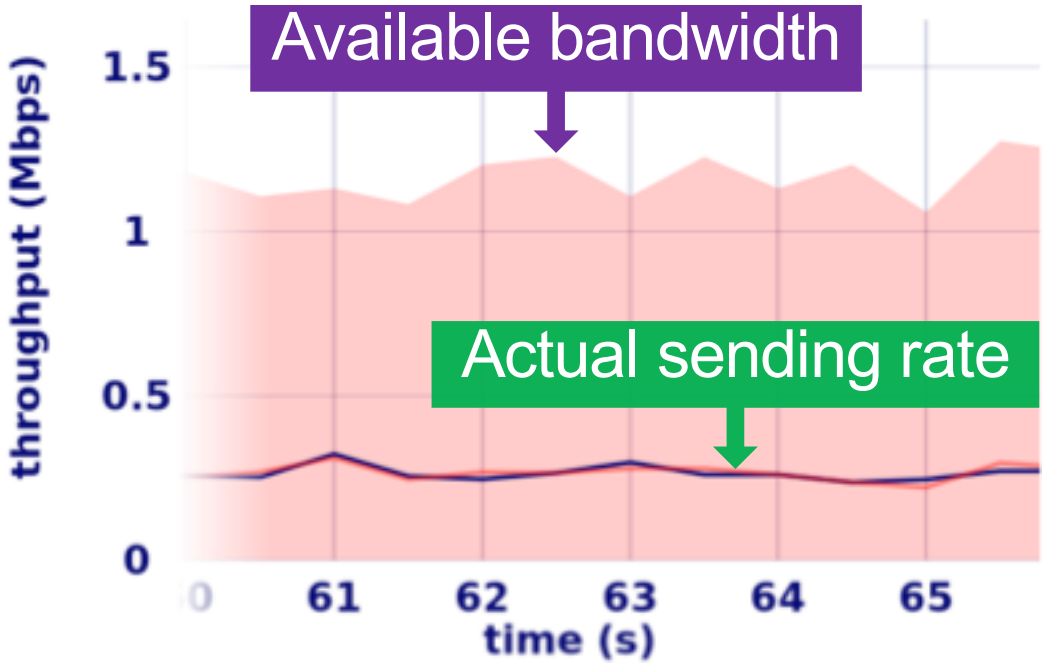
Dejavu: Enhancing Videoconferencing with Prior Knowledge

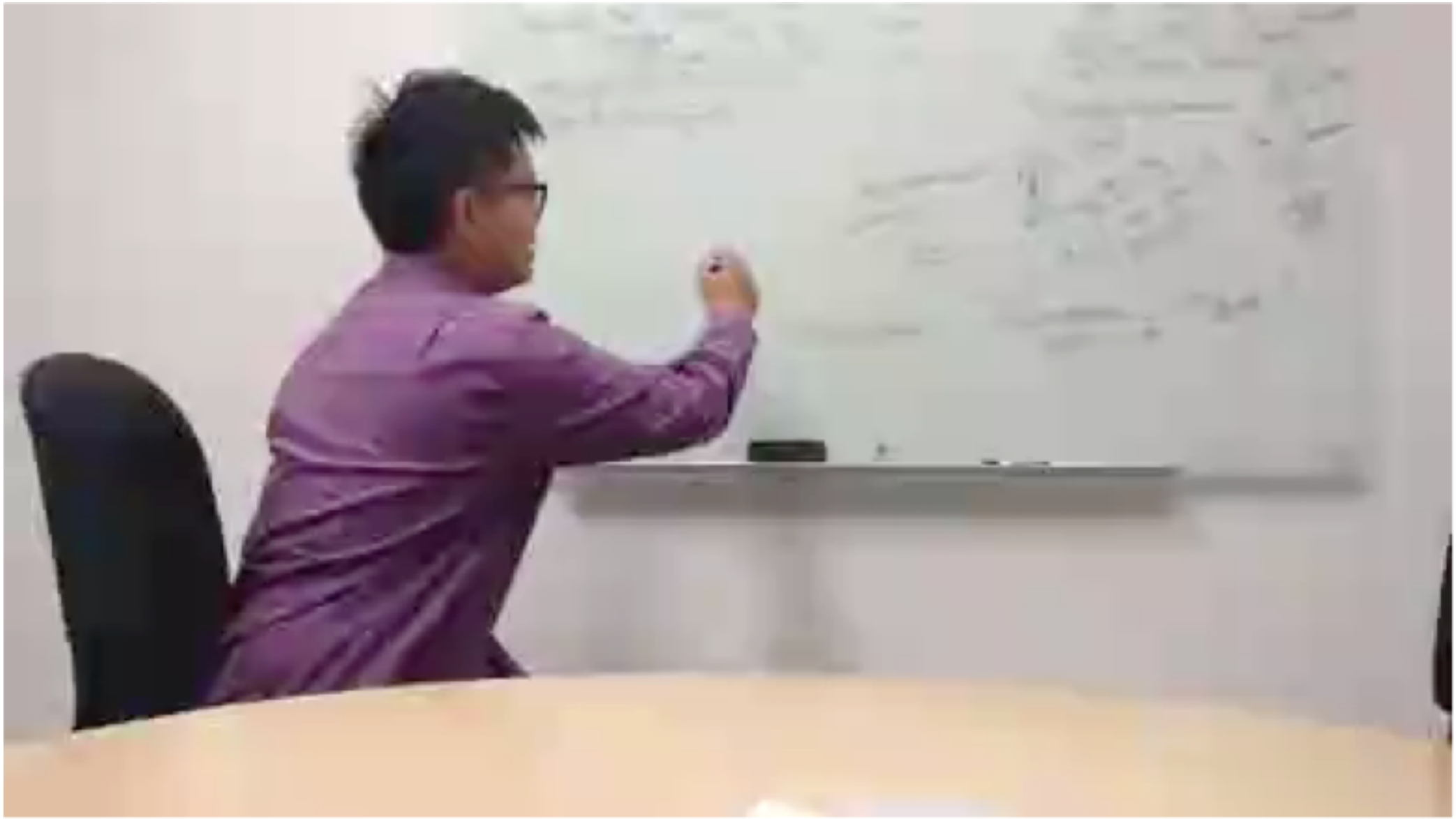
Pan Hu, Rakesh Misra, Sachin Katti
Stanford University and Uhana Inc.

Poor Quality of Videoconferencing over Wireless Links

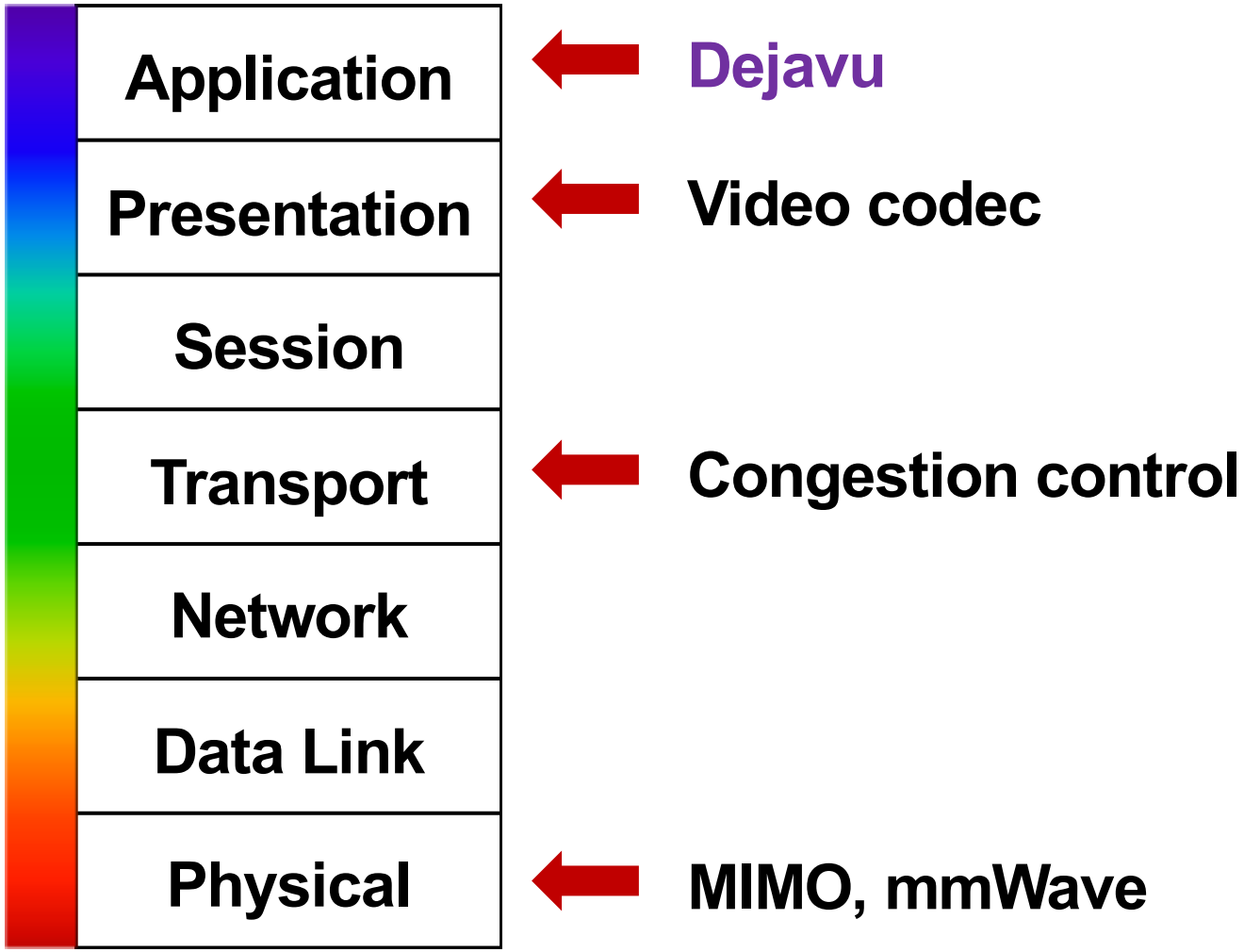


- Low uplink bandwidth over LTE
- Conservative bandwidth utilization to maintain interactivity

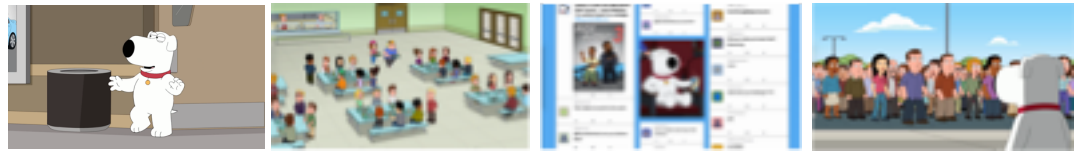
Poor Quality of Videoconferencing over Wireless Links

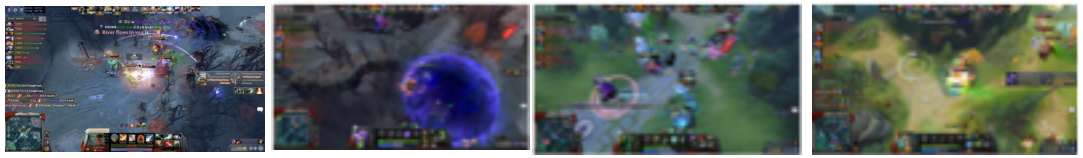


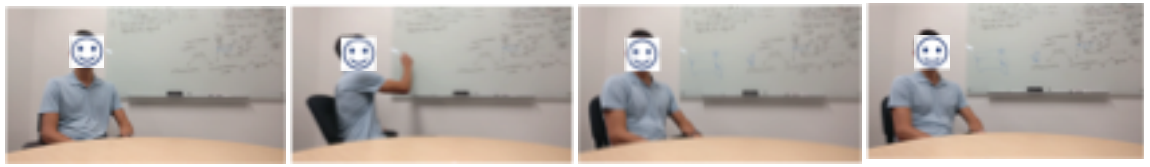
Prior Solutions for better videoconferencing

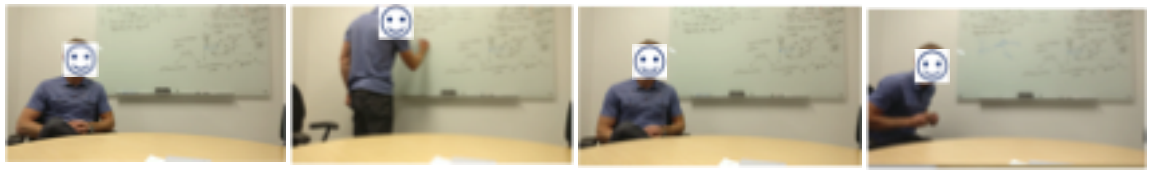


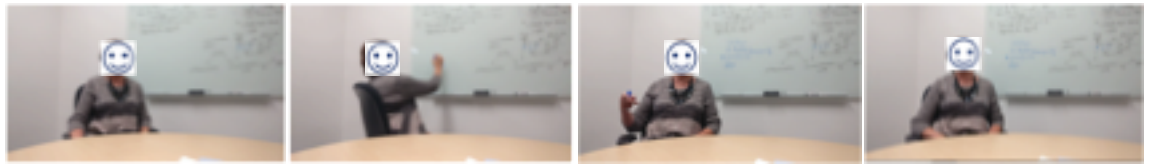
Key Insight: visual similarities

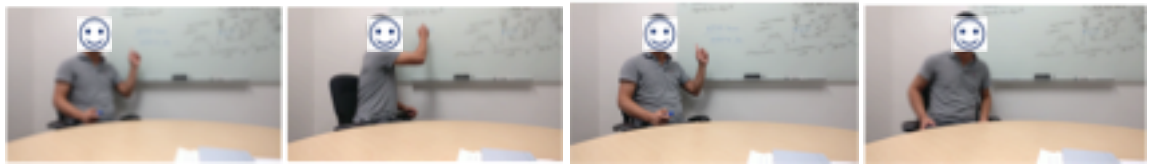












Arbitrary videos from Youtube:

few visual similarities

Videoconferencing in the same room:

abundant visual similarities

Dejavu: is a system that optimizes videoconferencing performance by leveraging similarities across past and current sessions

How to Leverage the Similarities?

- **Dejavu: let neural network learn the similarities**

Low quality training input

NN with Knowledge

High quality training output

How to Leverage the Similarities?

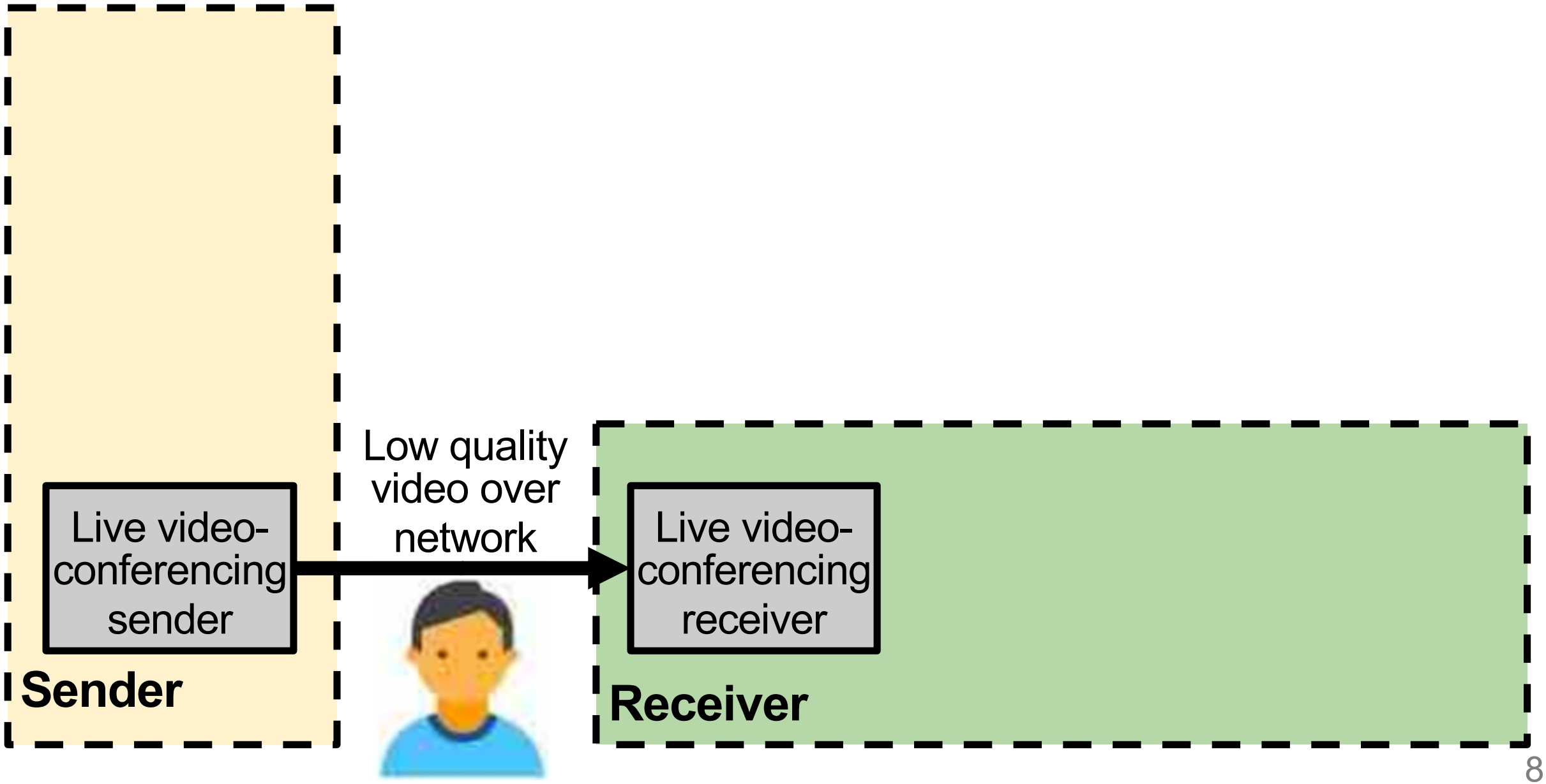
- Dejavu: let neural network learn the similarities

Low quality test input

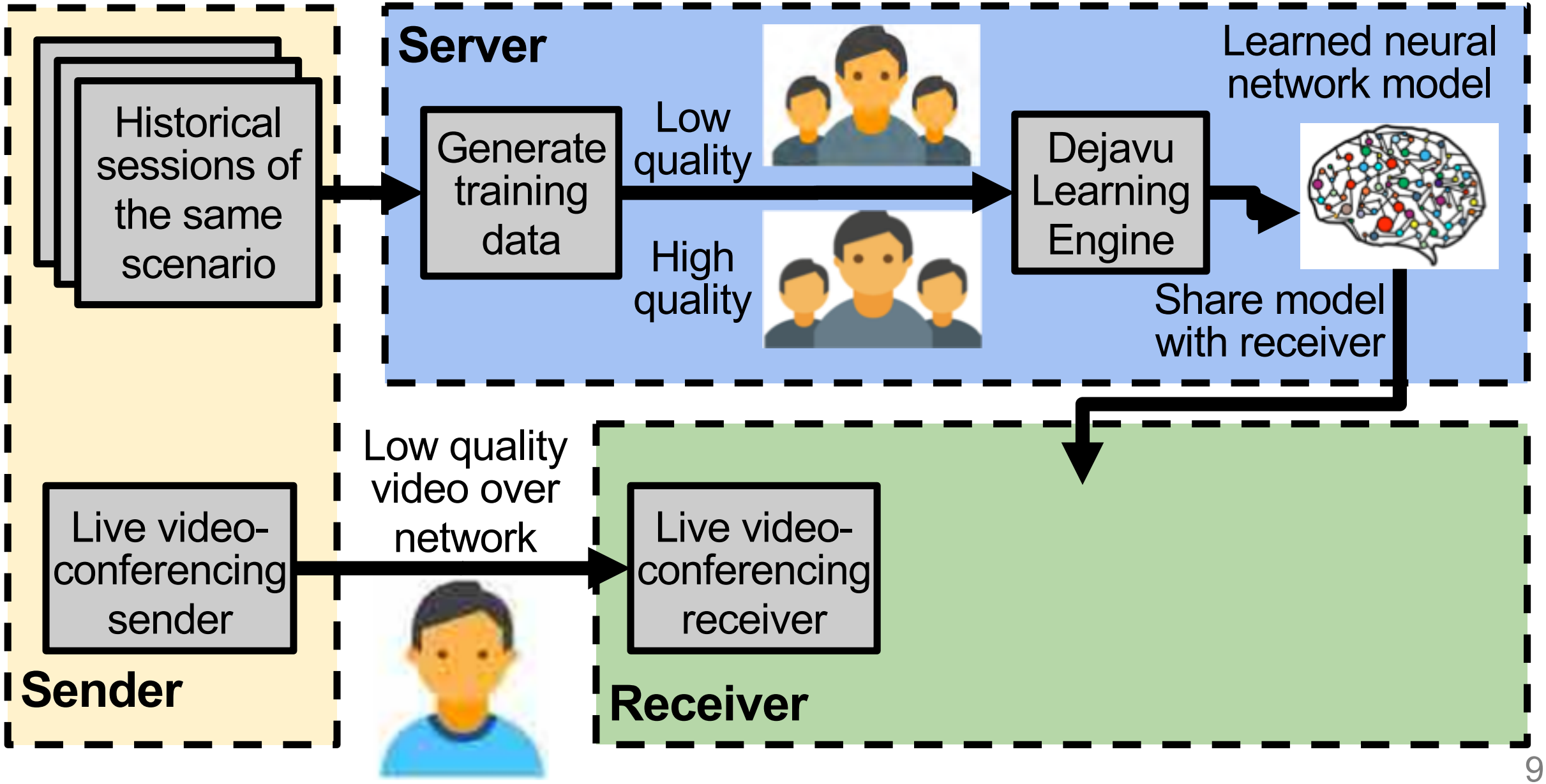
NN with Knowledge

High quality test output

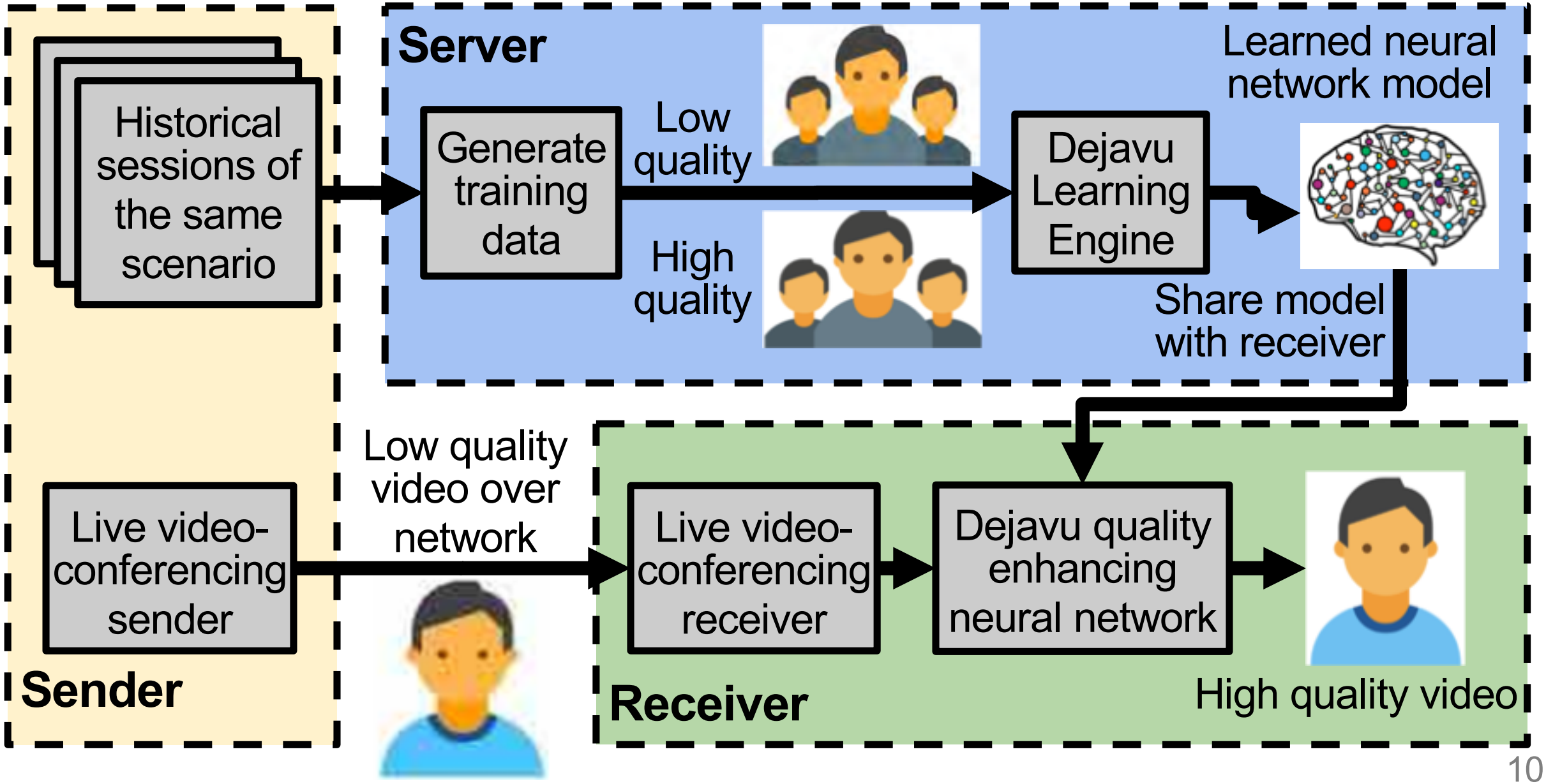
Current System



Dejavu Offline Stage

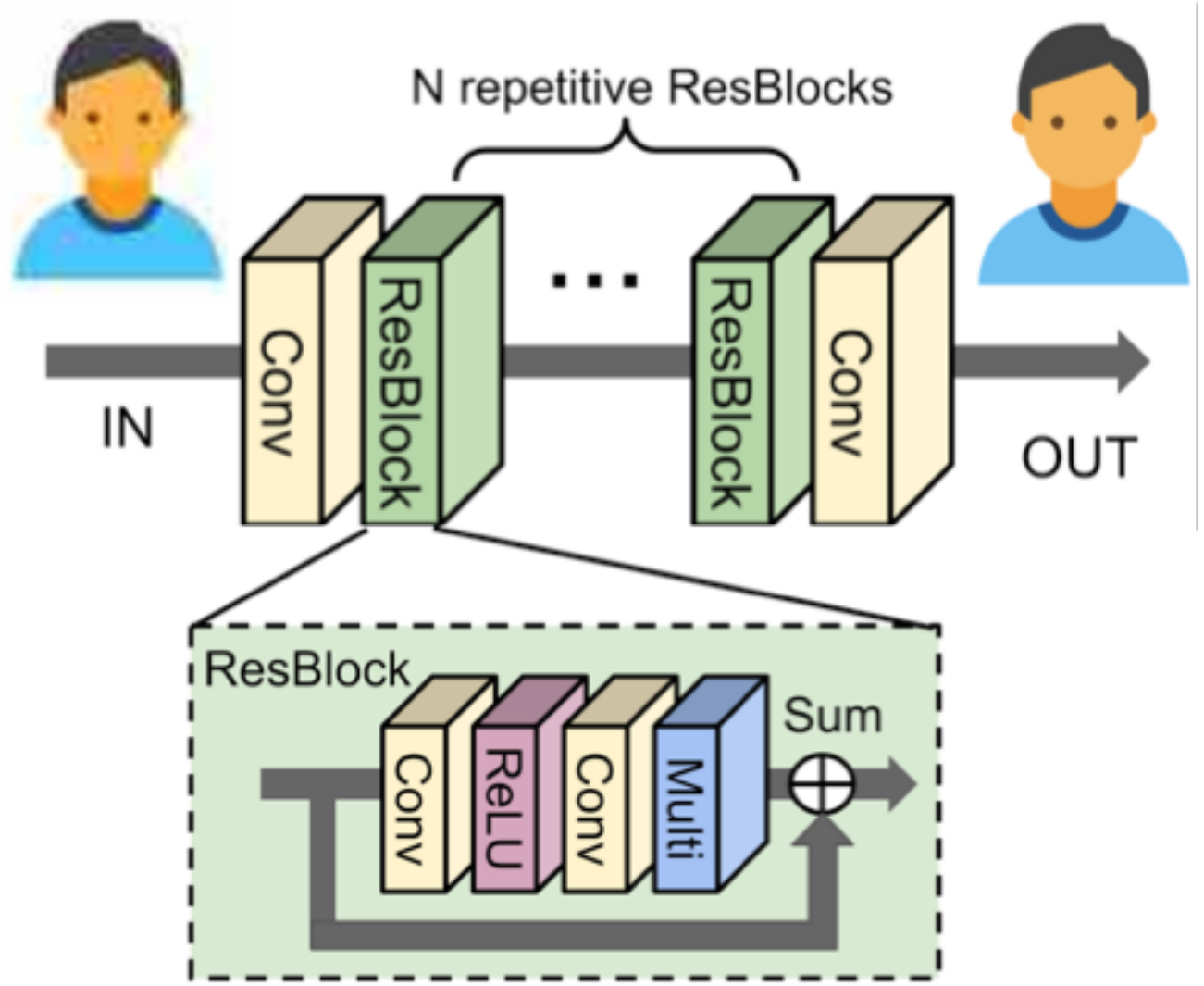


Dejavu Online Stage

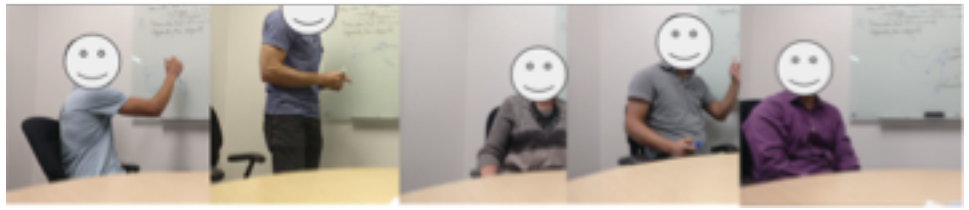


Design of Dejavu Learning Engine

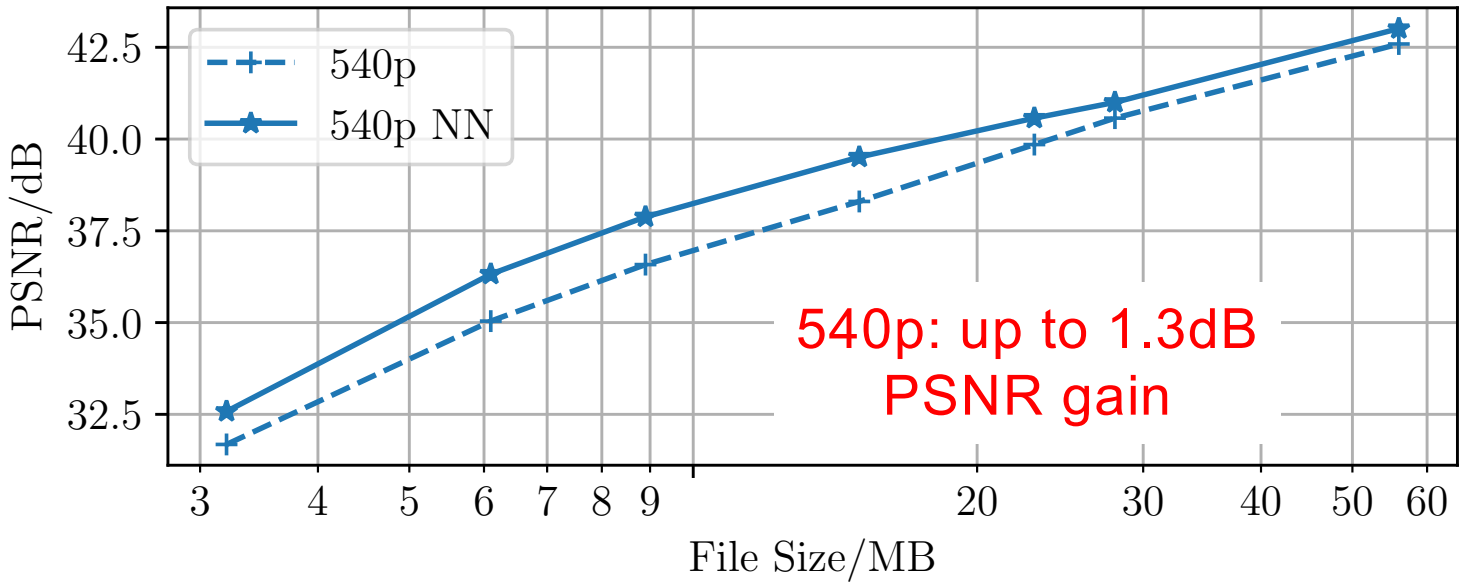
- **NN Architecture**
  - Convolution layers + Residual blocks
- **Preprocessing**
  - Compress videos into different quality levels with FFMPEG
  - Train on shuffled small patches rather than full frame
  - Convert RGB into YUV, processing on Y only to speed up inference

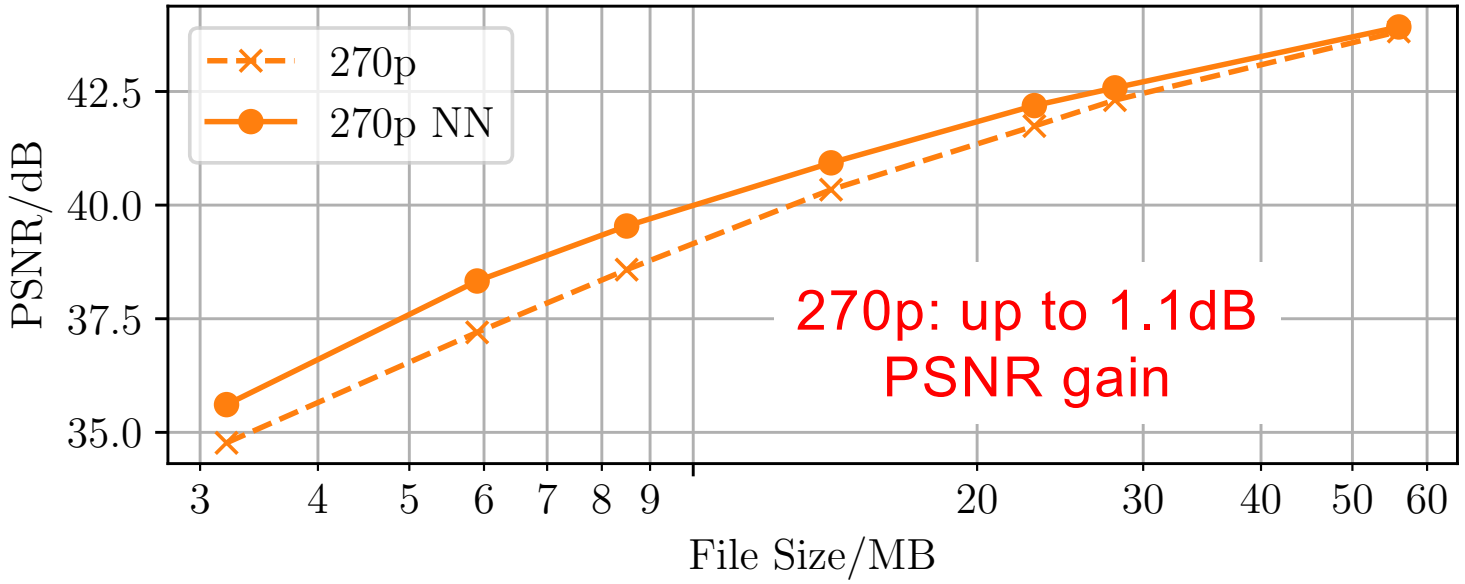


Performance Benchmark: PSNR Gain

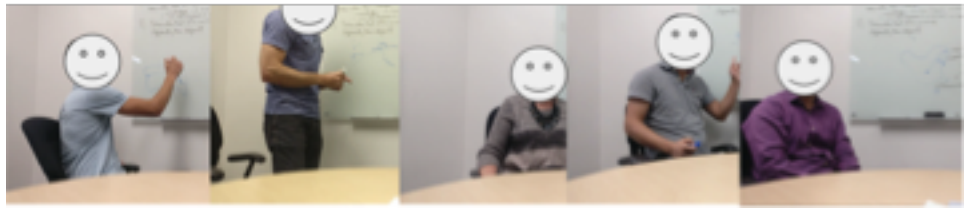


- Train/validate on the first four videos and test on the last one
- Video format
  - 270p(480*270) and 540p(960*540)
  - [100, 200, 300, 500, 800, 1000, 2000] kbps
- Measure Peak Signal to Noise Ratio

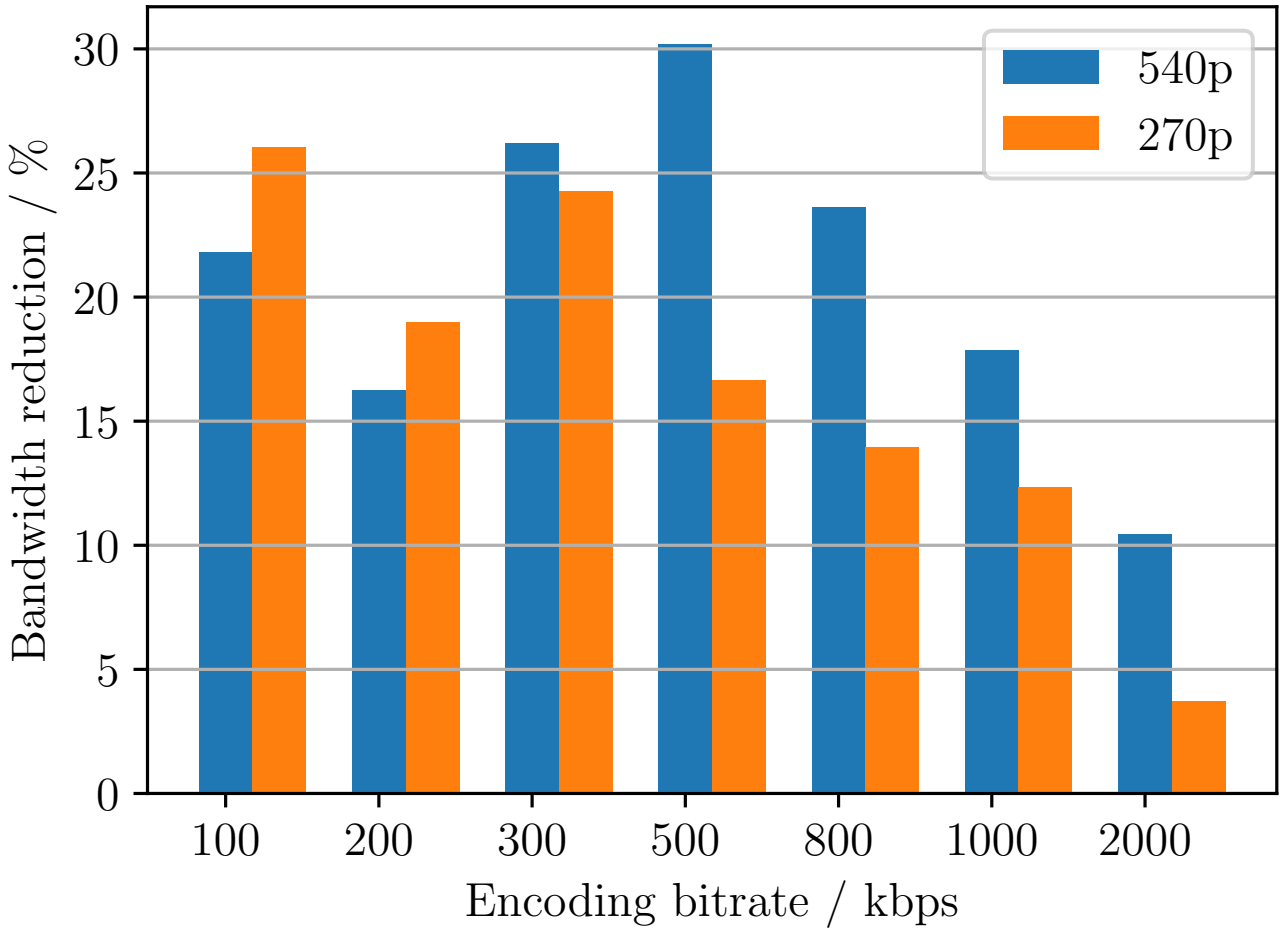




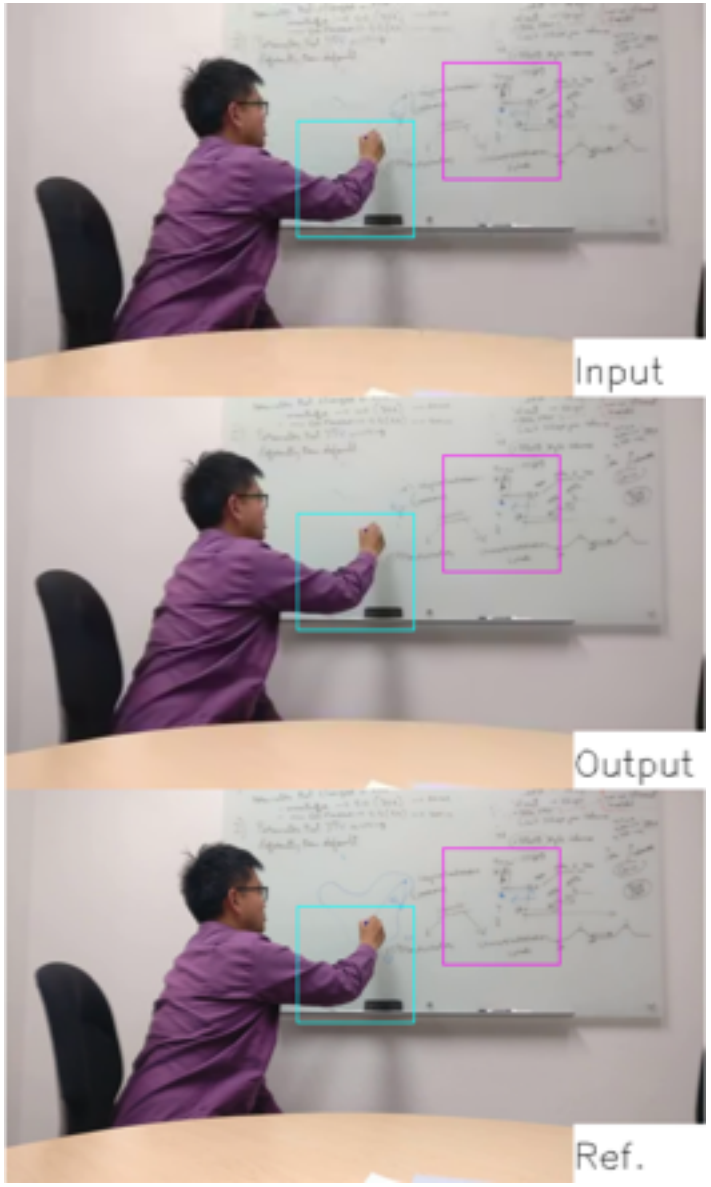
Performance Benchmark: Bandwidth Saving

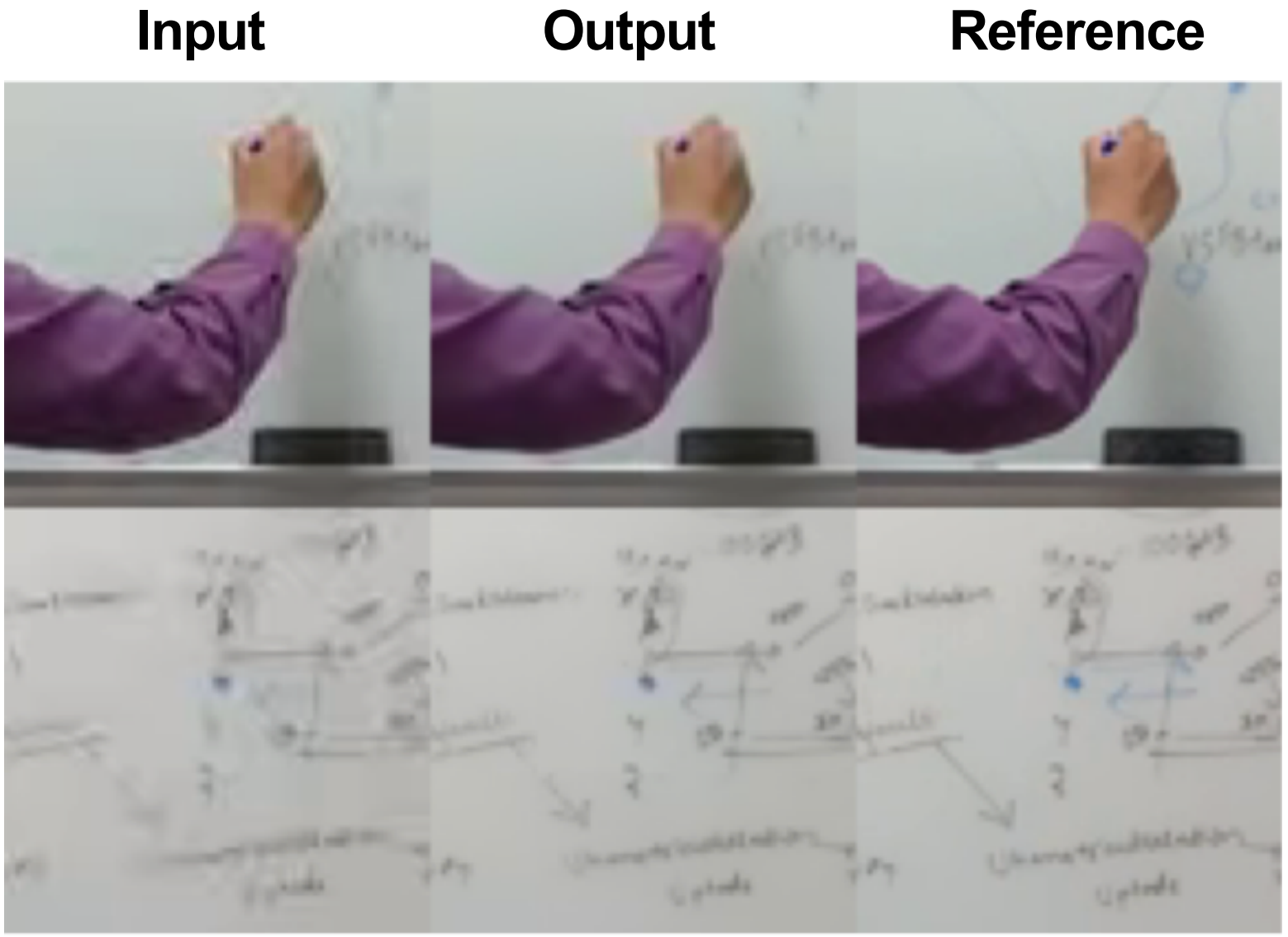


- **Up to 30%** bandwidth saving for the same PSNR
- Similar performance gain as **developing a new generation** of video codec



Performance Benchmark: Visual difference





Future Work

- **Evaluate real-world performance**
  - Collect large-scale, real-user dataset.
  - Evaluate user experience that includes processing delay in real system
- **More efficient inference**
  - Exploit inter-frame similarity based on motion estimation (from codec) or reuse part of NN
  - Knowledge distillation or model compression / quantization to speed up / fit in small RAM

Conclusion

- **Summary**
  - Dejavu leverage similarities across videoconferencing sessions to improve future video performance – **caching live content**!
  - Similar mechanism could be applied to a wide range of video streaming apps (like Twitch / Youtube) to improve quality or reduce CDN cost!
- **Future work**
  - Evaluate real-world performance
  - More efficient inference