# Popularity Prediction of Facebook Videos for Higher Quality Streaming

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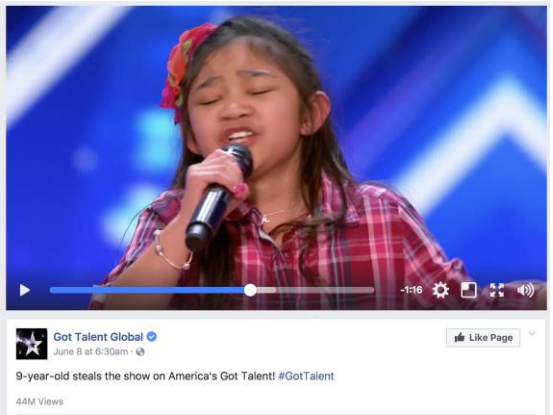
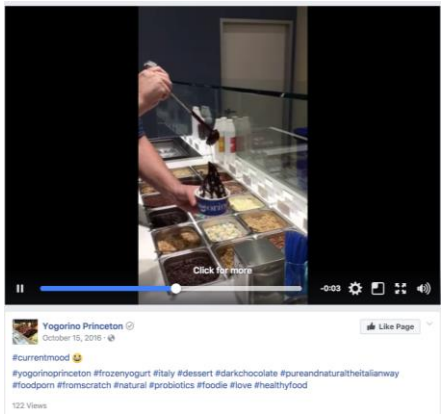
# Videos are Central to Facebook
## 8 billion views per day



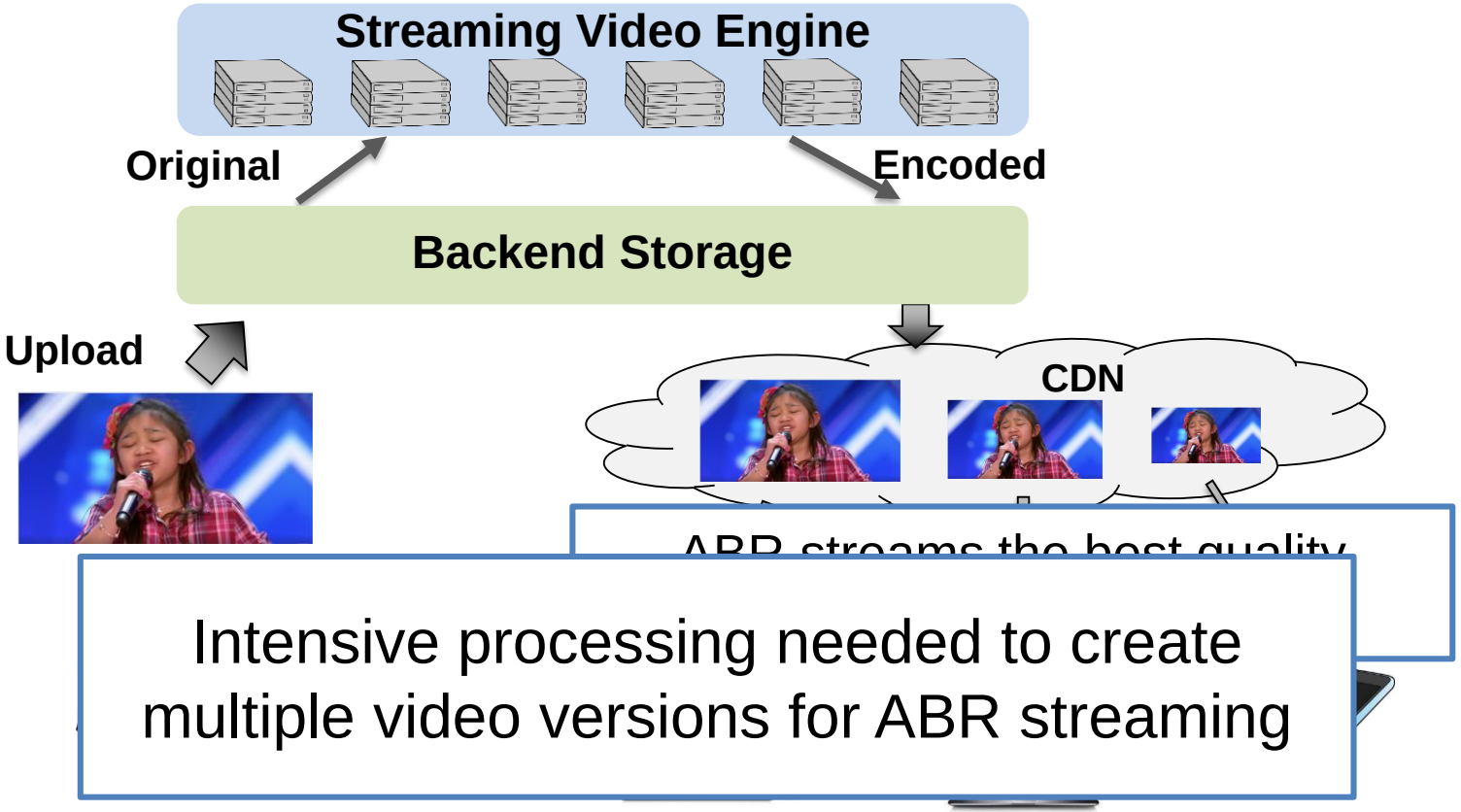

9-year old singing on America's Got Talent
44M views


Black bear roaming in Princeton
3.8K views




Small shop making frozen yogurt
122 views

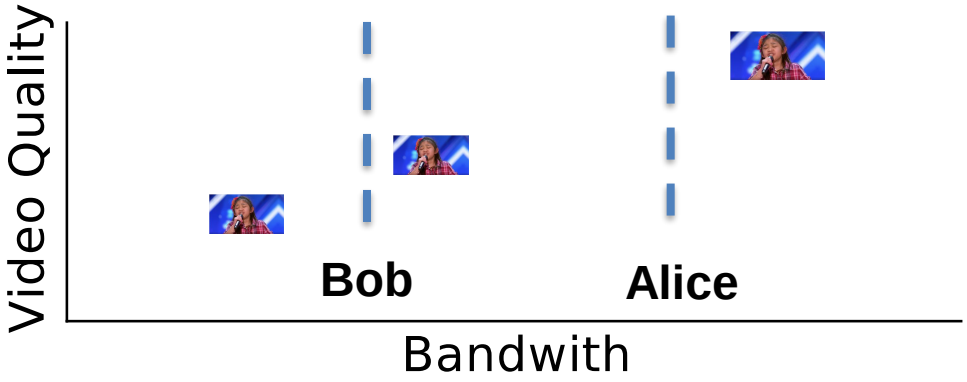
# Workflow of Videos on Facebook




Intensive processing needed to create multiple video versions for ABR streaming

# Better Video Streaming from More Processing

- Better compression at the same quality
- QuickFire: 20% size reduction using 20X computation
- More users can view the high quality versions



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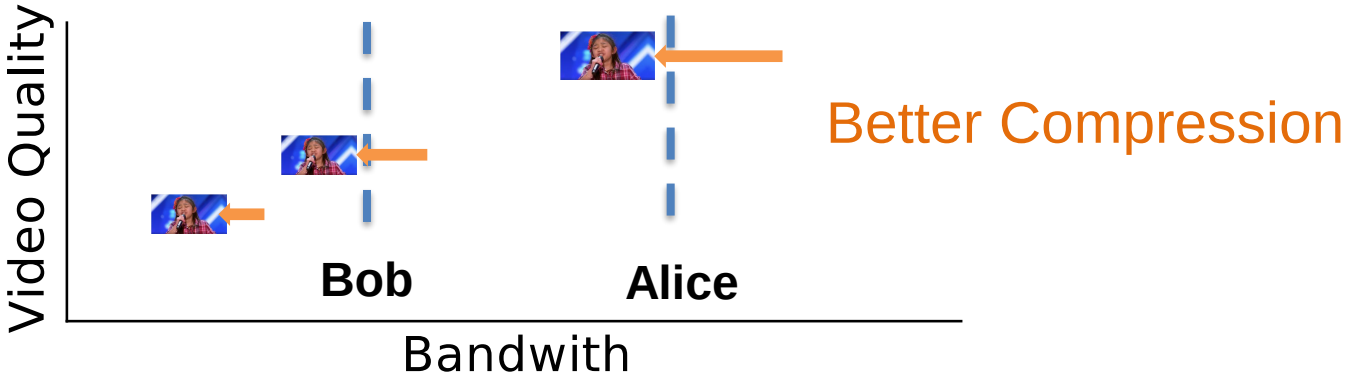


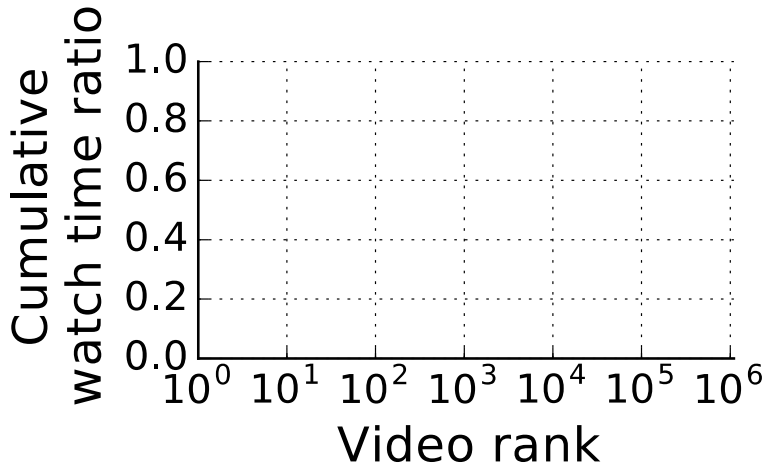
# How to apply QuickFire for FB videos

- Infeasible to encode all videos with QuickFire
  - Increase by 20X the already large processing fleet

- High skew in popularity
  - Reap most benefit with modest processing?

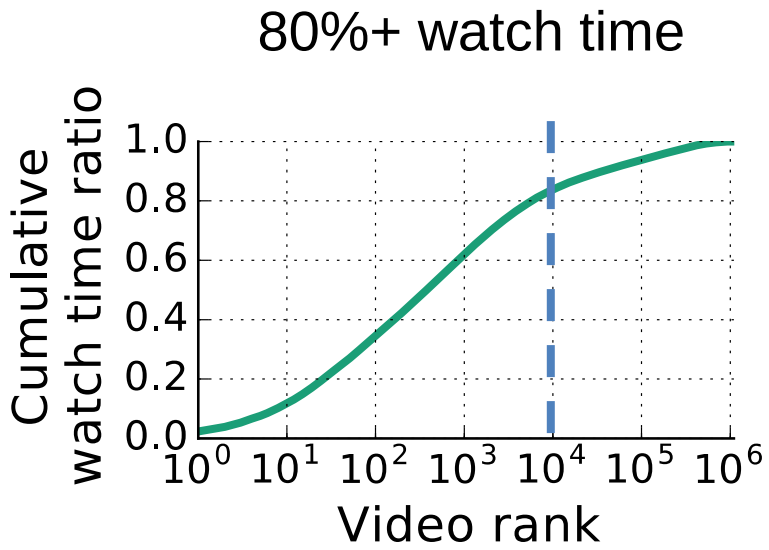
# Opportunity: High Skew in Popularity

- Access logs of 1 million videos randomly sampled by ID
- Watch time: total time users spent watching a video



# Opportunity: High Skew in Popularity

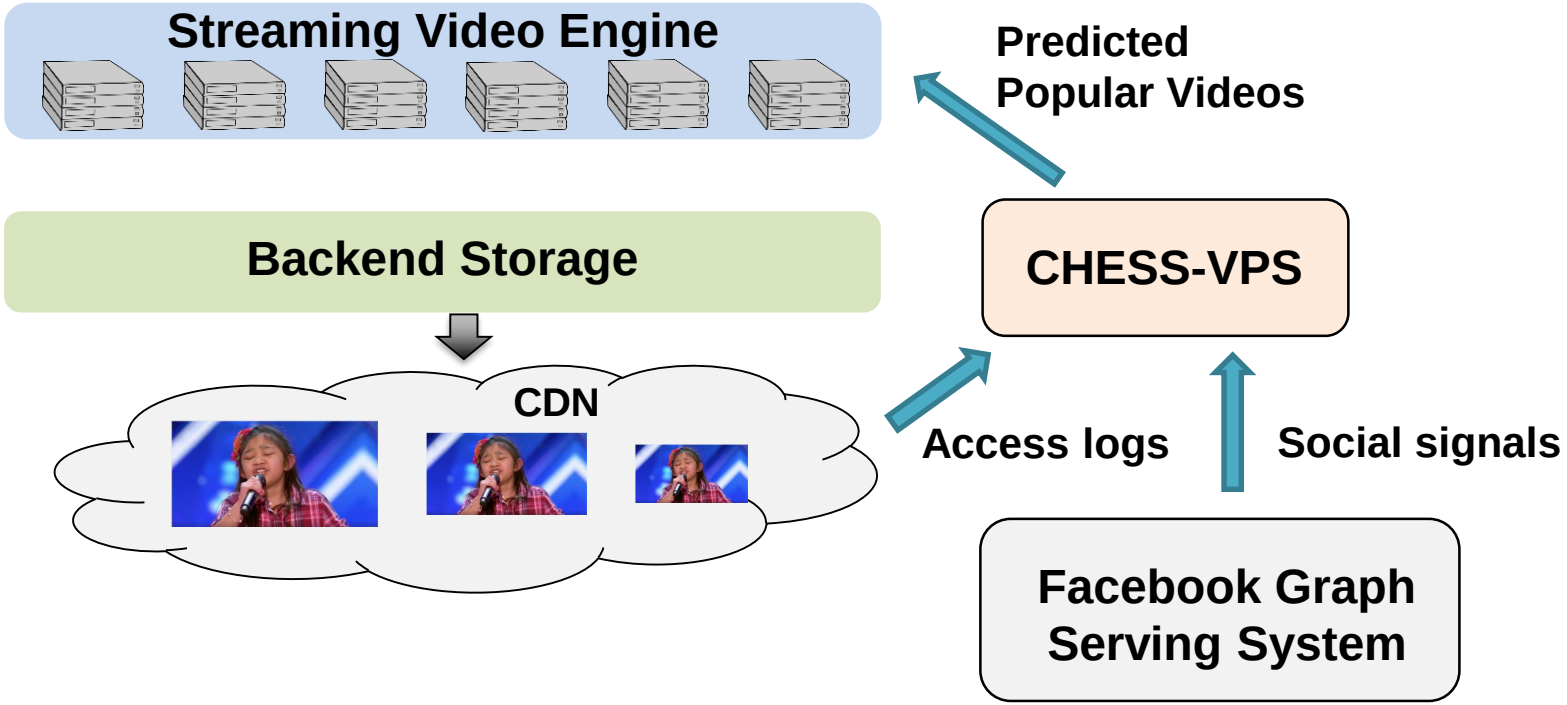
- We can serve most watch time even with a small fraction of videos encoded with QuickFire
- Can we predict these videos for more processing?



# CHESS Video Prediction System

- Popularity prediction is important for higher quality streaming
  - Direct encoding on videos with the largest benefit
- Goal of CHESS video prediction system
  - Identify videos with highest future watch time
  - Maximize watch-time ratio with budgeted processing

# CHESS Video Prediction System



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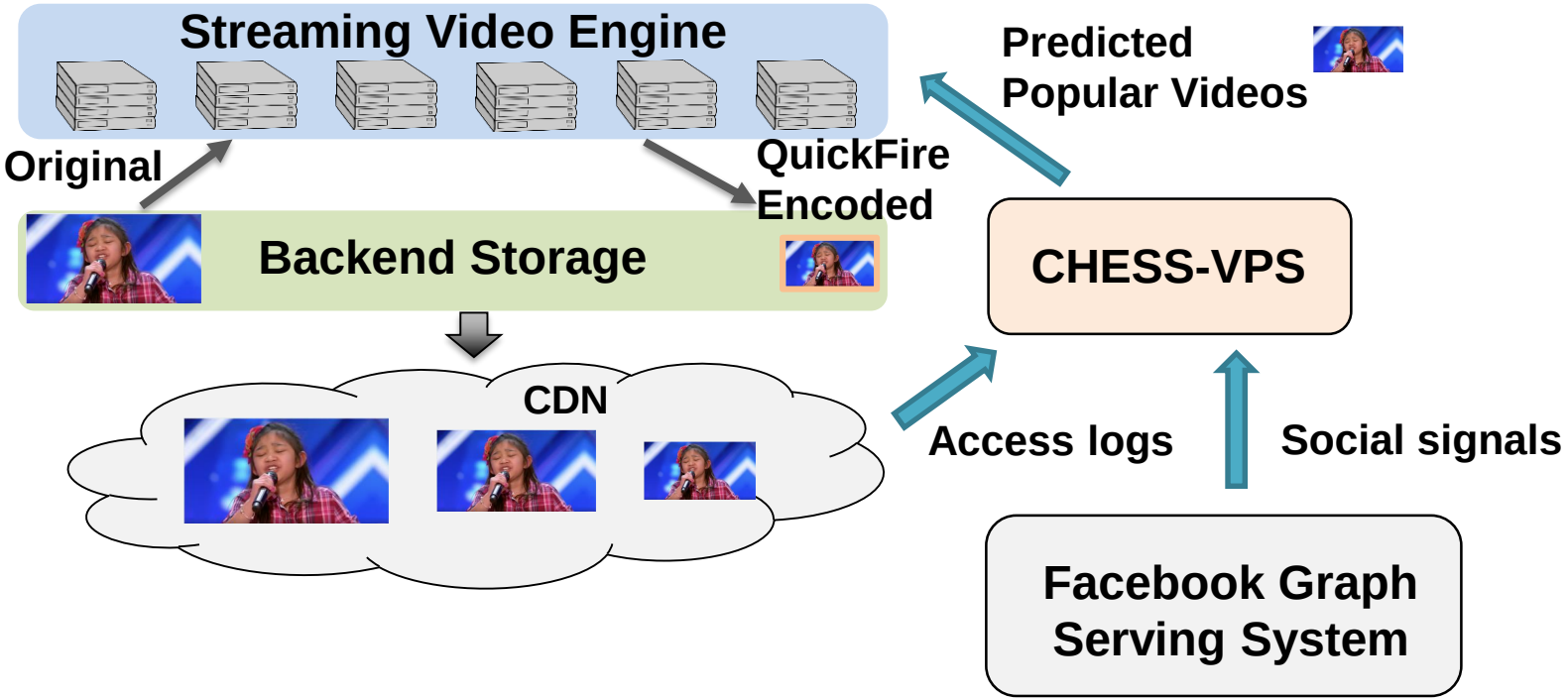

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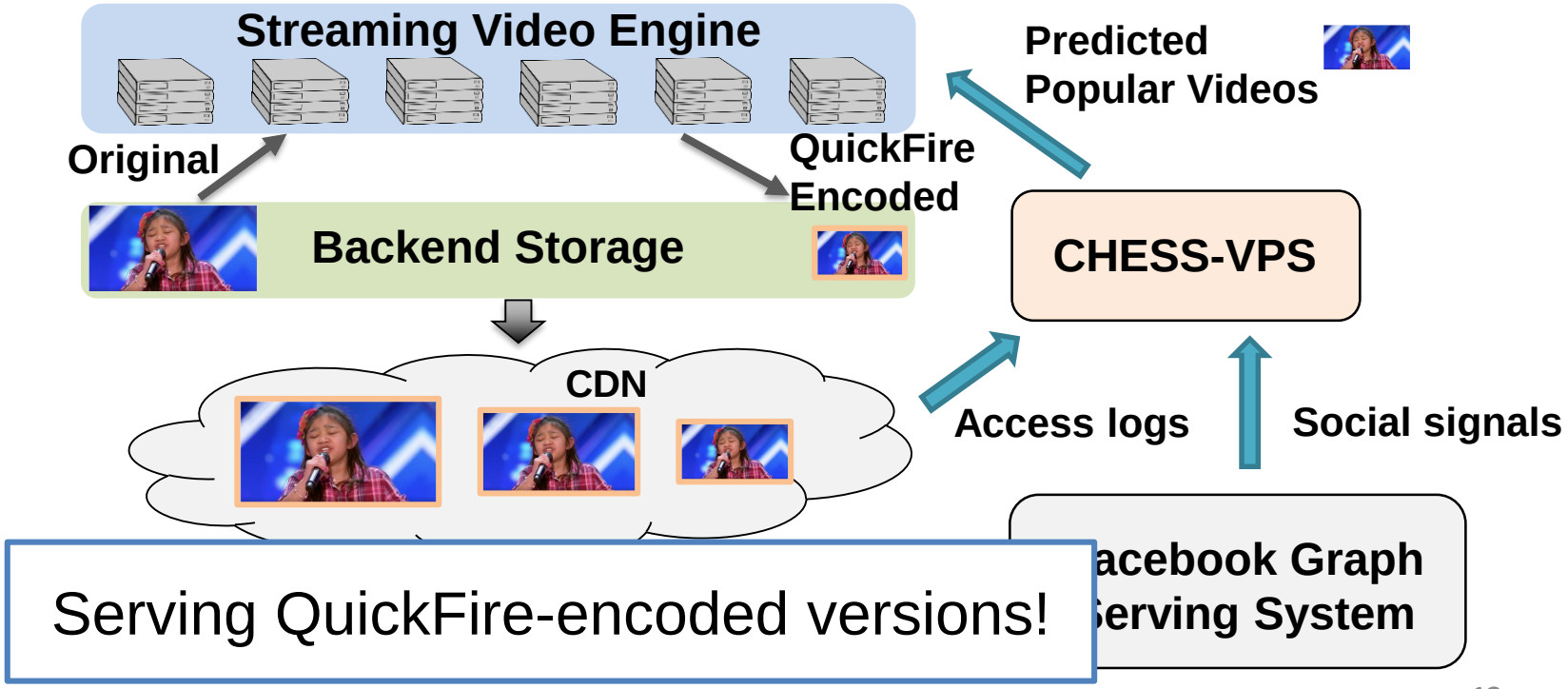


# Requirements of CHESS-VPS

- Handle working set of ~80 million videos
- Generate new predictions every few minutes

- Requires a new prediction algorithm: CHESS!

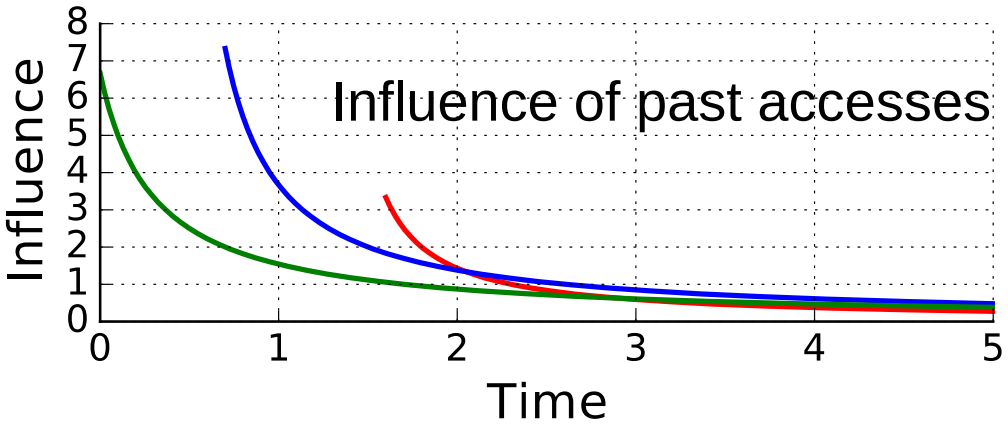
# CHESS Key Insights

- Efficiently model influence of past accesses as the basis for scalable prediction

- Combine multiple predictors to boost accuracy

# Efficiently model past access influence

- Self exciting process
  - A past access makes future accesses more probable, i.e. provides some *influence* on future popularity



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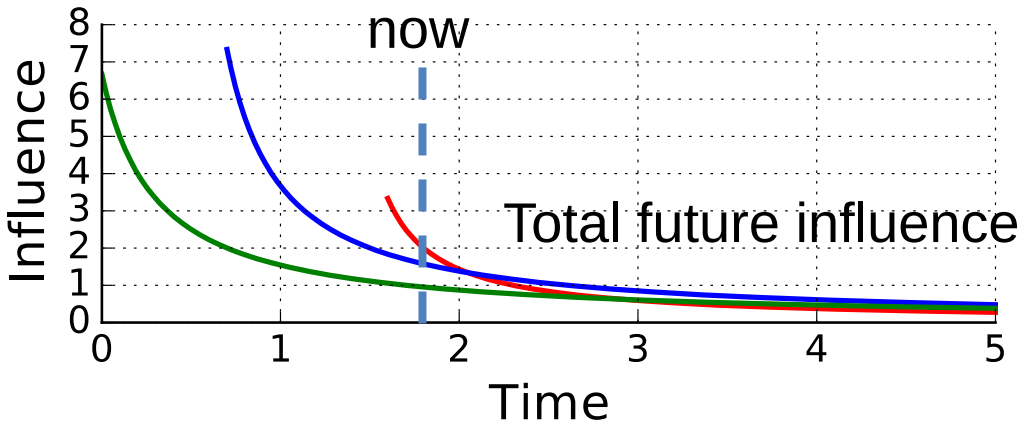
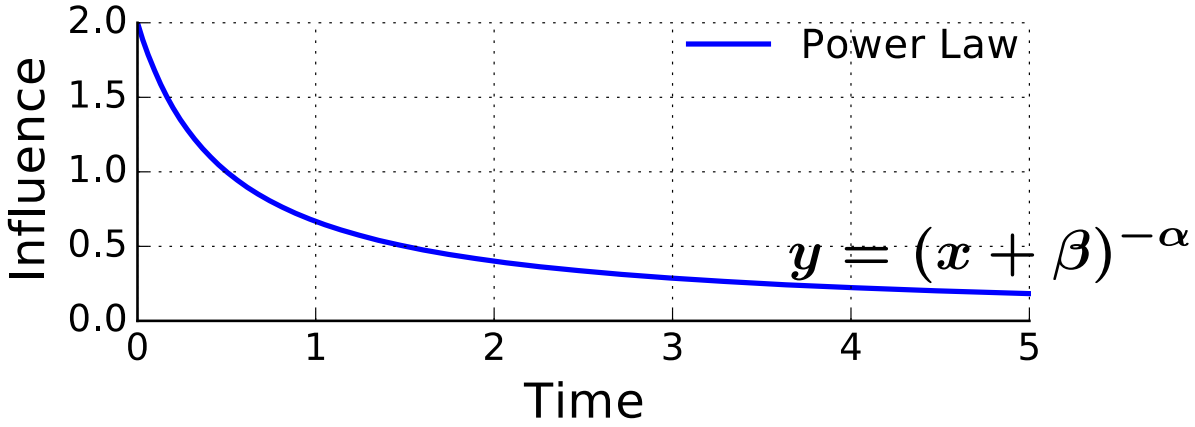
  - Prediction: sum up total future influence of all past accesses



# Efficiently model past access influence

- Influence modeled with kernel function
- Power-law kernel used by prior works
  - Provides high accuracy
  - Scan all past accesses, O(N) time/space not scalable



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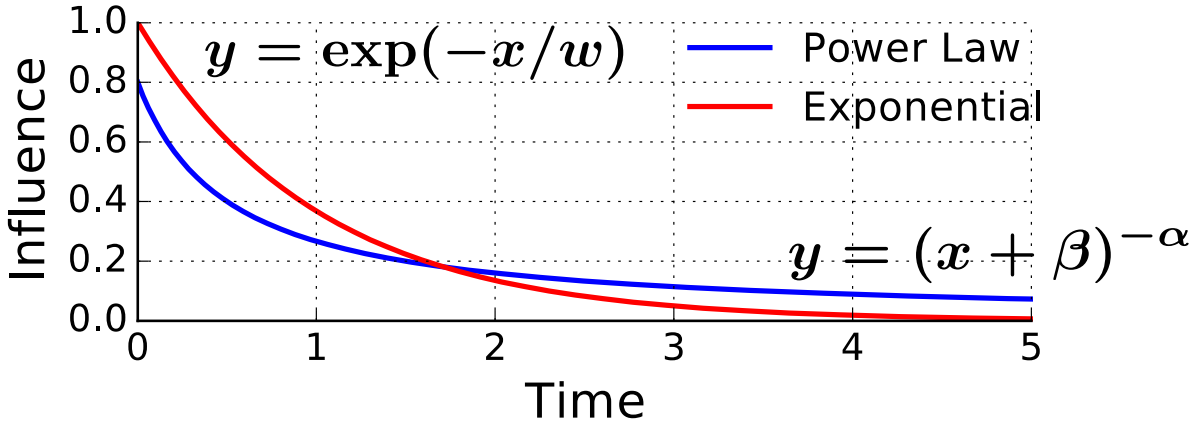
- Power-law kernel used by prior works
- Key insight: use exponential kernel for scalability



# Efficiently model past access influence

- Self exciting process with the exponential kernel

$$\tilde{F}(t) = \frac{x}{w} + \exp\left(\frac{-(t-u)}{w}\right)\tilde{F}(u)$$

*Current Access Watch-time* + *Exponential Decay* x *Previous Prediction*

# Efficiently model past access influence

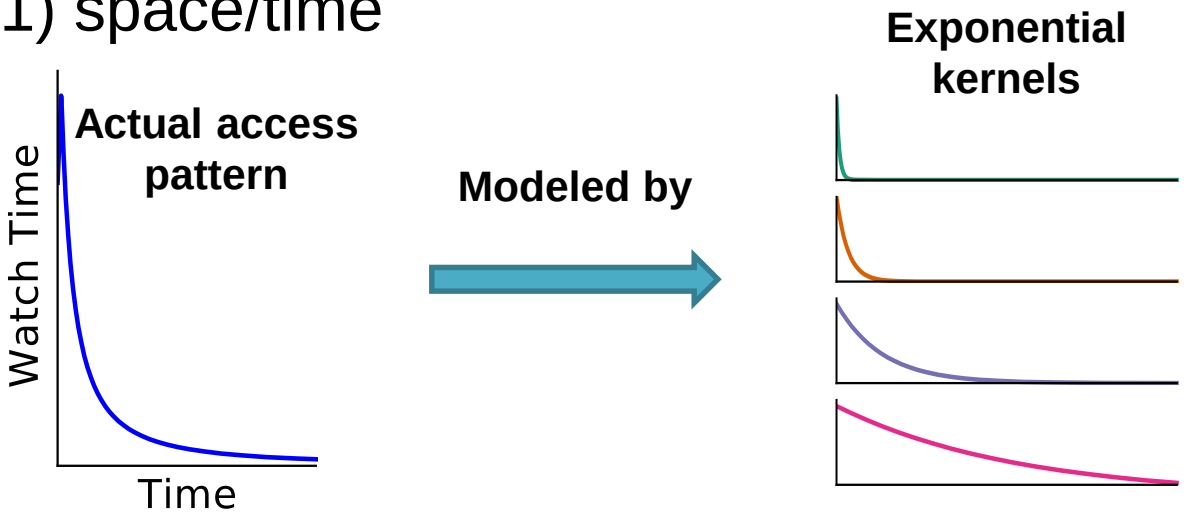
- Single exponential kernel is less accurate than power-law kernel
  - 10% lower watch time ratio

- O(1) space/time to maintain

Single exponential kernel is less accurate yet scalable

# Combining Efficient Features in a Model

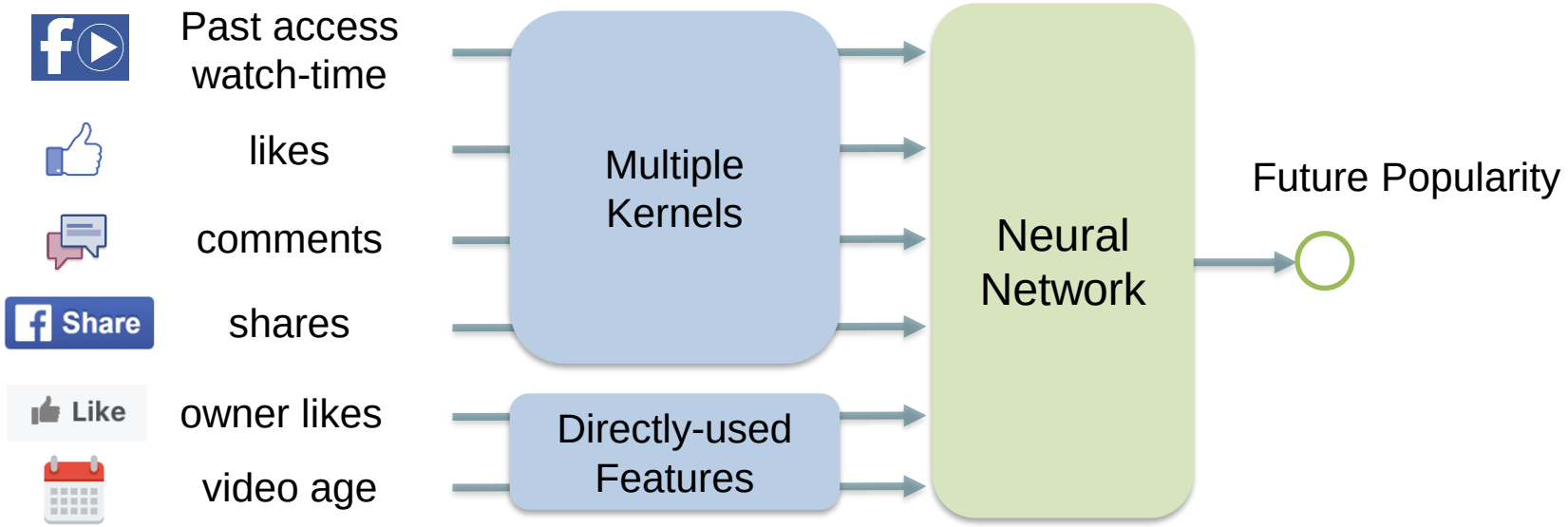
- Key insight: maintain multiple exponential kernels
- O(1) space/time




Combining multiple exponential kernels is as accurate as a power-law kernel

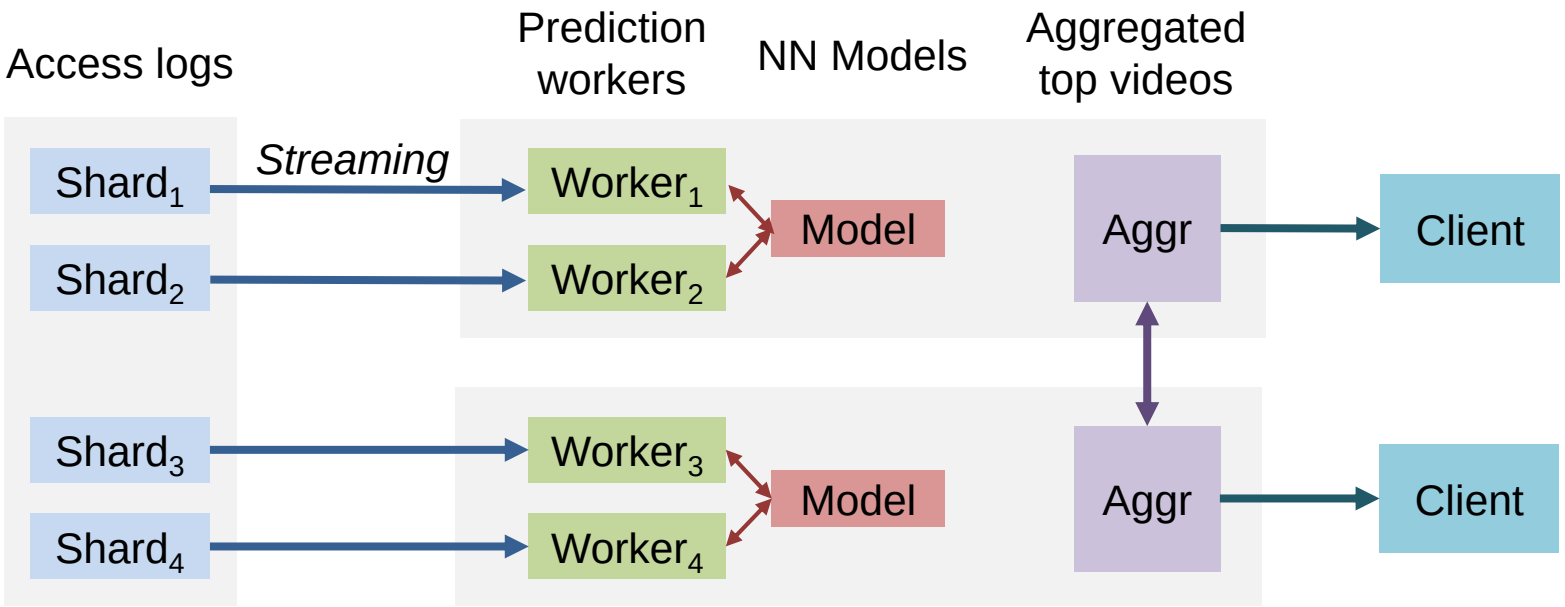
# Combining Efficient Features in a Model

## Raw features




Social signals further boosts accuracy

# CHESS Video Prediction System



# Evaluation

- What is the accuracy of CHESS?
- How do our design decisions on CHESS affect its accuracy and resource consumption?
- What is CHESS’s impact on video processing and watch time ratio of QuickFire?

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# Metrics

- Watch time ratio
  - Ratio of watch time from better encoded videos
  - Directly proportional to benefits of better encoding

- Processing time

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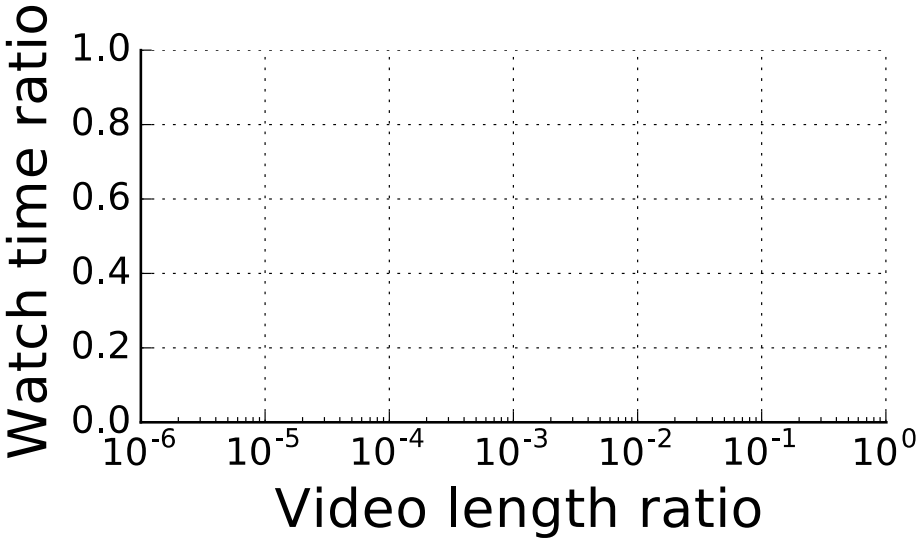
- Watch time ratio
  - Ratio of watch time from better encoded videos
  - Directly proportional to benefits of better encoding

- ~~Processing time~~ (infeasible to encode all videos)
  - Video length $\propto$ processing time
  - Video length ratio ≈ computation overhead

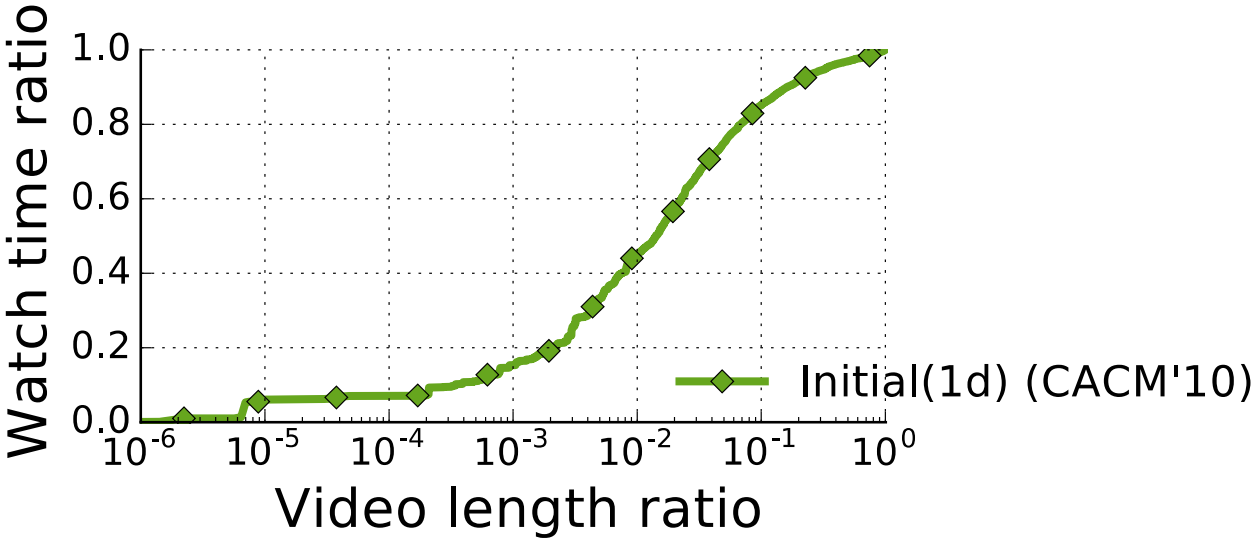
# CHESS is Accurate

- Vary video length ratio (proxy for processing overhead)
- Observe watch time ratio of better encoded videos



# CHESS is Accurate

- Initial(1d): initial watch time up to 1 day after upload



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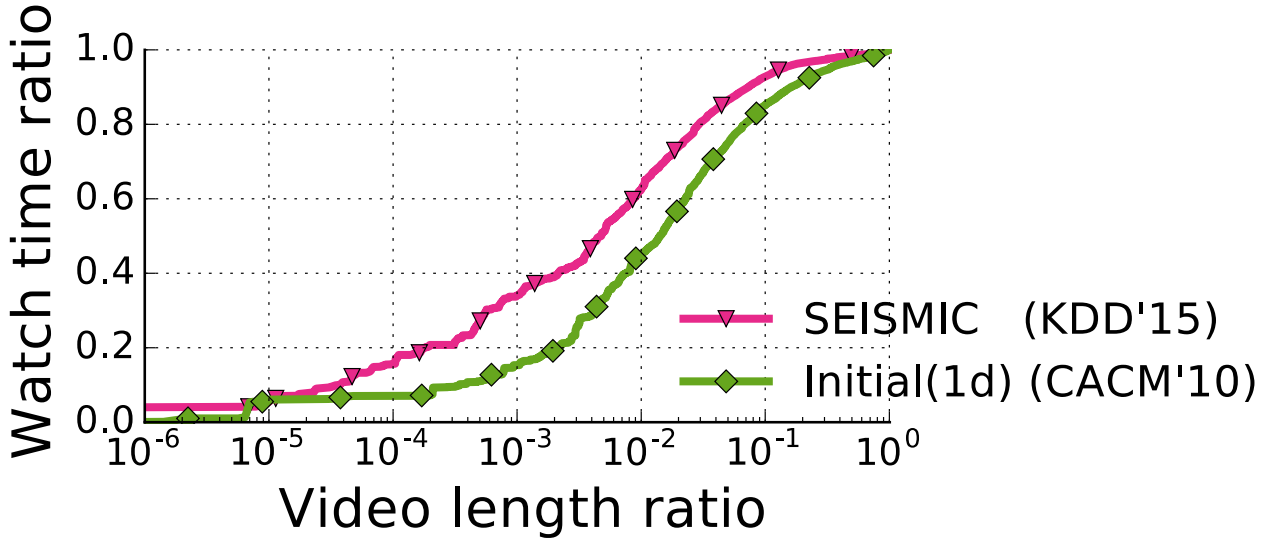
- SESIMIC: handcrafted power-law kernel



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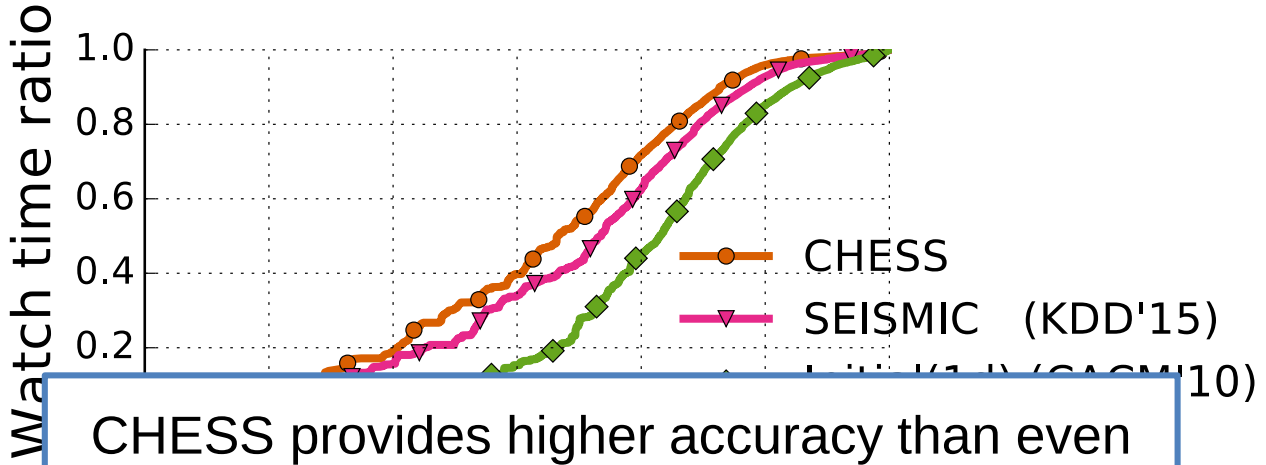
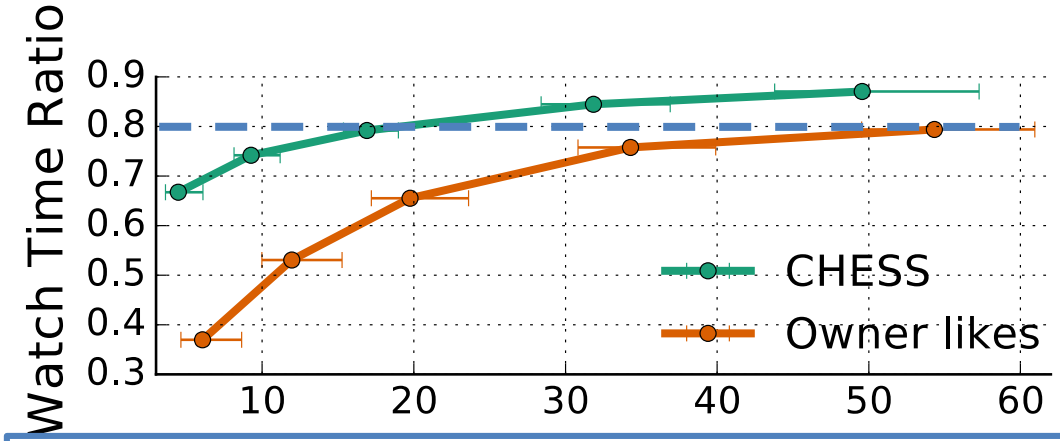



CHESS provides higher accuracy than even the non-scalable state of the art

# CHESS Reduces Encoding Processing

- Predict on whole Facebook video workload in real-time
- Sample 0.5% videos for actual encoding




CHESS reduces CPU by 3x (54% to 17%)
for 80% watch time ratio

# Related Work

## Popularity Prediction

Hawkes'71, Crane'08, Szabo'10, Cheng'14, SEISMIC'15

CHESS is scalable and accurate

## Video QoE Optimization

Liu'12, Aaron'15, Huang'15, Jiang'16, QuickFire'16

Optimize encoding with access feedback

## Caching

LFU‘93, LRU’94, SLRU‘94, GDS’97, GDSF‘98, MQ’01

Identify hot items to improve efficiency

# Conclusion

- Popularity prediction can direct encoding for higher quality streaming

- CHESS: first scalable and accurate popularity predictor
  - Model influence of past accesses with O(1) time/space
  - Combine multiple kernels & social signals to boost accuracy

- Evaluation on Facebook video workload
  - More accurate than non-scalable state of the art method
  - Serve 80% user watch time with 3x reduction in processing