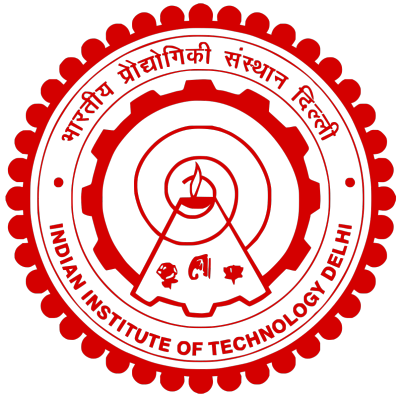
Estimating WebRTC Video QoE Metrics Without Using Application Headers



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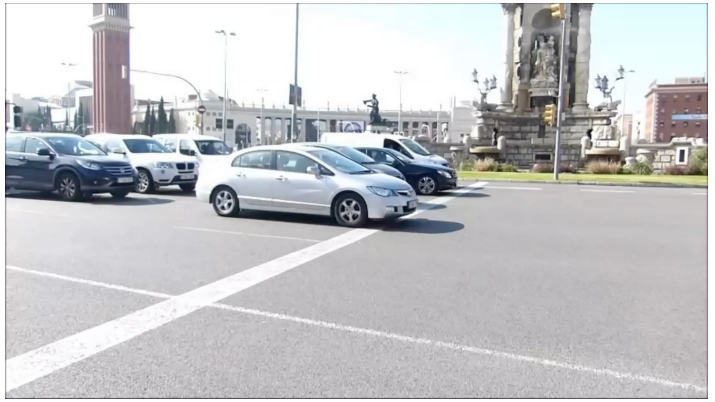
Motivation

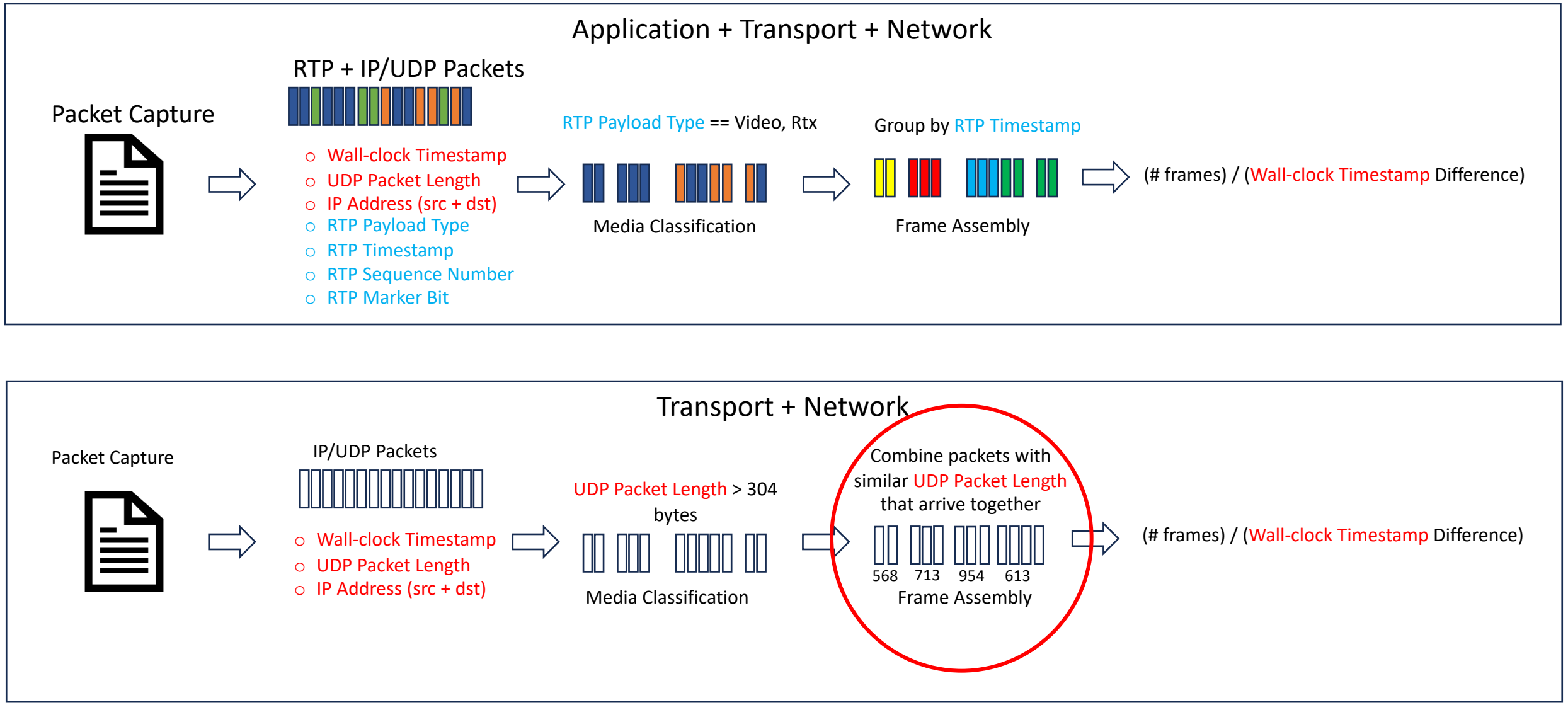
- Video Conferencing QoE is typically inferred using application (RTP) layer headers
- QoE can be improved by optimizing both the end hosts and the network
- Network operators lack access to end hosts
- Sometimes RTP headers may not be accessible
- **Goal:** Can we only use the signals in the network (IP) and the transport (UDP) layers to infer QoE?

Measures of QoE

- Frame Rate (Smoothness)
- Bitrate (Data transfer rate)
- Frame Jitter (Consistency)
- Resolution (Detail)

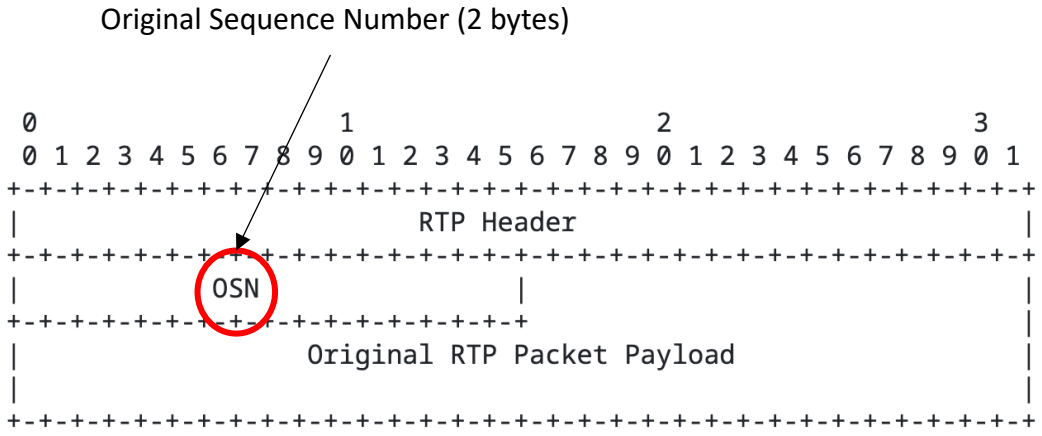


Frame Rate Inference Sketch



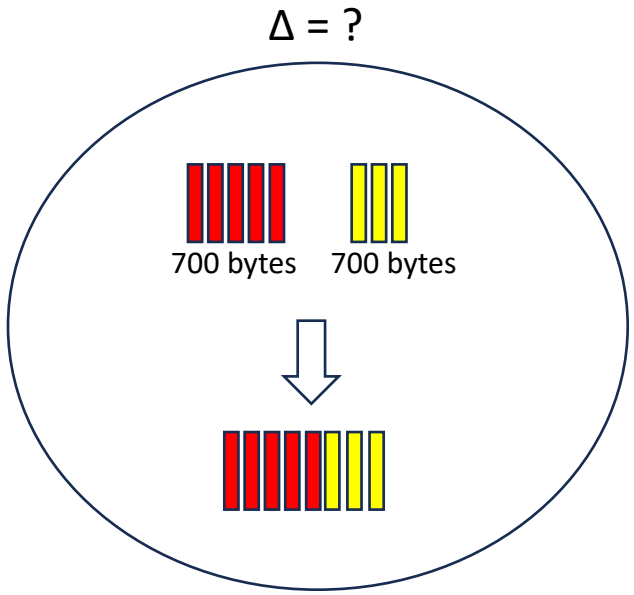
IP/UDP Heuristic

- How to group similarly sized packets?
  - Maintain a state of *L* previously seen packets
  - *L* = Lookback Parameter
  - For every new packet of length *S*,
    - Select the last packet P from previous *L* packets such that:
      - |Length of P – S| ≤ Δ bytes
      - Assign the new packet the same frame as P
    - If no P is found, put the new packet in a new frame

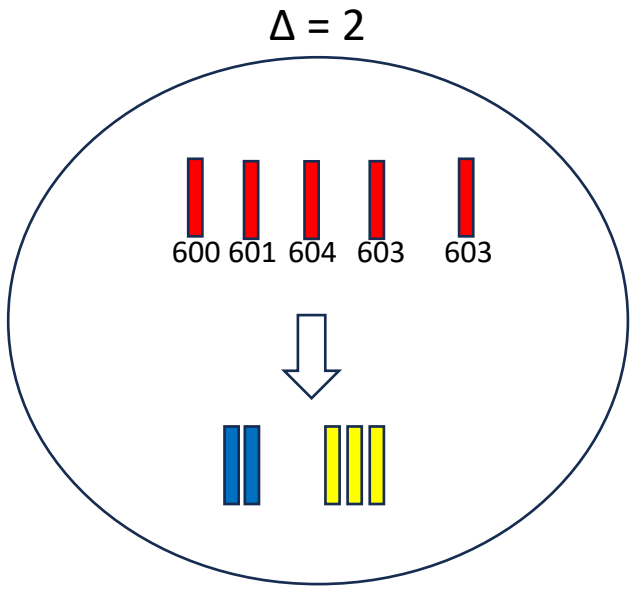


Δ = 2 is a natural choice!

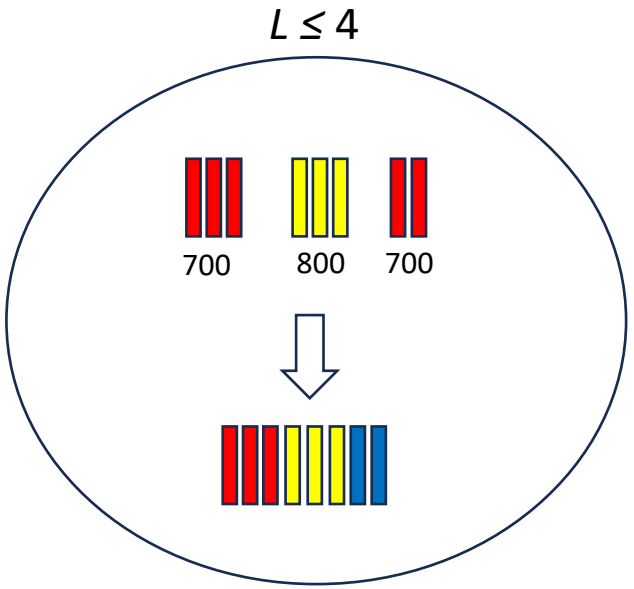
IP/UDP Heuristic Challenges



Coalesce



Split



Interleave

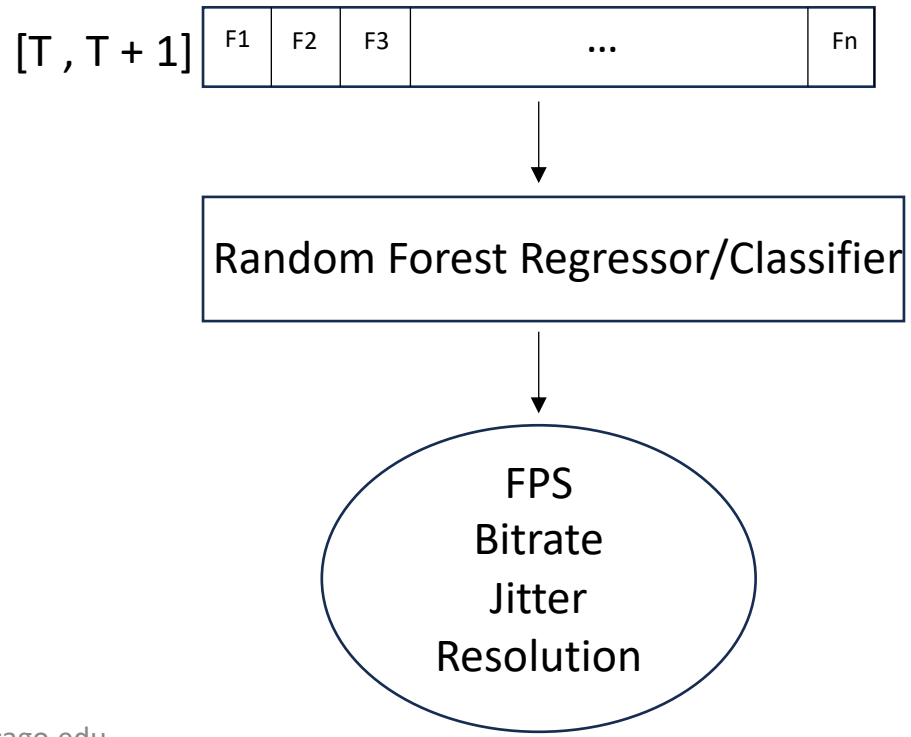
No single parameter value can handle all failure cases!

Applying Machine Learning

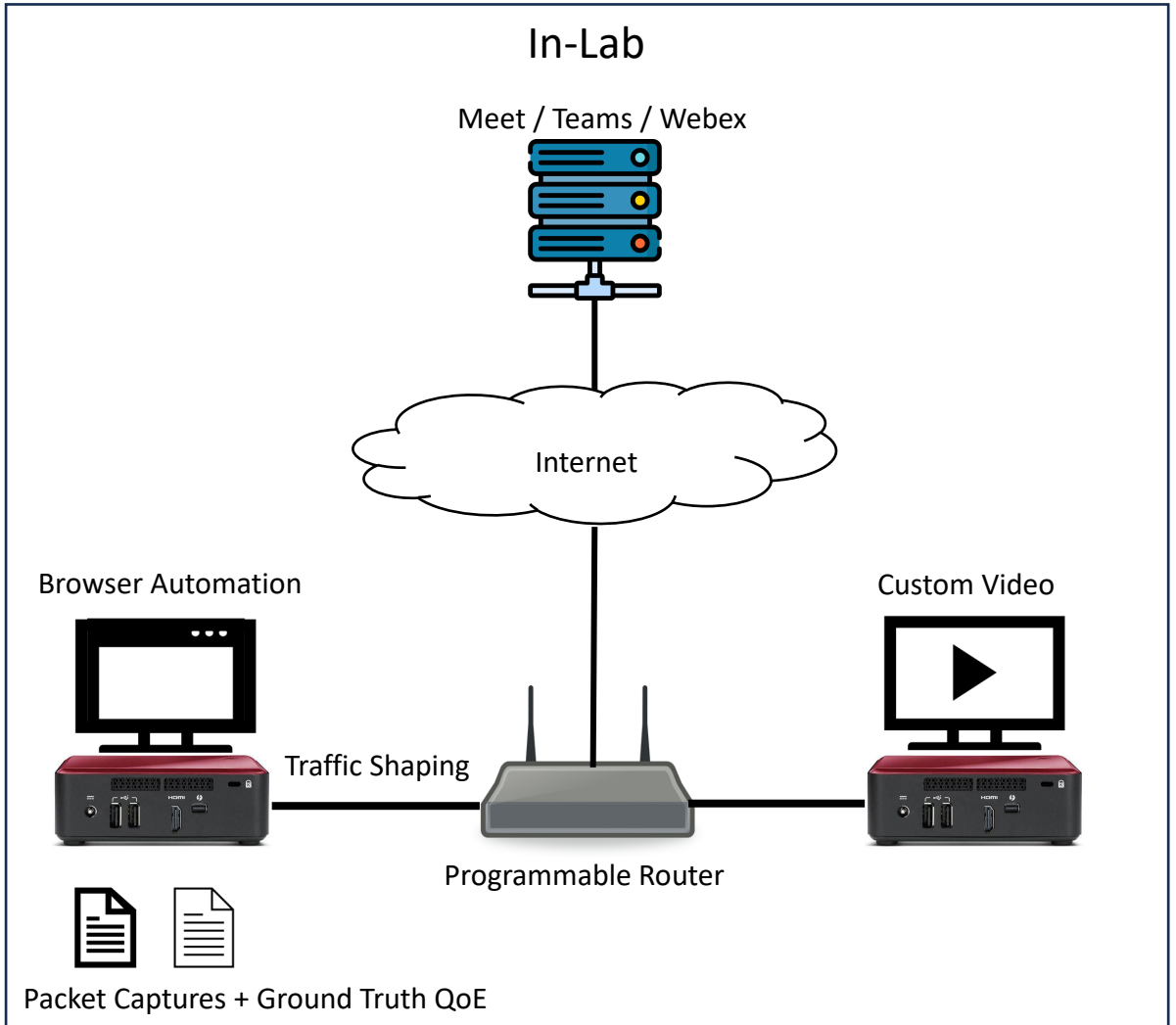
- VCA Semantics-based features
  - Number of unique packet sizes
  - Number of microbursts
- Window-level features
  - Bytes per second
  - Packets per second
  - Packet size statistics
  - Inter-arrival time statistics

Classical supervised ML models:

- Decision Trees
- **Random Forests**
- Support Vector Machines (SVMs)

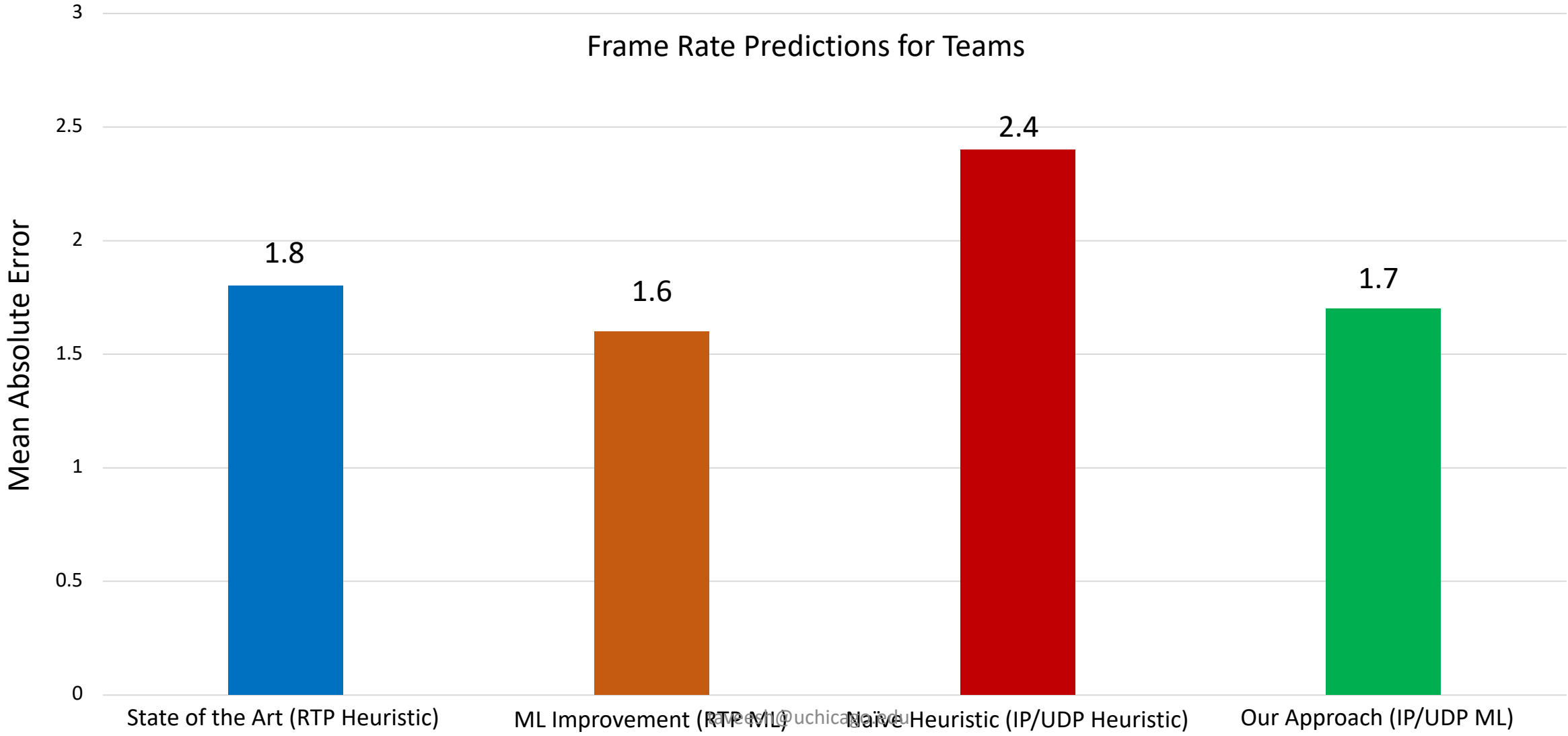


Datasets



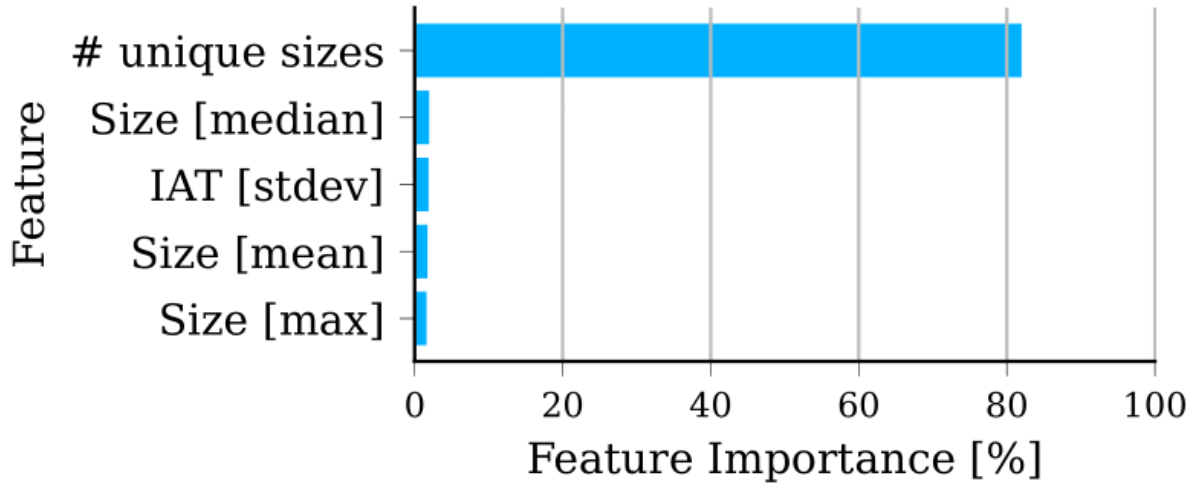
- In-Lab:
  - 900 VCA calls
  - ~29,000 seconds
  - Google Meet, Microsoft Teams, Cisco Webex
  - Varying throughput, delay, jitter, packet loss
- Real-World:
  - 15 households
  - 915 VCA calls
  - ~25,000 seconds
  - Google Meet, Microsoft Teams, Cisco Webex

IP/UDP Layers Contain Enough Signals!

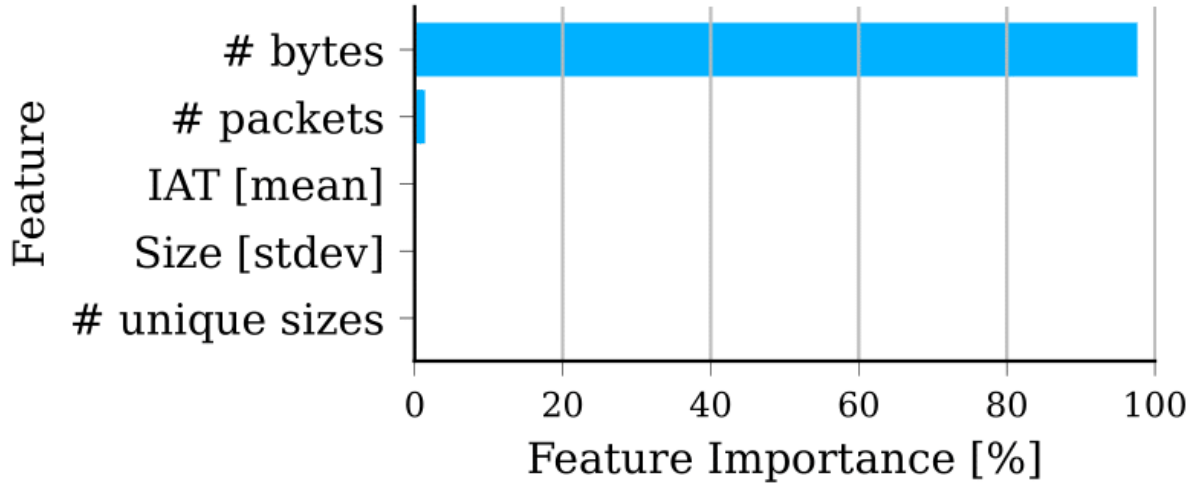


Which Features Are Important?

Frame Rate



Bitrate



Teams Feature Importance Scores (In-Lab)

Takeaways

- QoE signals in Transport and Network Layers equivalent to Application Layer signals
- Our Solution = VCA-Semantics Features + Window-level Features + Untuned Random Forest
- Future Work:
  - Native Clients and non-WebRTC VCAs
  - Application Modalities – Screen sharing, Multiple participants, etc.
  - Deployability

Questions?

Check out our code and datasets:

https://github.com/noise-lab/vcaml

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