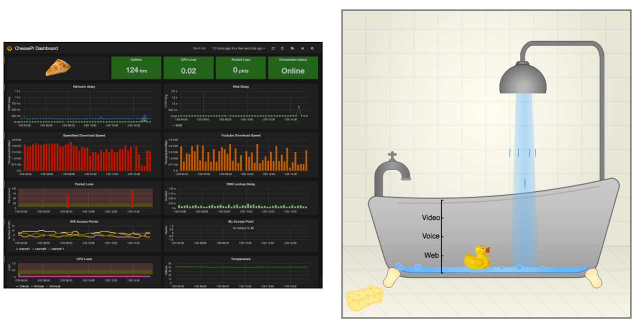

Fig. 2: *Dashboards.* Technical and non-technical.

II. Results obtained via CheesePi

A. Delay measurements:

A simple application to measure the network delay using both ends of a TCP connection.The idea is to use TCP as a "better ping". An insight is to separate the network delay from the object retrieval. During a web page request and retrieval, the latency encountered is caused by a combination of the end-terminal and network processing.

B. VoIP:

Using CheesePi, we soak tested the connections using VoIP sessions, varying from excellent to good performance quality.

[2]https://www.youtube.com/watch?v=_OBlgSz8sSM

C. High intensity traffic tests:

Generating traffic to characterize large capacity network links with high accuracy in transport backbones is important for Internet service providers. We used `iperf3` to measure throughput, and indirectly congestion on links within a network. Using short bursts at high utilization can ascertain whether a connection can support capacity sensitive applications, such as video streaming. Repeating the process to capture day-night effects can categorize links for management decisions over busy-quiet periods. As a request from one ISP, where they needed CheesePi nodes to generate higher data rates, we investigated additional single-board computers.

D. Media events:

In the third mode, the Pi acted as a home node to quantify Internet quality during a popular event. One such event was a boxing match between Mayweather-Pacquiao in 2015. We gathered 10 hours of data resulting in 80K measurements from three distributed Pis to three servers screening the event. IP networking delays using `ping` and the HTTP frontend server responses using `httping` were captured. The latter tool measures a GET request to the remote webserver. `Traceroute` and `mtr` were used as reachability tools.

E. Hardware:

Finally we tested Pis 2/3 and Odroids for energy use, quietness, long-term performance and reliability.

III. Status

We have implemented and tested the following services on CheesePi: VoIP, Iperf, 3-way TCP handshake time and popular media event analysis. Feedback on these will be available during the demonstration or can be found via the cheesepi.sics.se website.

IV. Future

In collaboration with the Université Catholique Louvain, Belgium, and Karlstad university, Sweden we will evaluate multipath TCP. Topics will be path selection and low-latency packet scheduling in the Raspberry Pi kernel, evaluated as part of the CheesePi network.

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