

Understanding Throughput Stability and Predictability to Enable Better ~~Video~~ QoE

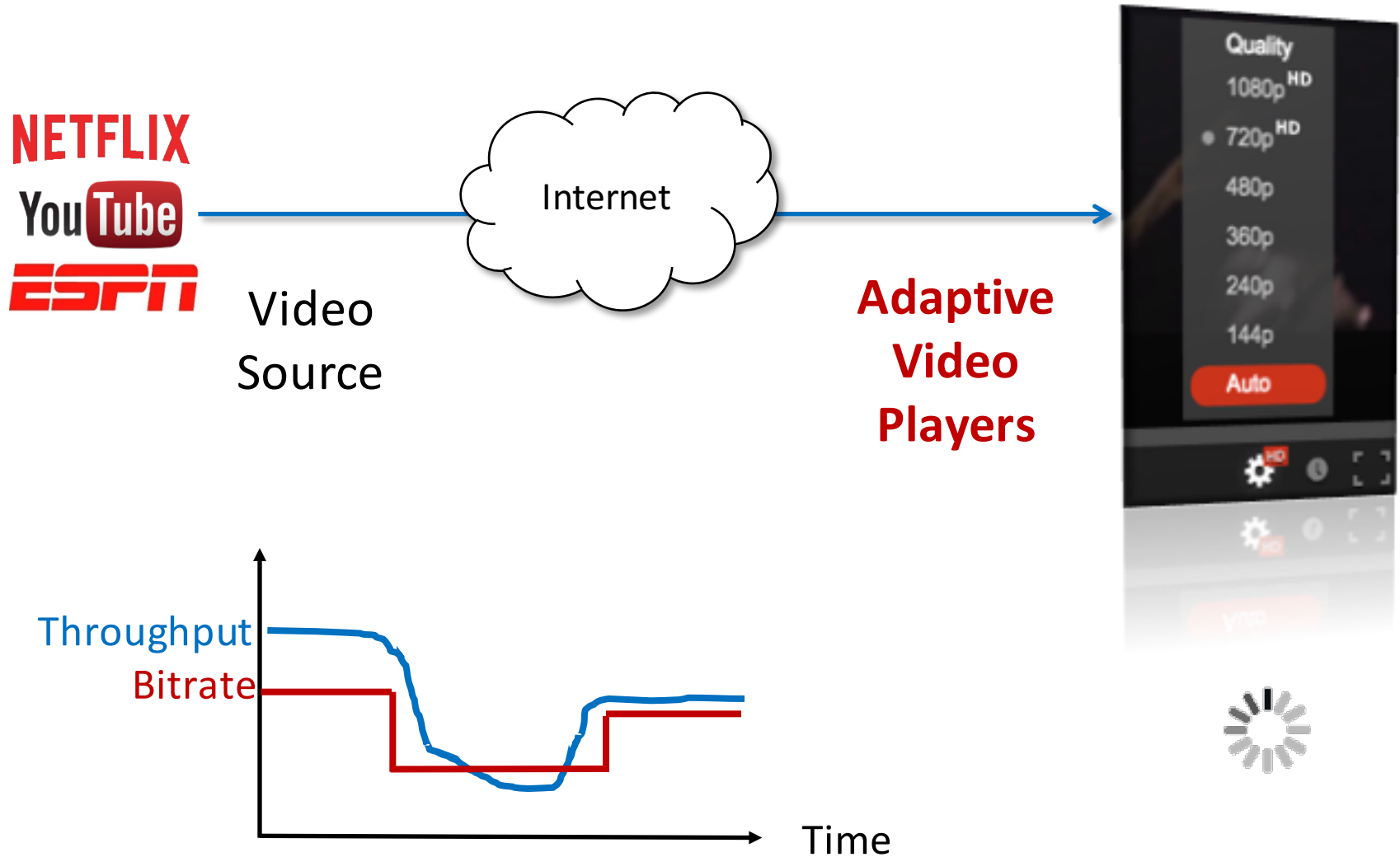
Vyas Sekar

Joint with:

Xiaoqi Yin, Junchen Jiang, Bruno Sinopoli, Hui Zhang

Carnegie Mellon

Dynamic Adaptive Streaming over HTTP (DASH)



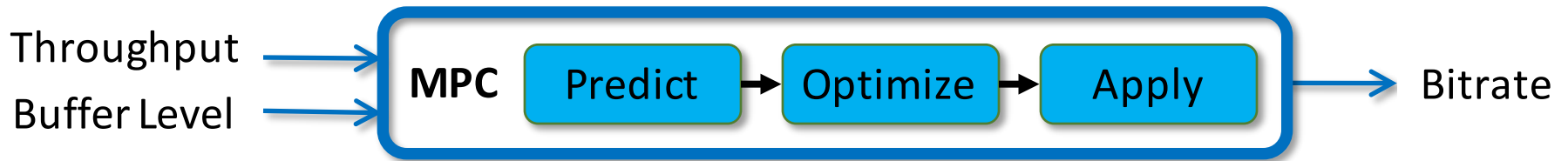
Designing DASH algorithms is hard

- Weird interactions with TCP [1]
- Various factors can impact QoE
 - Often in conflict, e.g., high bitrate vs. few stalls
- Discrete feedback and control
 - Discrete bitrate levels
 - Change bitrate only in discrete time

A control-theoretic approach [Sigcomm' 15]

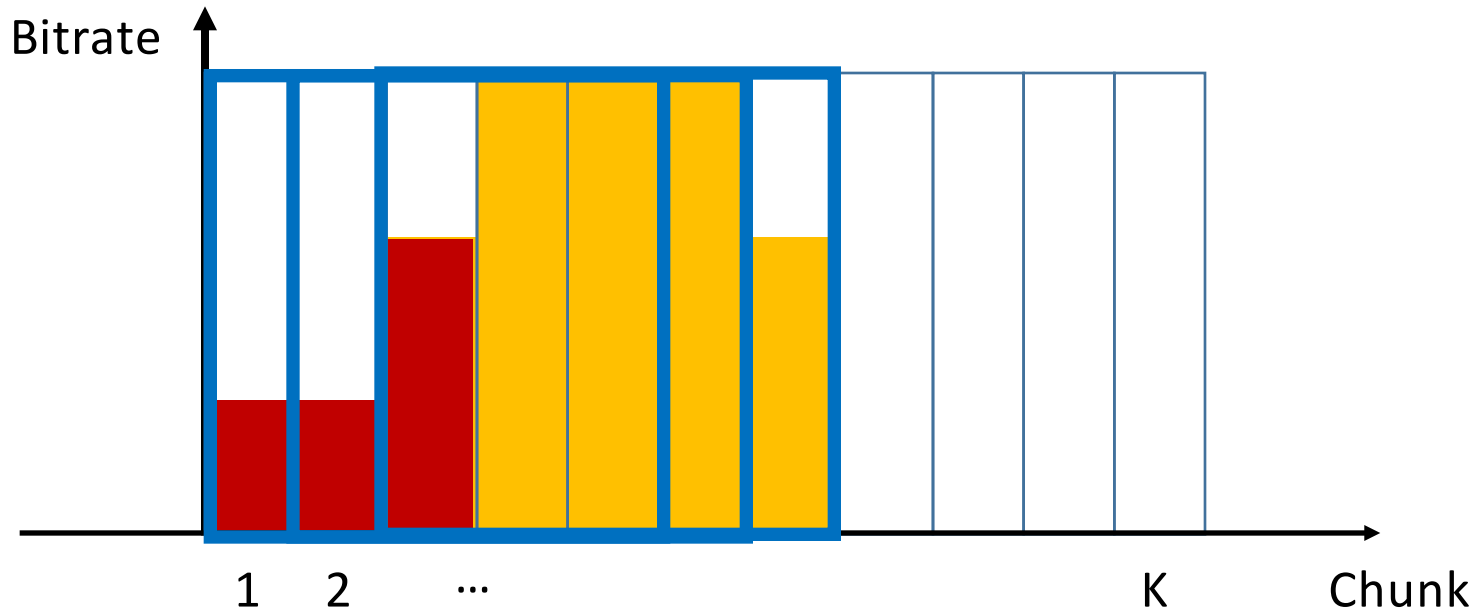
- **Develop a principled framework**
 - Modeling DASH as a control-theoretic problem
 - Shed light on
- **Design better algorithm: Model Predictive Control (MPC)**
 - MPC algorithm is a natural choice
 - Combine throughput and buffer information
- **Implement MPC in practice**
 - Fast and robust MPC implementation in DASH.js
 - Code + Demos
<http://users.ece.cmu.edu/~vsekar/mpcdash.html>

Using Model Predictive Control (MPC)

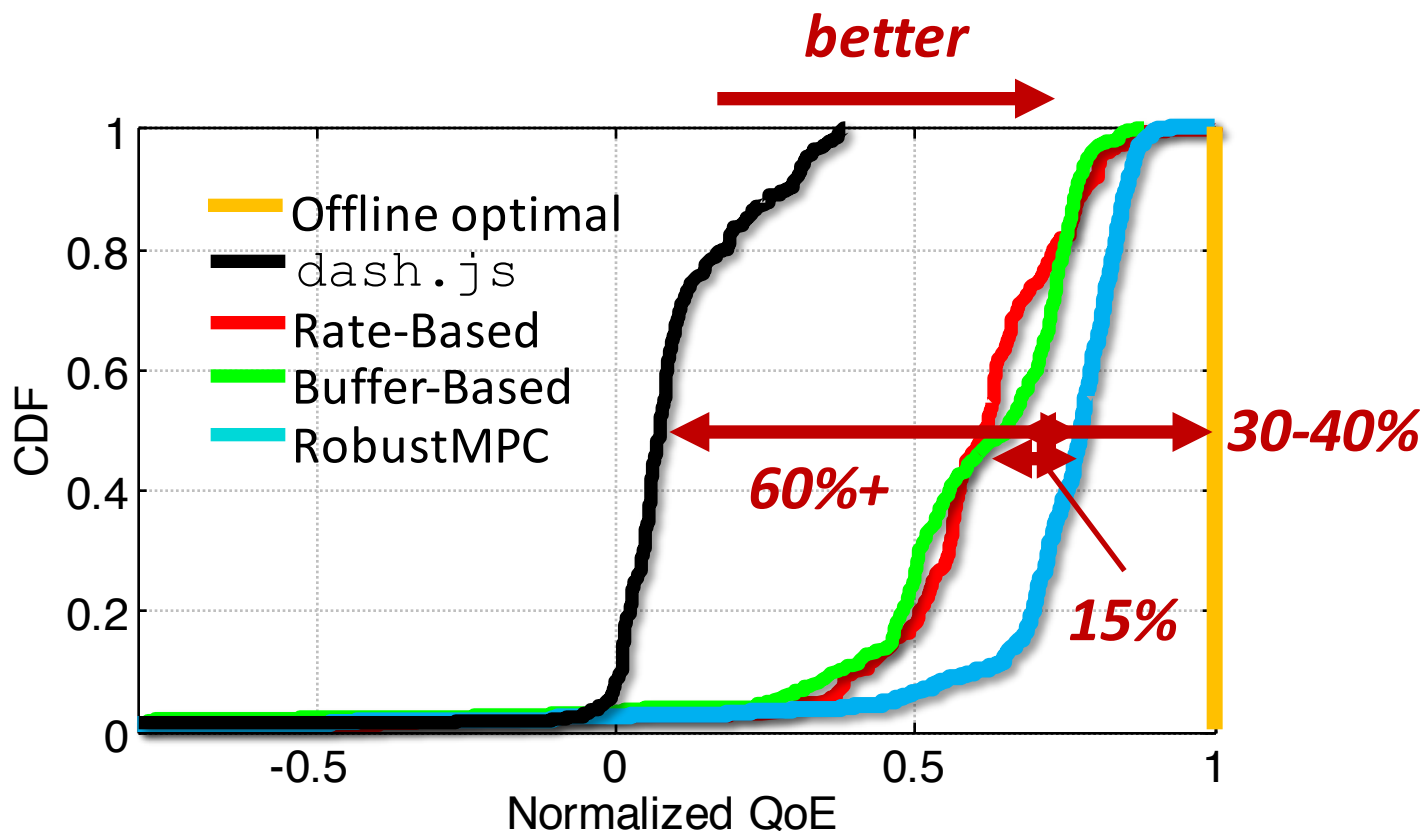


B. Apply Downward optimization for next N chunks forward

- Solve a MILP using commercial solver (e.g., CPLEX)



QoE in broadband trace



1. Room to improve: **30-40%**
2. RobustMPC vs. dash.js: **60%+** median QoE
3. RobustMPC vs. state-of-art: **15%** median QoE

What have we learned from this process?

- Throughput predictability can help
 - E.g., Picking initial bitrate
- Understanding throughput stability can help
 - E.g., when to use buffer vs rate vs hybrid?
- Need better prediction models
 - E.g., Harmonic mean vs. Something else?

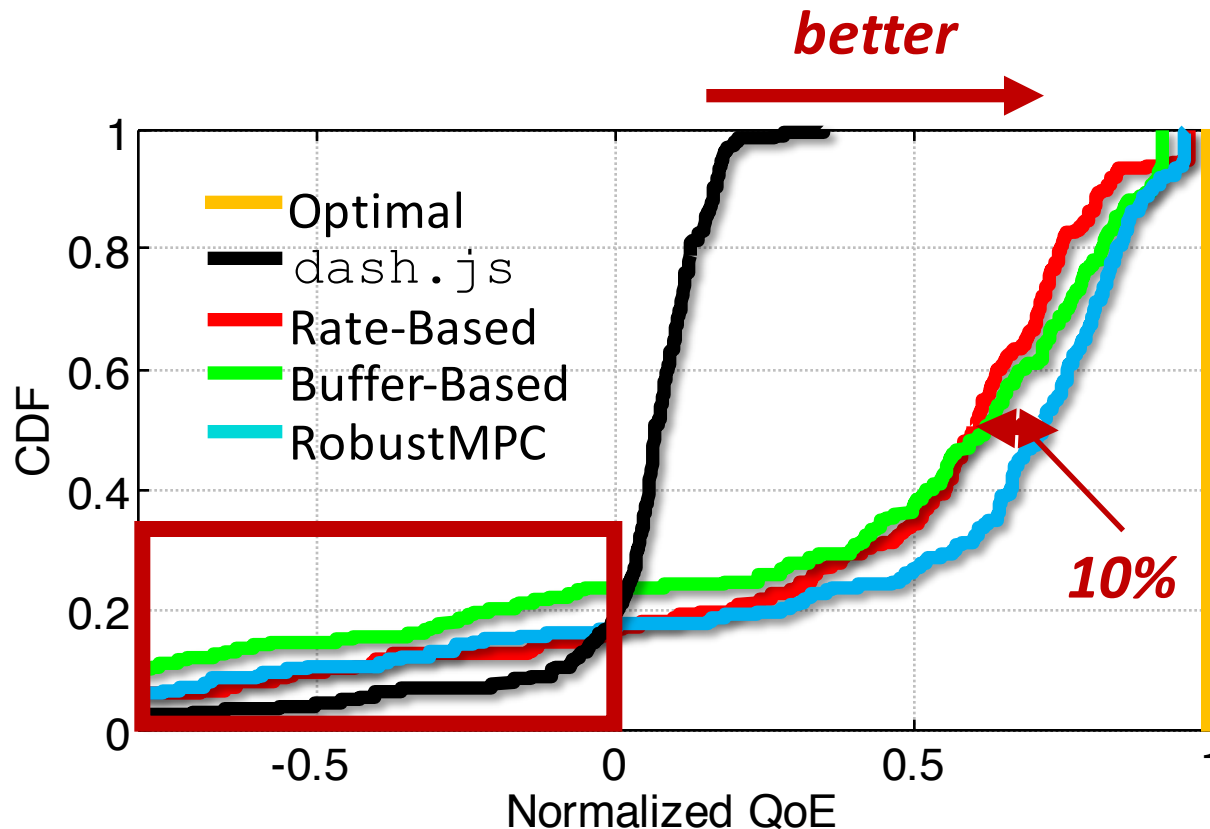
Our “rallying cry” ...

- There is very little understanding of these issues!
- Closest work we know of is dated/limited in scope
 - E.g.,
 - Balakrishnan et al Analyzing Stability in WideArea Network Performance. In *Proc. ACM SIGMETRICS*, 1997
 - Zhang and Duffield. On the constancy of Internet path properties. In *IMW*, 2001.
 - He et al., On the predictability of large transfer TCP throughput. In *Proc. ACM SIGCOMM*, 2005.
- How can we shed light on these problems?
 - Measurement data (E.g., Comcast, Netflix?)
 - Active measurements (E.g., FCC MBA)
- Community effort to create “models” and “datasets”

Conclusions

- Designing DASH algorithms is important and hard
- Model-Based Throughput Prediction
 - ➔ QoE improvements for video streaming
- What we need: Better understanding of
 - throughput predictability
 - throughput stability
 - throughput “estimation” algorithms
- ➔ Need a broader community effort
- ➔ Likely useful for other apps beyond streaming!

Does Robust MPC work well in cellular trace?



1. RobustMPC vs. dash.js: **60%+** median QoE
2. RobustMPC vs. state-of-art: **10%** median QoE
3. Variability is too high -> fixed low bitrate is best