ACQUA : Application-level Quality of Experience at Internet Access

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Introduction to ACQUA

- Application for prediCting Quality of User experience at Internet Access, https://team.inria.fr/diana/acqua/
- What is Quality of Experience (QoE) ?
  - A subjective measure of human experience

    Good, Medium, Poor … for an audio conversation

    0, 1, 2, … for a video streaming

    ….
  - Obtained by a panel of testers
- How can QoE be estimated/predicted?
  - By linking it to measurable metrics (Quality of Service or QoS)
  - Application level, network level, device level, etc

ACQUA main features

- Application level QoE: Skype, YouTube, etc
- Measurements of network and device as input (QoS)
- Expected Quality of Experience as output (QoE)
- An application in ACQUA is a profile, a function, or a model

  For Application 1 f_1 (measurements) = QoE_1

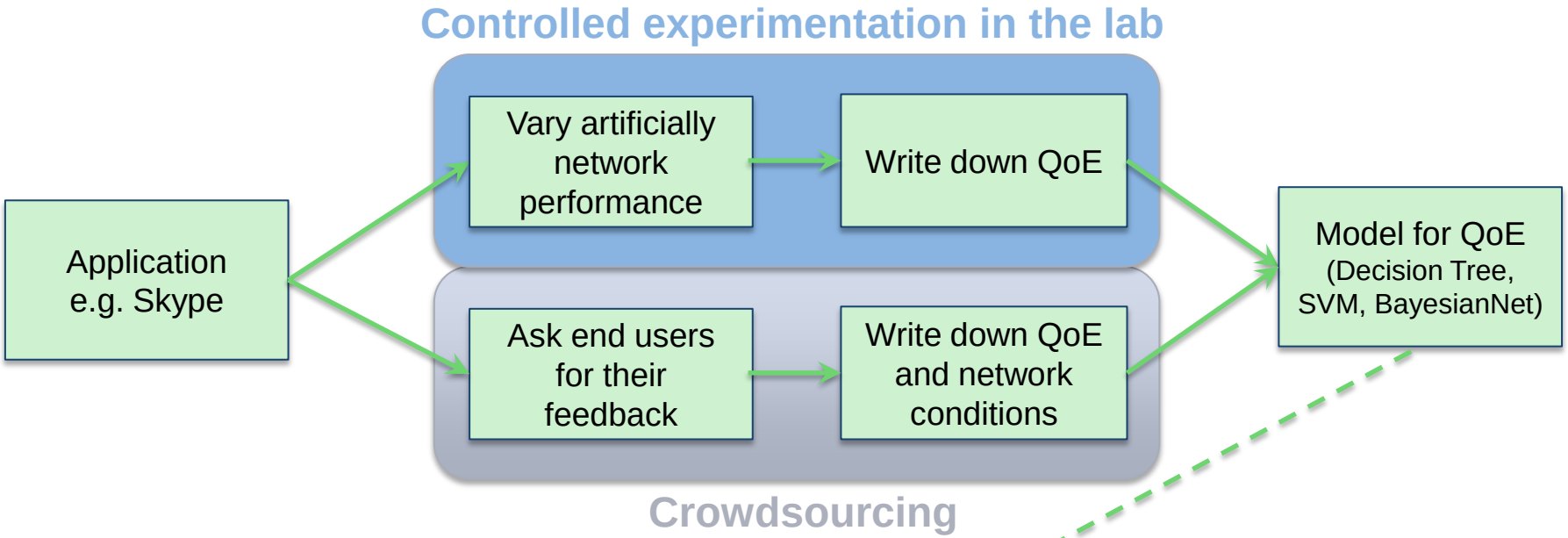
  For Application 2 f_2 (measurements) = QoE_2

  ….

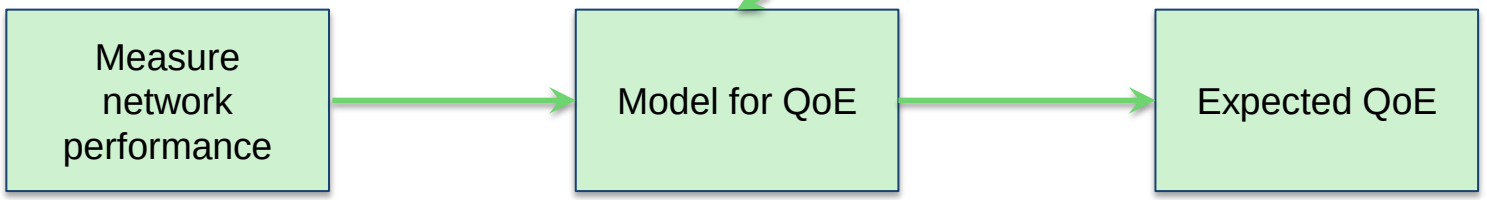
- QoE prediction thanks to direct linking to network level QoS
  - No need for applications to be running
- Reutilization of measurements
  - Measure network once, predict QoE for many applications

QoE vs. network QoS in ACQUA

Model Calibration Phase

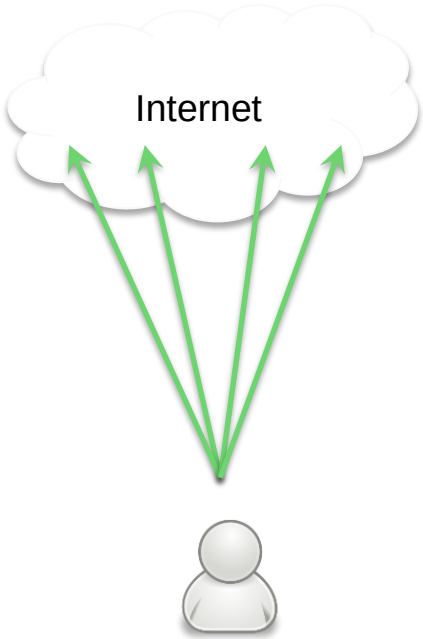


QoE Estimation/Prediction Phase

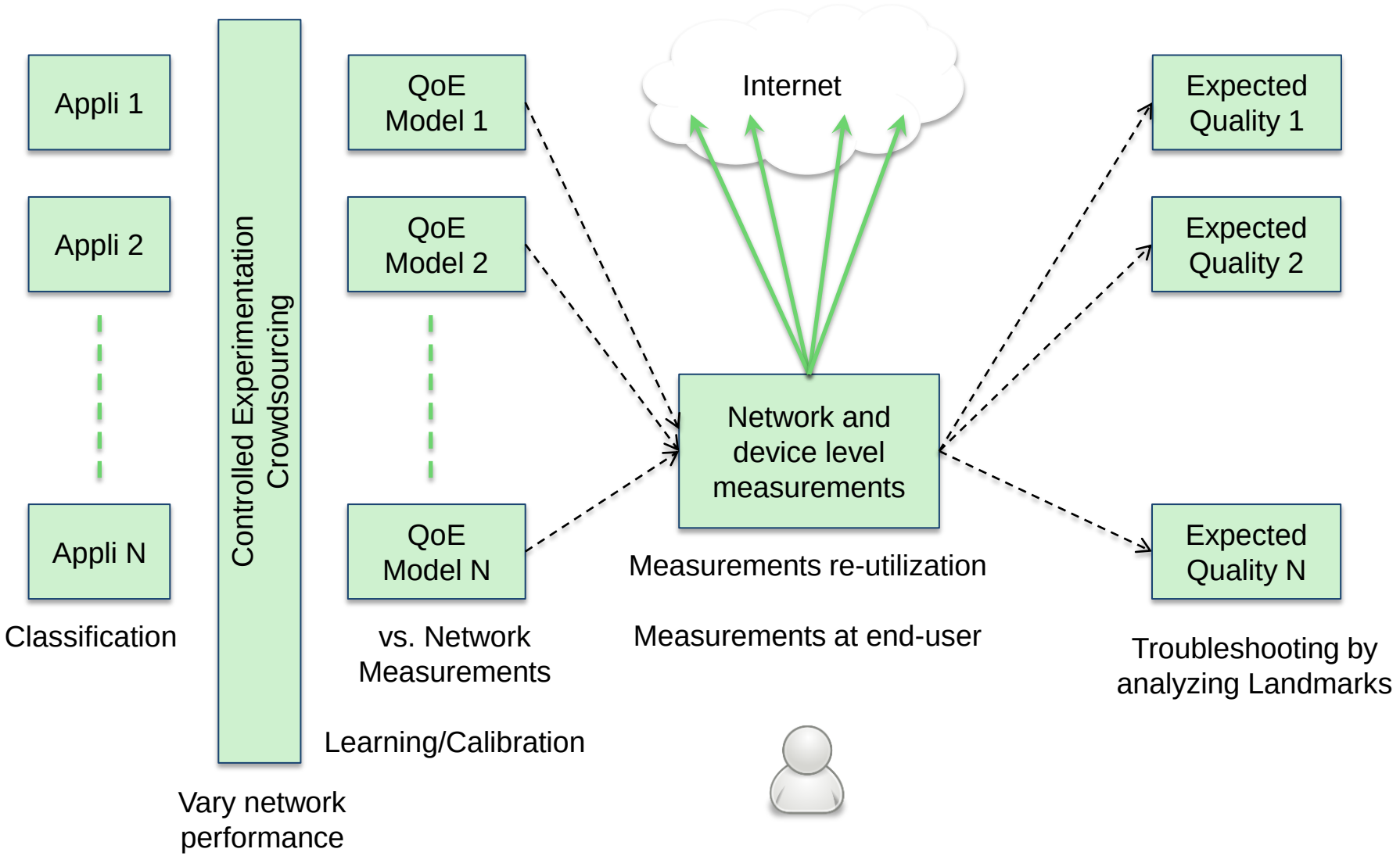


Network measurements in ACQUA

- Path-level measurements
  - Bandwidth, delay and loss, upload and download, …
- Device-level measurements
  - Signal strength, type of connection, traffic in/out, …
- Measurements inside and from the device
- Measurements to Landmarks
  - Measurement servers
  - Expected QoE per landmark
  - Statistics of QoE over landmarks
  - Troubleshooting by landmark elimination
  - Dozen of landmarks for a good span of QoE



ACQUA in a nutshell



Model calibration by controlled experimentation

Varying network conditions in ACQUA

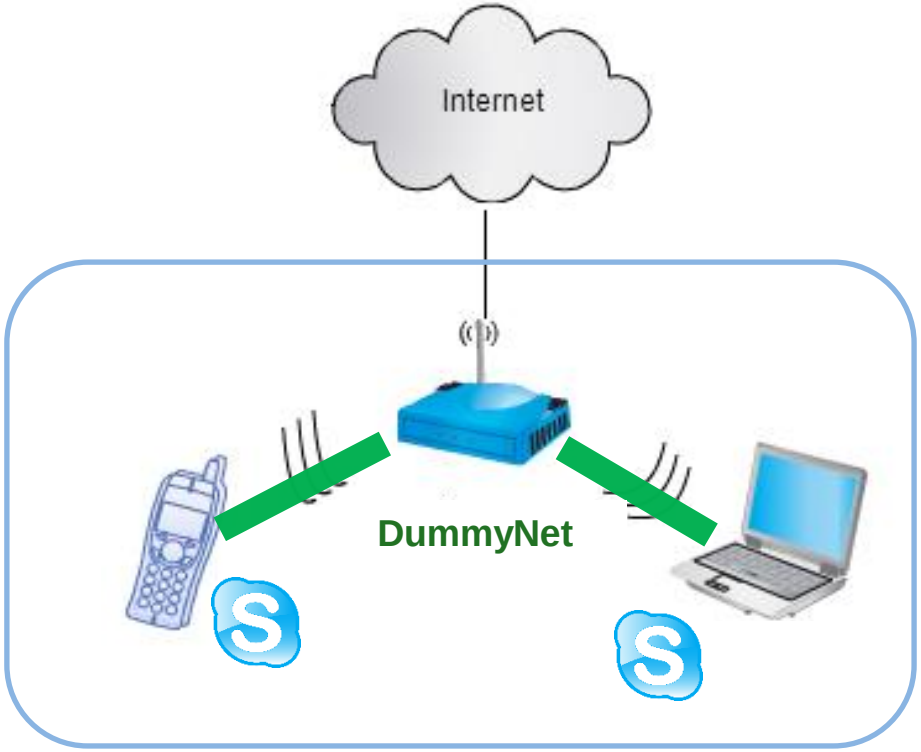
- Space of experimentation can be huge
  - One dimension per performance metric
  - Complexity power of the number of metrics

- A two-layer approach for space sampling
  - Fourier Amplitude Sensitivity Analysis (FAST) method for a fair coverage of the space and for sample suggestion
  - Active learning for sample acceptance/rejection (Vowpal Wabbit implementation)

- Only accepted samples transform into scenarios to experiment with

Experimenting with Skype

- Five measurable path metrics
  - Bandwidth and loss rate, both upload and download
  - Round-trip delay
- QoE = Skype quality meter
  - Four levels
  - Good, Medium, Poor, No Call
- Controlled experimental setup
  - DummyNet at access point
  - Both ways
  - Local Skype traffic
  - Around 600 experiments



Controlled experimentation

One experiment

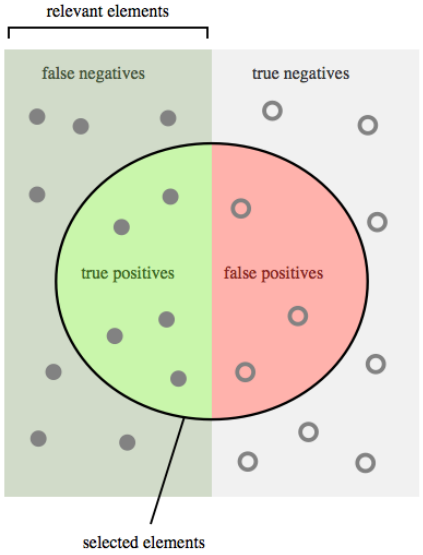
A local skype call
One network configuration
(5 values)

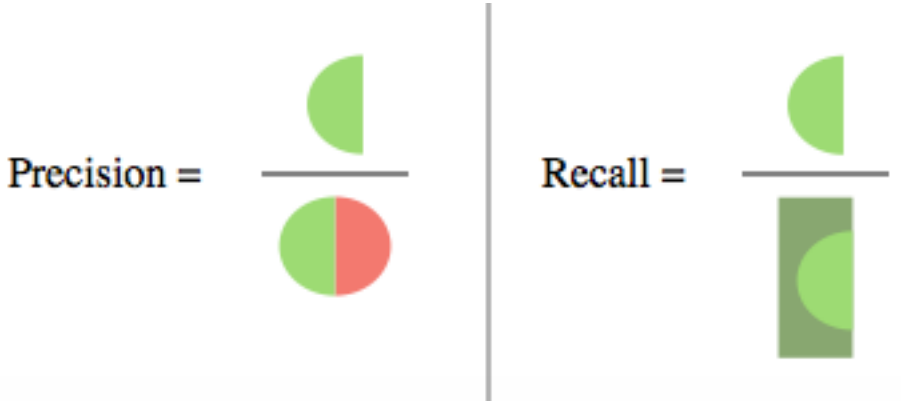
→

QoE of Skype
(Good, Medium, Poor, No Call)

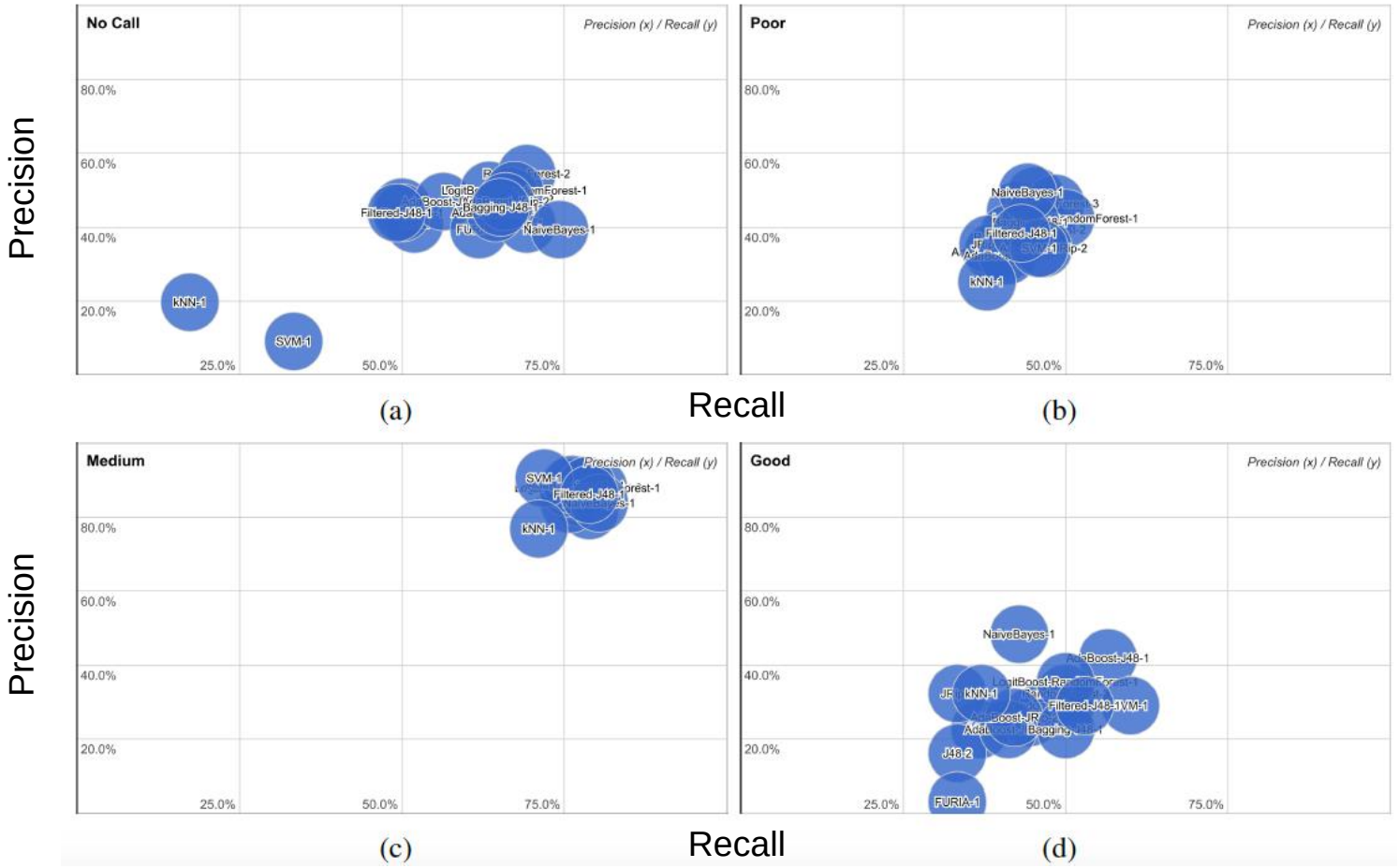
Modeling Skype Quality of Experience

- A variety of machine learning techniques
  - Decision Tree, Naïve Bayesian, Lazy learner, Support Vector Machine, etc.
- Focus on Decision Trees for their readability
- Performance metrics: Precision and Recall per Quality class



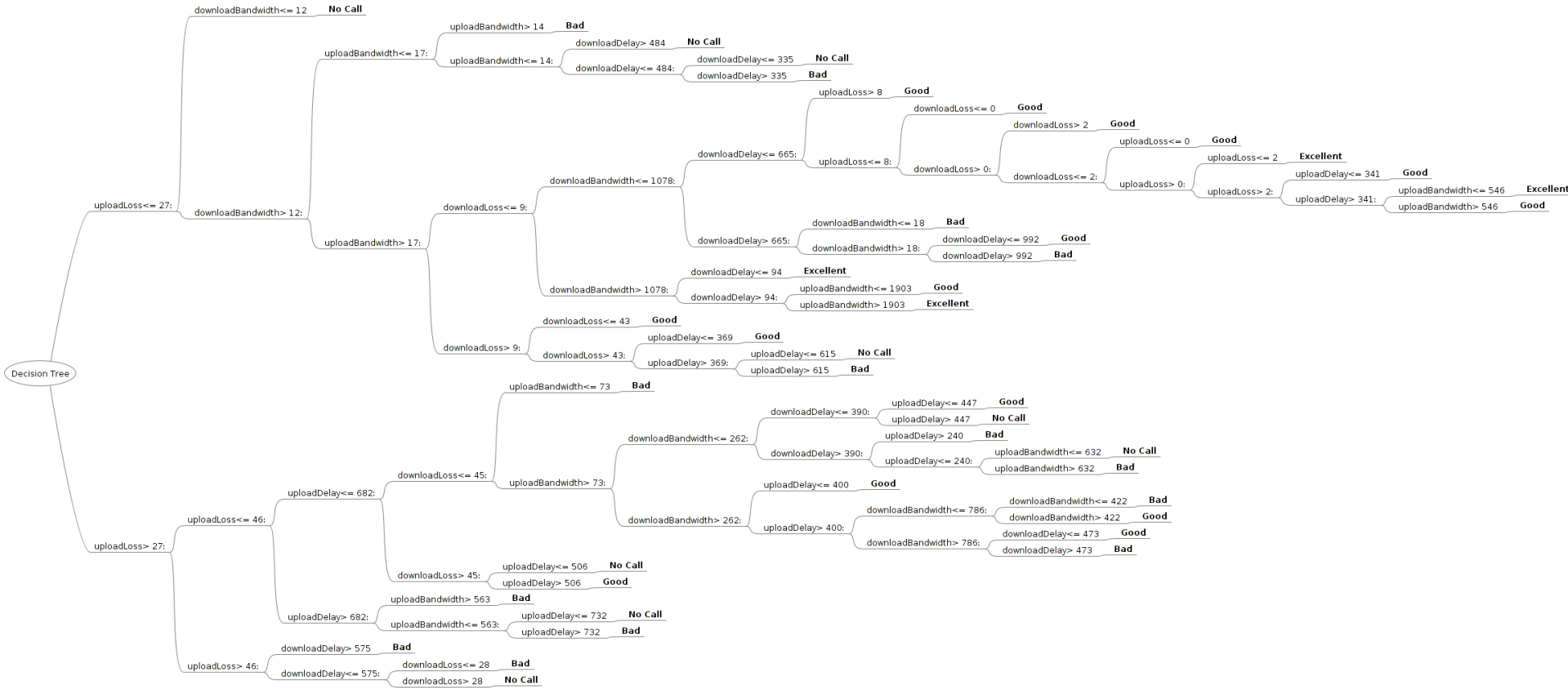


Skype QoE prediction accuracy



- Best performance for the Medium class, no particular technique outperforming
- Almost 70% prediction accuracy (or recall) on average

Skype tree sample



Skype Quality Rules

- Rule = set of branches from root to leaf
- 20 rules (after pruning)
  - **Rule 1:** Download Bandwidth > 1078, Download Delay <= 94 → class “Excellent” [84.1%]
  - **Rule 2:** Upd Bandwidth > 1903, Dwn Bandwidth > 1078 → class “Excellent” [70.7%]
  - **Rule 3:** Dwn Bandwidth <= 1078, Dwn Delay <= 665, Upd Loss > 0, Upd Loss <= 2, Dwn Loss > 0, Dwn Loss <= 2 → class “Excellent” [66.2%]
  - **Rule 4:** Dwn Bandwidth <= 12 → class “No Call” [90.6%]
  - **Rule 5:** Upd Bandwidth <= 14, Upd Loss <= 27 → class “No Call” [75.7%]
  - **Rule 6:** Upd Delay <= 506, Upd Loss > 27, Upd Loss <= 46, Dwn Loss > 45 → class “No Call” [61.2%]
  -
  -
  -
  - **Default class:** Good

ARQ/FEC

12kbs a critical rate

Skype can easily deal with one-way losses if bandwidth is available one-way delay up tp 400ms

Still many open issues

- Consideration of other multimedia and non-multimedia applications
- Scalability of network measurements
- Application to network regulation and optimization
- Current work focuses on
  - Consolidation of the audio and video case
  - ACQUA for mobiles (Inria ADT ACQUA)
  - Crowdsourcing

Thank you

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