A Novel Framework For Scalable Video Streaming Over Multi-Channel Multi-Radio Wireless Mesh Networks

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Outline

- Motivations & Challenges
- Background and Related Work
- Problem Formulation
- CAIRoQS Heuristics
- Performance Evaluation
- Conclusions

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Motivations

- Advances in communication technologies make wireless mesh networks (WMNs) a viable infrastructure for new services
- Video is becoming an element of many applications
- Use Case: transfer museum audio guides to video-based guides on personal smartphones for a better personalized user of experience.

Challenges

- Video is a resource demanding application
- Wireless environment is a challenged by variable channel conditions and interference.
- Enabling Technologies
  - Multicast: can help reducing demand on network resources
  - Scalable video coding represents a flexible encoding

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Background & Related Work

- Video streaming solutions in WMNs
  - Video over contention-free MAC
  - Video over contention-based MAC
- Contention Free MAC
  - [12] maximizes video quality of a multicast tree under transmission energy and channel access time constraints for a single-hop wireless network.
  - [16] maximizes the achievable rate of heterogeneous receivers for a multi-channel multi-radio TDMA WMN.
  - [18] proposes a video multicast framework over TDMA WMNs using SVC with heterogeneous user demands.

Background & Related Work

- Contention-based MAC
  - [9] maximizing the visual quality of an SVC multicast group by performing rate scheduling scheme that assigns each video layer a rate according to dependency between layers.
  - [14] minimizes the total video distortion of all receivers without incurring excessive network utilization.

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System Model

- Two-tier WMN for backbone and user access.
- Multi-radio multi-channel mesh routers
- Contention-based MAC over K orthogonal channel
- Wireless links between WMN routers have capacity C
- Multiple SVC videos are multicasted to end users from a single gateway

General Problem Formulation

- Maximize (received video quality)

  st

  channel assignment constraints

  Multicast Routing constraints

  traffic flow constrains

- The problem is shown to be NP hard
- A three-stage heuristic framework is developed for channel assignment, routing, and video quality control.

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CAIRoQS Framework

- Channel Assignment with Iterative Routing and Quality Selection (CAIRoQS) is a three stage solution
  - First: greedy orthogonal channel assignment to minimize the overall interference between the network links.
  - Second: optimizing the quality of streamed videos assuming the gateway to be the main network bottleneck.
  - Third: the multicast trees of different streams are iteratively identified
- The second and third stages are performed iteratively if the proposed routing algorithm identifies a new bottleneck in the network

Channel Assignment

- Objective: assign K channels to the WMN links to minimize the interference

1)Construct conflict graph for WMN links

2) Initialization: assign channels to the gateway interface

3)Channels are sequentially assigned in two steps: select and assign

  - **SELECT** the link with the largest number of interfering links.
  - **ASSIGN** channel k that has the least interference with neighboring links

Video Quality Selection

- Objective: Maximize the video quality by streaming a subset of layers from different videos
- The problem is modelled as a linear program

  max (sum rates of all layers of streams)

  s.t. layer dependency constraint

  total rate < bottleneck capacity
- We initially assume that the main system bottleneck capacity is at the gateway.

Multicast Routing with Ranked Links Algorithm

- Objective: identify a multicast tree for every stream (WMN gateway → all stream receivers)
- Combined routing cost metric as the product of
  - Link discouragement factor: lower for links serving more receivers
  - Link congestion factor: lower for lightly loaded links
- Each tree is created in a sequential manner
  - Identify shortest path to every receiver
  - Select the link that is shared among more receivers
  - Update link utilization and traffic load vector
  - If a new receiver is connected, trim non-terminated links and loop

Multicast Routing with Ranked Links Algorithm

- In case of all zero ranks → an in-network bottleneck
  - Update the maximum system capacity accordingly and repeat stage 2 and 3.
- Continue sequentially with all trees

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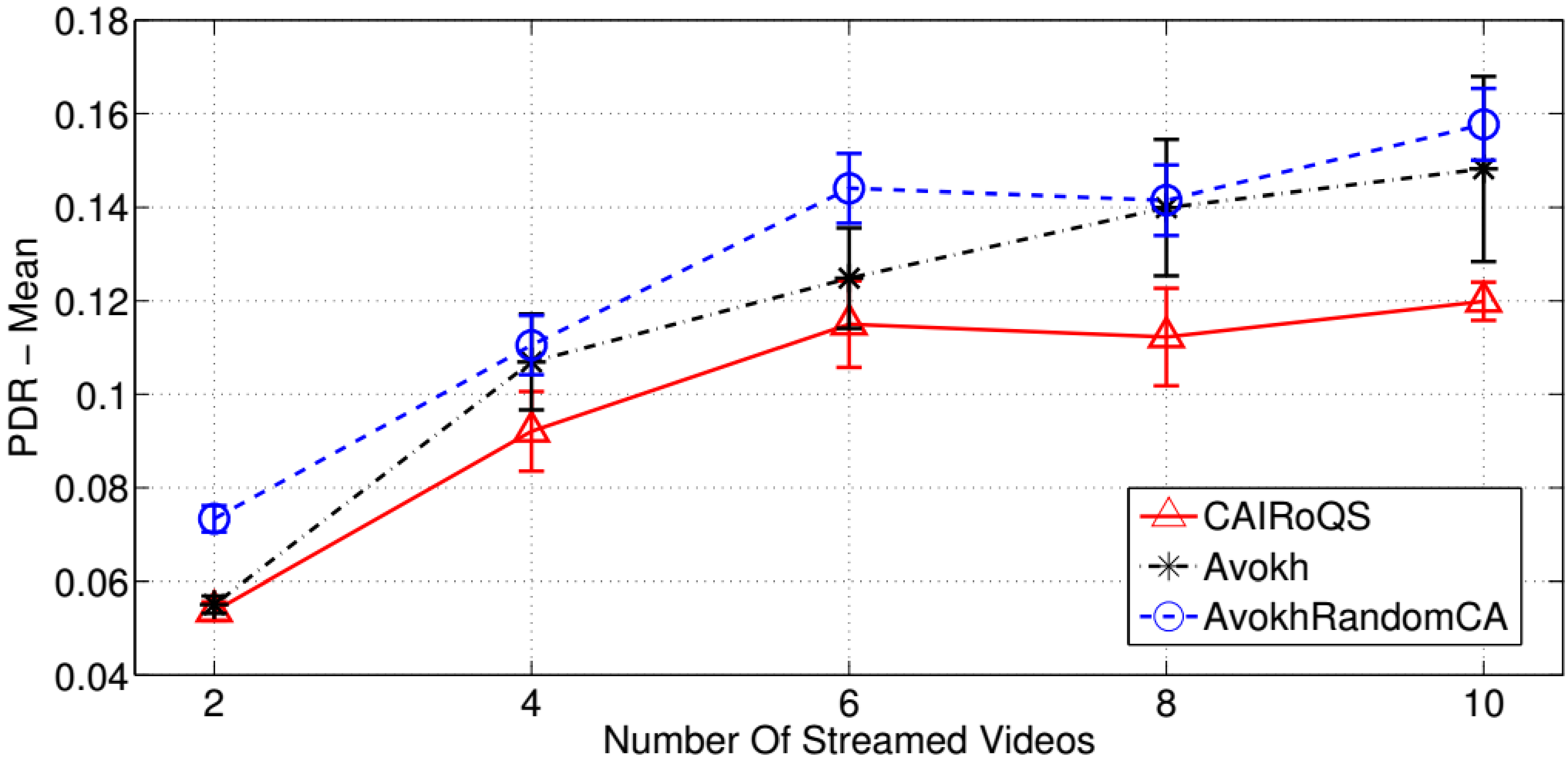
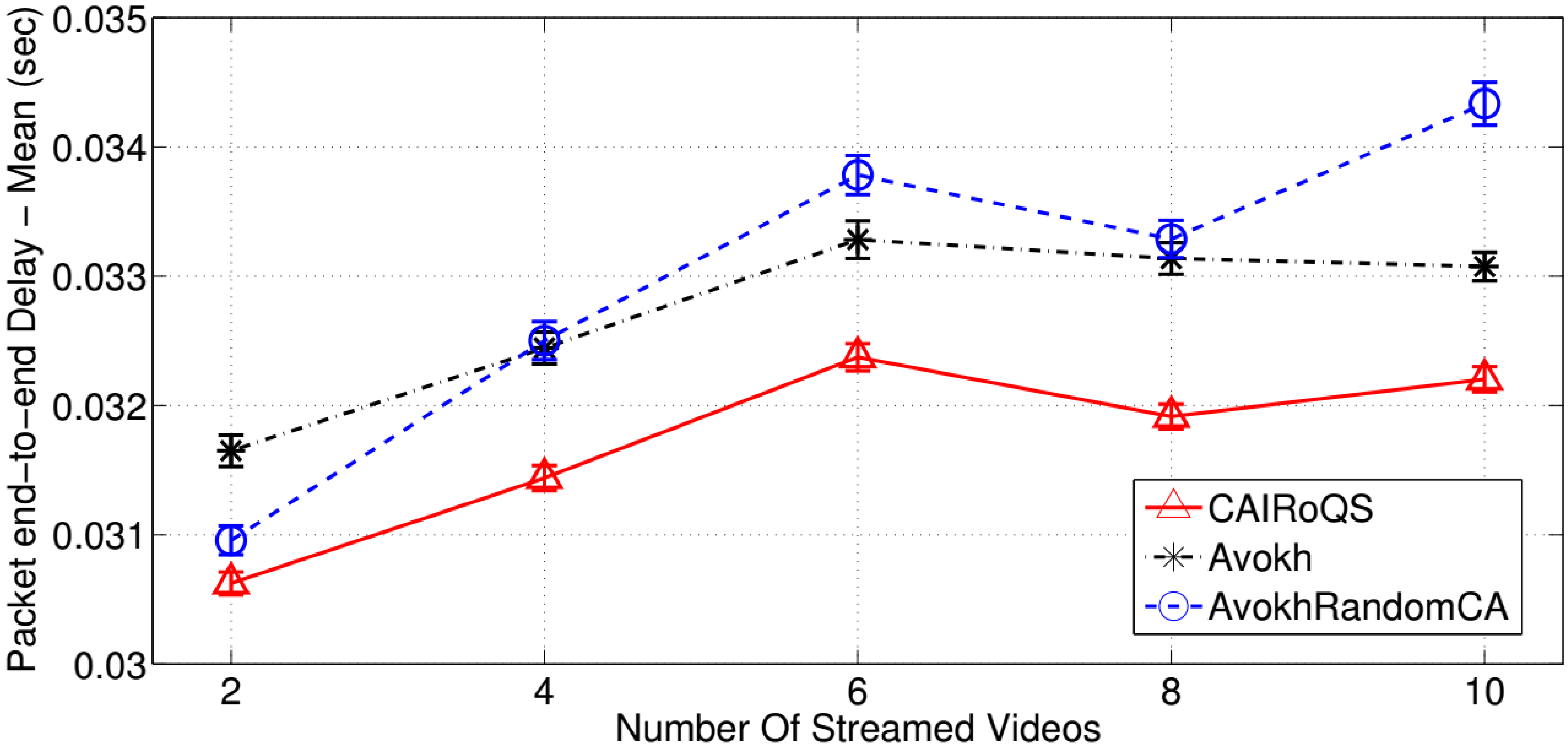
Evaluation Setup

- n * n grid of multi-channel multi-radio WMN in NS2.35
- NS2.35 is extended to support the proposed centralized multicast routing
- Each mesh router is equipped with 4 radios (3 backbone + 1 access)
- Backbone and access operate in different frequency ranges.
- Interference range twice the transmission range
- Mesh router links bit-rate of 30Mbps for each radio and a two ray propagation model.
- HD video sequences are encoded using JSVM at HD, 4CIF, and CIF with 30fps.
- CAIRoQS is compared with Avokh
- GUROBI library is used to solve optimization programs

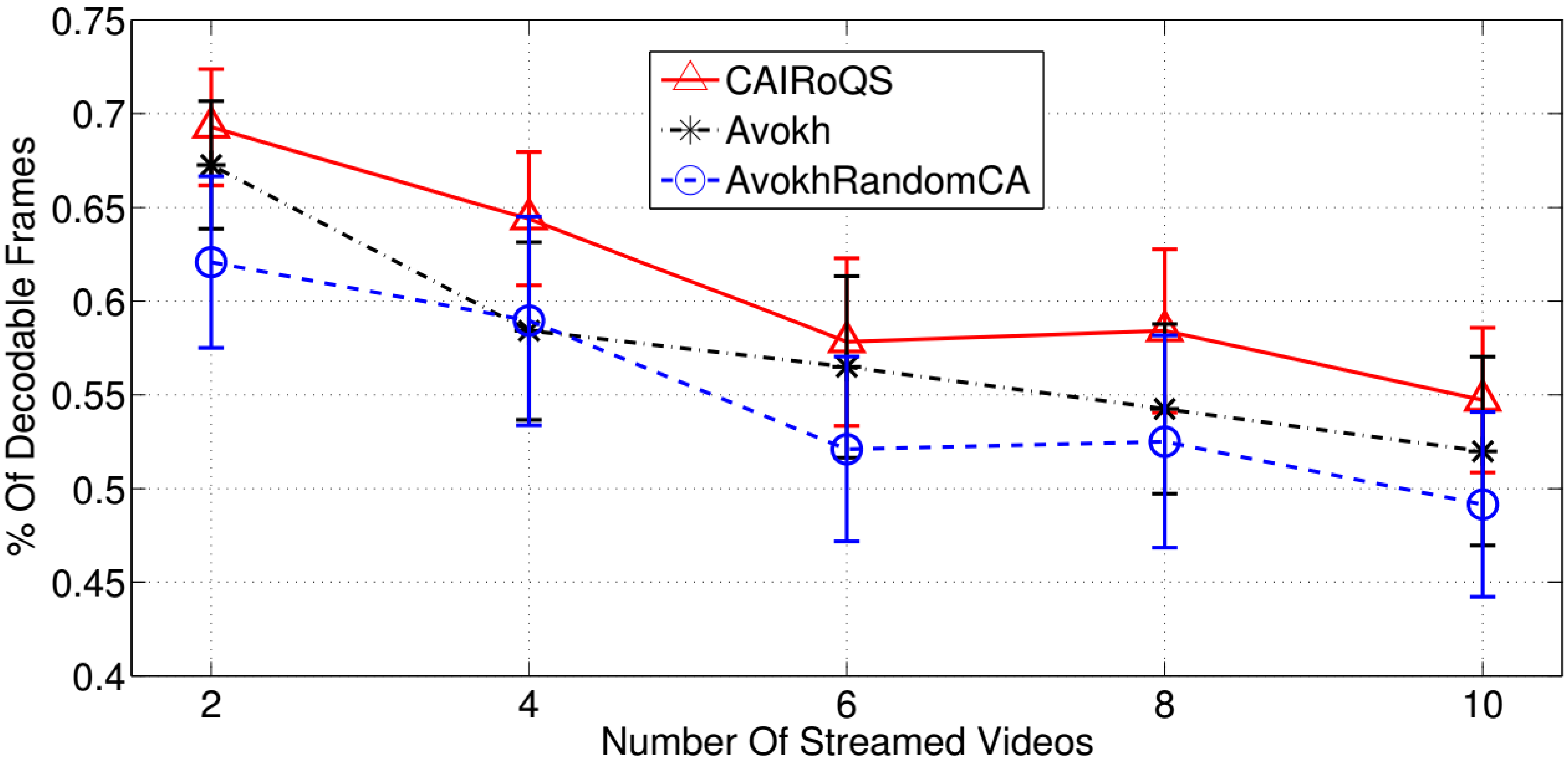
Packet Dropping Ratio



Packet End-to-End delay



Decodable frames



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Conclusions and Future Work

- The pervasiveness of video, smart devices and advanced technologies enables the development of new video services.
- The problem of joint channel assignment, multicast routing and quality selection is NP-hard.
- CAIRoQs is a promising framework for the combined problem of SVC multicast over multi-channel multi-radio WMN.
- As a future work, we consider changes the heuristics to increase the percentage of decoded frames.

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Received Video Quality