Scaling Video Analytics on Constrained Edge Nodes

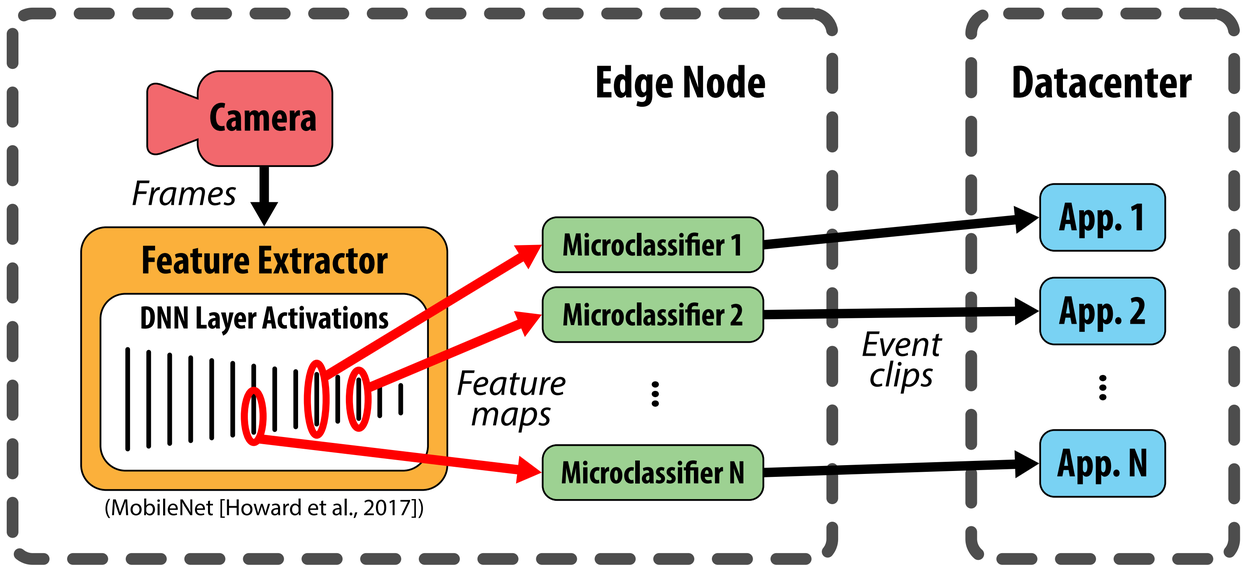
Christopher Canel, Thomas Kim, Giulio Zhou, Conglong Li, Hyeontaek Lim,
David G. Andersen, Michael Kaminsky[†], Subramanya R. Dulloor[‡]
Carnegie Mellon University; [†]Intel Labs; [‡]ThoughtSpot

MOTIVATION

- **City-wide camera deployments are ubiquitous**
- **Apps running in the cloud demand high-quality video**
- **Data volume is cost-prohibitive for wide-area networks**

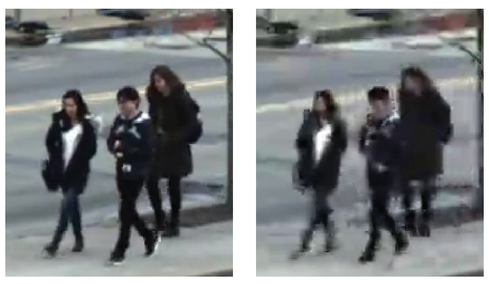
OUR WORK

- **Saves bandwidth by dropping irrelevant frames**
- **A scalable framework that enables edge nodes to determine which frames are relevant to cloud apps**



FilterForward (FF): Accurate and Scalable Video Filtering on the Edge

Compression obscures critical, subtle details



1000 Kb/s *100 Kb/s*

KEY IDEAS

- **Apps receive high-quality data at a fraction of the bandwidth cost**
- **Exposing fine frame details enables precise filtering**
- **Computation sharing allows filtering to scale to many apps**

Datacenter:

- Communicates filter parameters to edge nodes
- Receives relevant frames, distributes them to apps

Edge node (the core of FilterForward):

- Runs a base Deep Neural Network (e.g., MobileNet) on each frame to extract semantic features
- Uses features as input to many *microclassifiers (MCs)*, thereby amortizing expensive pixel processing
- Forwards frames filtered by MCs back to cloud

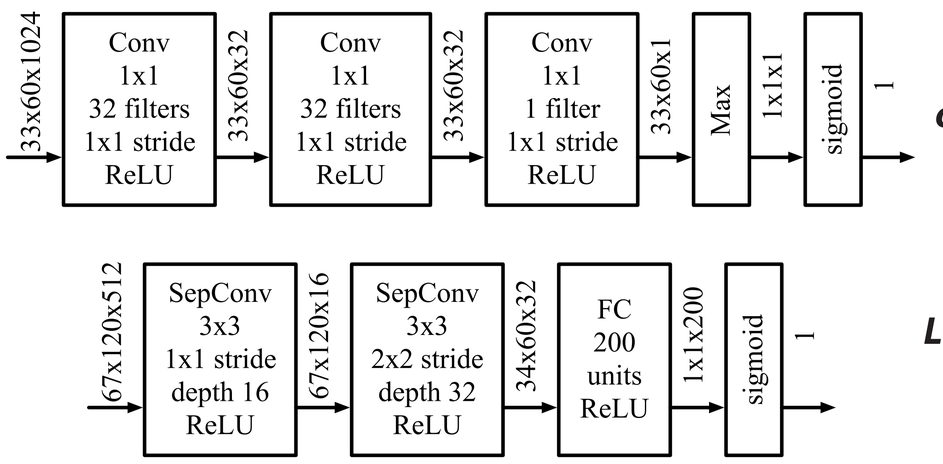
Microclassifiers: Small Neural Networks that Filter Content Relevant to Cloud Applications

Sensitive to fine-grained details

- Base DNN processes full-resolution (e.g., 1080p) frames
- Feature maps are drawn from any layer in the base DNN
- Spatially cropping feature maps enables MCs to localize

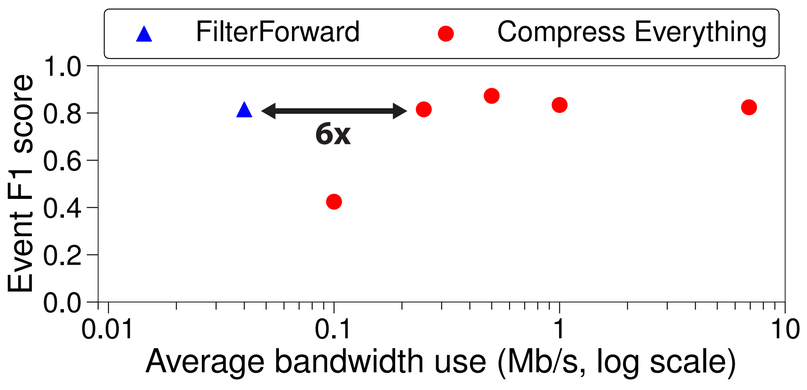
Computationally scalable

- Using a base DNN shares the pixel processing across all MCs
- Operating directly on semantic features makes MCs lightweight
- Adding more MCs amortizes the expensive base DNN

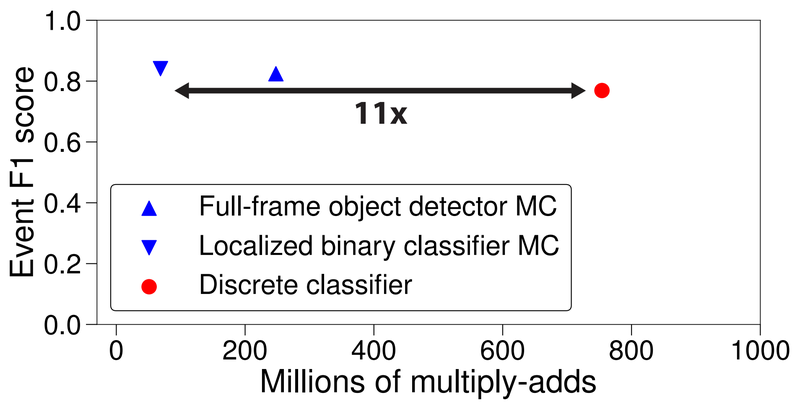


Evaluation: FilterForward Uses Less Bandwidth for Same Accuracy; Scales to Many Apps

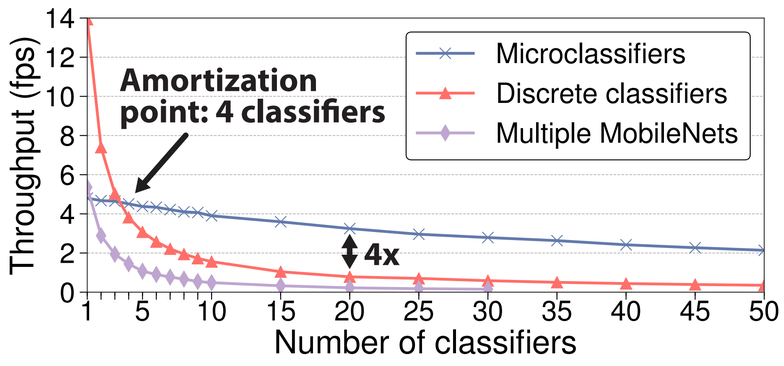
FilterForward uses **6x** less bandwidth compared to compressing the entire video, without sacrificing accuracy



Microclassifiers have up to **11x** lower marginal cost, yet similar accuracy, compared to pixel-level classifiers (NoScope [Kang et al., 2017])



Computation sharing makes FF more efficient than pixel-level classifiers when running **≥4**, with **4x** higher throughput with 20 classifiers



Carnegie Mellon University

Learn more at: *github.com/viscloud/filterforward*