Broadcasting Video in Dense 802.11g Networks Using Application FEC and Multicast

Project Update

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All project material, including papers and tools, are locations at: http://www.cs.clemson.edu/%7Ejmarty/projects/WiFi/CiscoWiFi.html

Review of the Project Objectives

- The proposed research will provide theoretical and simulation-based results that will help the academic community better understand the feasibility, limitations, challenges and possible solutions surrounding large-scale deployment of video broadcast in extremely dense 802.11 deployments when using modern handheld devices and state-of-the-art application coding strategies.
- Research objectives: This research proposal provides theoretical and simulation-based results that will be used to better understand the feasibility and limitations of large-scale deployment of video broadcast in extremely dense 802.11 deployment. Emerging Sports and Entertainment venues are the motivating application domain. The intellectual merit of the study goes beyond simply assessing the capabilities of current state-of-the-art deployments: we seek to develop and evaluate improved protocols and practices that support dense WiFi deployments in emerging application domains such as Sports and Entertainment. In the proposed research we will explore the following questions:
  1. For a given set of traffic assumptions, what are the limits of the system? How many users can be supported?
  2. What are the key parameters that allow the system to support the maximum number of users? In particular, the following questions are relevant: what is the optimal frame size? What is the optimal FEC strength? What are the optimal video encoding techniques/parameters? What are the optimal 802.11 MAC parameter settings?
  3. What benefits might adaptive applications and/or protocols provide?

Status

- We have developed the the analytic and modeling foundations needed
- Papers and Results:
  - Paper 1: "Modeling Application Based Forward Error Correction": this served to document our basic understanding of the problem space.
  - Paper 2: "Multicasting Video in Dense 802.11g Networks Using Application FEC" – this will be submitted to IEEE CCNC (Consumer Communications and Networking Conference), the submission deadline is 6/5/2011 This paper serves as our baseline work. It introduces the problem and our analysis framework and methodology.
  - Paper 3: An extension to the baseline paper that incorporates realistic channel models as observed from live 'crowd spots'. We solve the off line optimization problem and we propose an evaluate an adaptive scheme the approximates the off line algorithm. This will likely be completed by the end of the year.
- Final project report:
  - This will directly address the three research objectives. We have a draft of this available now based on current results. However, as we continue making progress we expect that we will be able to expand on these findings.
- Completion strategy for the project
  - We want to have a 'phase 1' completion point ASAP. We will present our work as well as address the original research questions. We would like Phase 1 to complete the Cisco Research Project.
  - We want to then identify 'phase 2' We would like to continue collaborating with you as we continue with the project.
    - Suggestions: In addition to Paper 3, we are considering a tool network operators can use for two purposes: first to predict streaming quality for a particular deployment; second, to provide guidance as to the best choice of (N,k).

Experiment Definition: top level scenarios

Experiment	FEC parameters	Flow under observation	Background traffic	Loss process
3xy	Vary blockSize or the coding rate	5 downstream CBR unicast/ multicast flows 768Kbps, packetsize 1400)	none	Bernoulli or Gilbert-Elliot
4xy	Vary blockSize with fixed coding rate	Variable number of multicast and unicast flows	Mix of competing traffic	Congestion
5xy	Vary blockSize with fixed coding rate	Variable number of multicast and unicast flows	Mix of competing traffic	Path loss/Propagation model

EXP3xy Definition

Experiment	FEC parameters	Flows under observation	Background traffic	Loss process
311	Vary blockSize (#1 below), fixed redundancy 0.20	5 downstream CBR flows (768Kbps, packetsize 1400)	none	Bernoulli, vary loss (#2 below)
321	Vary blockSize (#1 below), fixed redundancy 0.20	5 downstream CBR flows (768Kbps, packetsize 1400)	none	Gilbert-Elliot, vary loss (#2 below) by varying state duration (#3 below)
351	Vary blockSize (#1 below), fixed redundancy 0.20	5 multicast streams (see note 1) (768Kbps, packetsize 1400)	none	Gilbert-Elliot, vary loss (#2 below) by varying state duration (#3 below)
381	Vary blockSize (#1 below), fixed redundancy 0.20	5 multicast streams (see note 1) (768Kbps, packetsize 700)	none	Gilbert-Elliot, vary loss (#2 below) by varying state duration (#3 below)
361	Vary blockSize (#5 below), fixed redundancy 0.20	5 downstream CBR flows (768Kbps, packetsize 1400)	none	Gilbert-Elliot, fix loss, vary level of correlation (#4 below)
371	Vary blockSize (#5 below), fixed redundancy 0.20	5 multicast CBR streams (768Kbps, packetsize 1400)	none	Gilbert-Elliot, fix loss, vary level of correlation (#4 below)

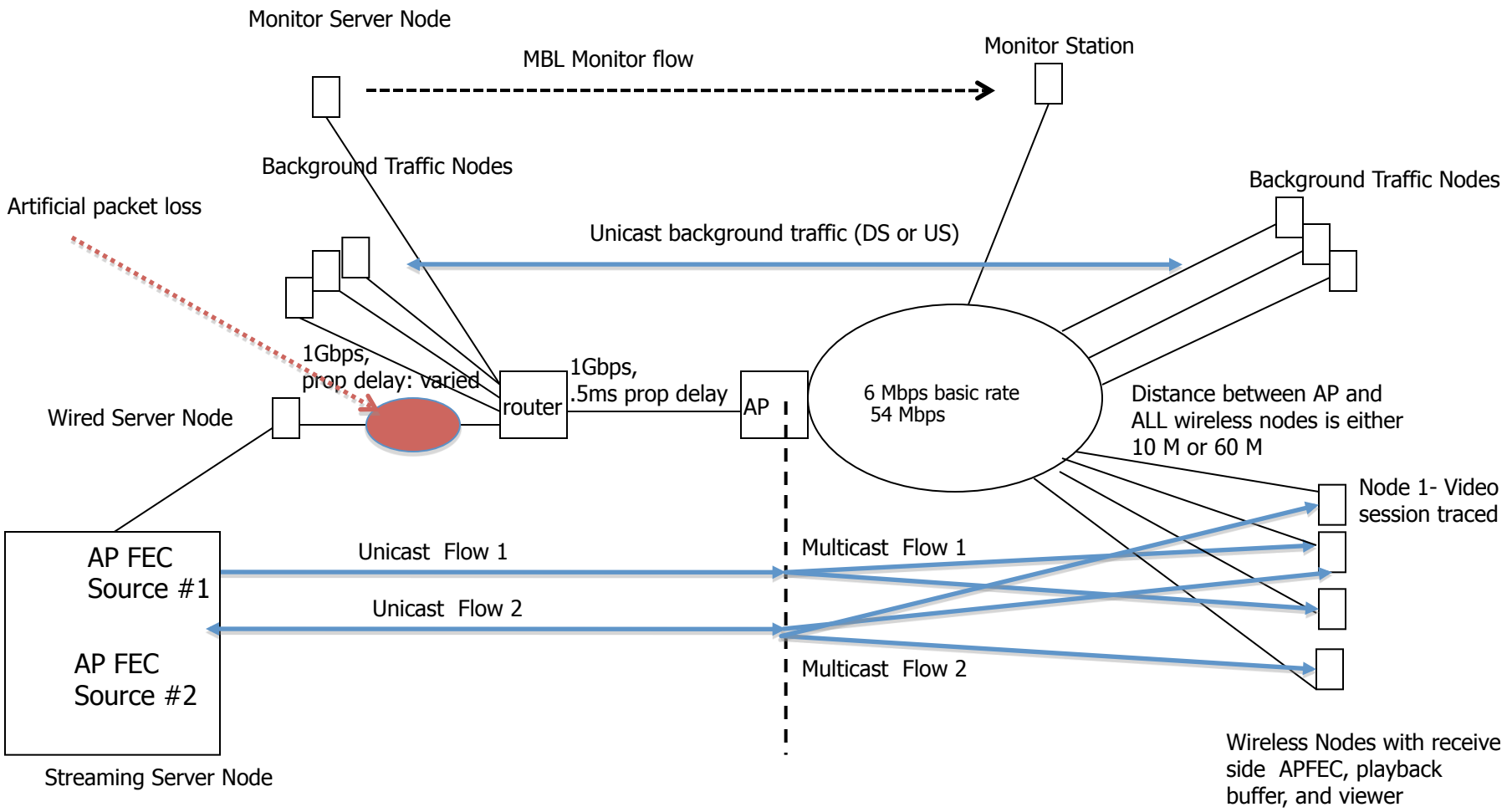
Note 1: we configured this two ways. First, with 25 stations, 5 multicast groups, 5 members per group. Second, a single multicast flow with 1 station. These two configurations are referred to as 'original' and 'modified'

EXP3xy Definition

Experiment	FEC parameters	Flows under observation	Background traffic	Loss process
382-386	Fix k, vary coding rate	5 multicast CBR flows (768Kbps, packetsize 1400)	none	Gilbert-Elliot, fix loss, vary level of correlation (#4 below)

1. BlockSizes (N,k) (fixed code rate 0.20): (5,4), (10,8), (20,16), (40,32), (80,64), (160,128), (320,256), (640,512), (1280,1024), (2560,2048)
2. Long term loss rates: 0.10, 0.12, 0.14, 0.16, 0.18, 0.20, 0.22, 0.24
3. Gilbert-Elliot (varying rates) avg good run length : avg bad run length: (225:25), (182.5:25), (153.5:25), (131.5:25), (113:25), (100:25) (87,25), (79,25)
4. Gilbert-Elliot (fixed loss 0.14, vary run lengths for HUGE correlation: (153.5,25), (460.7,75), (767.9,125), (1075,175), (1382.1,225), (1689.3,275), (1996, 325), (2304,375)
5. BlockSizes (N,k) (fixed code rate 0.20): (20,16), (40,32),(80,64), (160,128), (320,356), (640,512), (1280,1024), (2560,2048), (5120,4096), (10240, 8192)

Simulation Model



Baseline Analysis Experimental Definition

Experiment	FEC parameters	Flows under observation	Background traffic	Loss process
1	Variable block size (#1 below), fixed redundancy 0.20	5 downstream CBR flows (768Kbps, packet size 1400)	none	Bernoulli, vary loss (#2 below)
2	Variable block size (#1 below), fixed redundancy 0.20	5 downstream CBR flows (768Kbps, packet size 1400)	none	Gilbert-Elliot, vary loss (#2 below) by varying state duration (#3 below)
3	Variable block size (#1 below), fixed redundancy 0.20	5 multicast streams (5 stations/ group) (768Kbps, packet size 1400)	none	Gilbert-Elliot, vary loss (#2 below) by varying state duration (#3 below)
4	Variable block size (#1 below), fixed redundancy 0.20	1 multicast stream (1 station) (768Kbps, packet size 1400)	none	Gilbert-Elliot, vary loss (#2 below) by varying state duration (#3 below)
5	Variable block size (#5 below), fixed redundancy 0.20	5 multicast CBR streams (768Kbps, packet size 1400)	none	Gilbert-Elliot, fix loss, vary level of correlation (#4 below)
6	Fixed block size 640 packets, vary redundancy	5 multicast CBR streams (768Kbps, packet size 1400	none	Gilbert-Elliot, fix loss, vary level of correlation (#4 below)

1. BlockSizes (N,k) (fixed code rate 0.20): (5,4), (10,8), (20,16), (40,32), (80,64), (160,128), (320,256), (640,512), (1280,1024), (2560,2048)
2. Long term loss rates: 0.10, 0.12, 0.14, 0.16, 0.18, 0.20, 0.22, 0.24

Tool

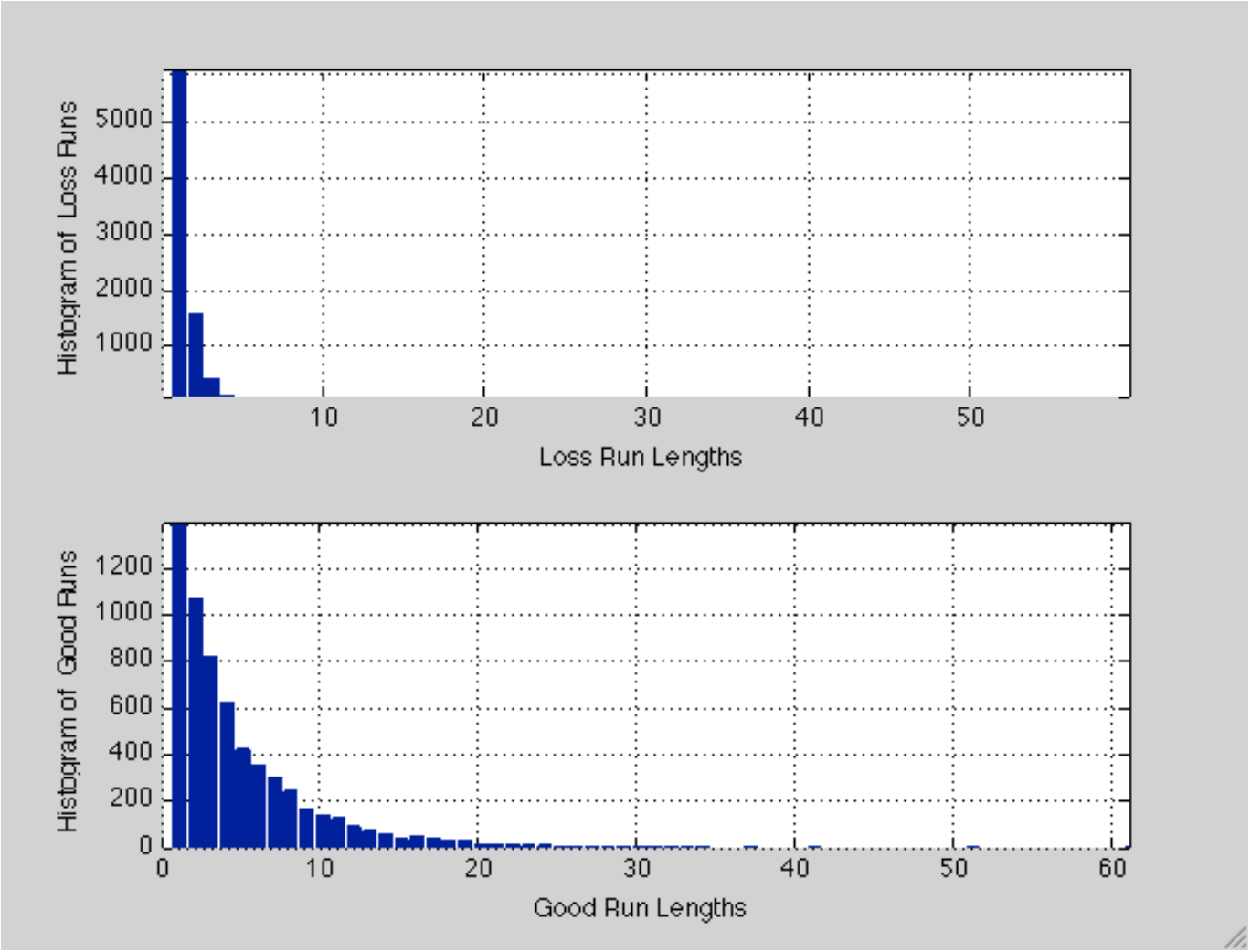
- Sender: sends a video stream in a manner that emulates a video stream. Parameters:
  - Packet size, sending rate (mean and variability), compression factor (e.g., on average the raw stream is compressed by this factor).
- Receiver: receives the stream. Periodically (or at the end of the test), computes:
  - Loss rate statistics, including the distribution of loss runs
  - Guidance for optimal choice of (N,k)

Tool

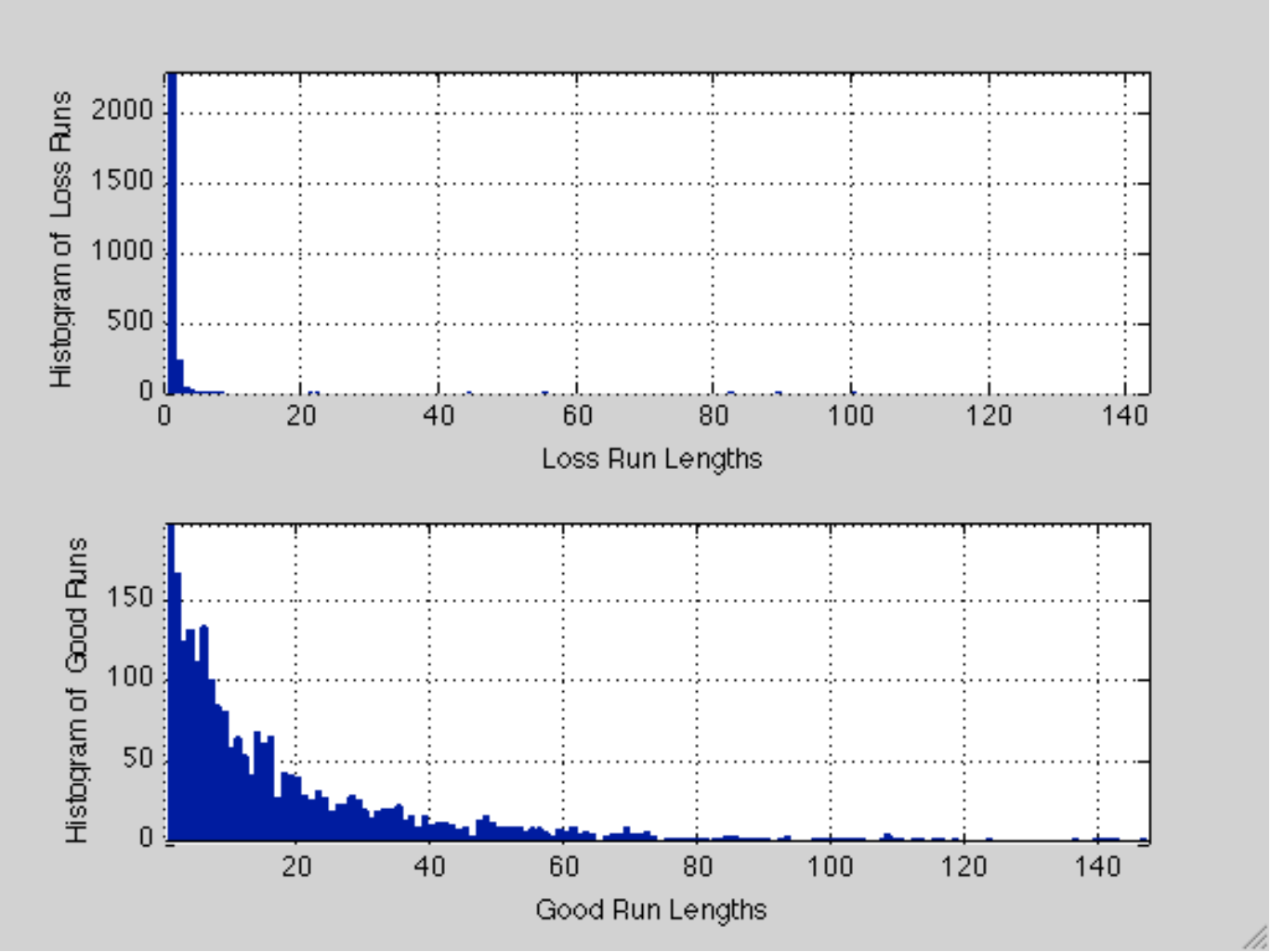
- Results 1: receiver located 200 feet away from home AP – located outdoors behind a few bushes/trees. Avg loss rate 75%
- Results 2: receiver located 200 feed away but in less obstructed path. Avg loss rate 6.5%.

- Reference point: The simulation (using a version of the tool that runs in simulation) : Simulation run is 5 multicast sessions with artificial loss active (experiment 3 in paper 2, see Figure 4):
  - Average loss rate=0.14 (goodRun,lossRun): (153.5,25.0)
  - (N,k): (40,32) (redundancy : 0.20)

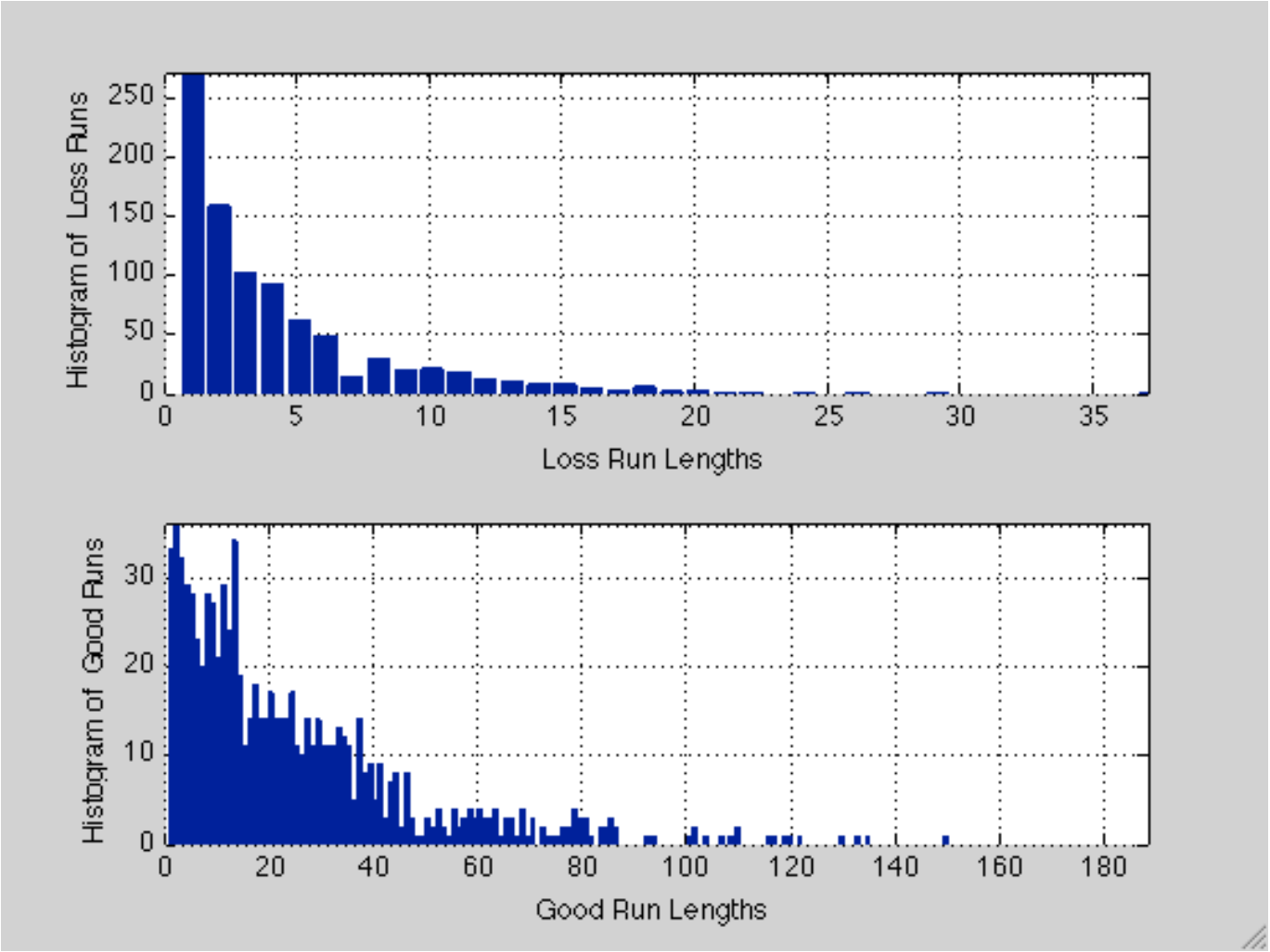
Results 1 (MBL:1.52)



Result 2 (MBL:1.43)



Reference Point: Simulation Result (MBL 4.22)



Results 1

plotLossMetrics
plotLossMetrics: plotFlag:1, oldFileName:wifiTestData.1, newFileName:LMVideoTraceArrived.out
procLossMetrics: File size: 37684, Number of samples: 37684, TotalTime:8.090990e+02, field#:5
procLossMetrics: MBLMetric i:189, numerator:12315.000000, sum:8089.000000
SampleSize:37684, Interarrival Times stats: /nMean:21470.622864, median:12116.000000, std:35709.363680, max,min:3110062.000000,min:0.000000
procLossMetrics: total bytes:615750000.000000, total time:809.098952, BW: 6088254.085392
procLossMetrics: Loss process results: /nloss rate:0.754, #drops:12315, lossRate2:0.607, JitterDrops:11
procLossMetrics: Numbergaps:8089, avgGapSize:1.522, avgGapSizeCount:8089, maxLossRun:189, maxGoodRun:61
procLossMetrics: MBLMetric: 1.522 (maxLossRun:189), ILDMetric: 4.805 (maxGoodRun:61)
plotLossMetrics: Returned from procLossMetrics: PSR:0.000, TotalLR:0.754, LR2:0.607, CorrCoeff:0.000, MBLM: 1.522, MILDM:4.805

Reference Point: Simulation Result

plotLossMetrics
plotLossMetrics: plotFlag:1, oldFileName:wifiTestData.1, newFileName:LMVideoTraceArrived.out
procLossMetrics: File size: 21950, Number of samples: 21950, TotalTime:3.004899e+02, field#:5
procLossMetrics: MBLMetric i:37, numerator:3799.000000, sum:899.000000
SampleSize:21950, Interarrival Times stats: /nMean:13689.743098, median:11587.000000, std:14978.364316, max,min: 426991.000000,min:0.000000
procLossMetrics: total bytes:5558000.000000, total time:300.489861, BW: 147971.714759
procLossMetrics: Loss process results: /nloss rate:0.148, #drops:3799, lossRate2:0.129, JitterDrops:0
procLossMetrics: Numbergaps:899, avgGapSize:4.226, avgGapSizeCount:899, maxLossRun:37, maxGoodRun:188
procLossMetrics: MBLMetric: 4.226 (maxLossRun:37), ILDMetric:24.729 (maxGoodRun:188)
plotLossMetrics: Returned from procLossMetrics: PSR:0.000, TotalLR:0.148, LR2:0.129, CorrCoeff:0.000, MBLM:4.226, MILDM: 24.729

Result 2

plotLossMetrics
plotLossMetrics: plotFlag:1, oldFileName:wifiTestData.1, newFileName:LMVideoTraceArrived.out
procLossMetrics: File size: 46277, Number of samples: 46277, TotalTime:8.094157e+02, field#:5
procLossMetric: total:49998, highestSeqNumber:49998, lossCount:3721, JitterLoss Effect: :0
procLossMetrics: MBLMetric i:143, numerator:3721.000000, sum:2612.000000
SampleSize:46277, Interarrival Times stats:
Mean:17490.669555, median:12106.000000, std:24557.829374, max,min:2371746.000000,min:0.000000
procLossMetrics: total bytes:5209400.000000, total time:809.415715, BW: 51488.004529
procLossMetrics: Loss process results:
loss rate:-0.000, #drops:3721, lossRate2:0.000, JitterDrops:0
procLossMetrics: Numbergaps:2612, avgGapSize:1.425, avgGapSizeCount:2612, maxLossRun:143, maxGoodRun:200
procLossMetrics: MBLMetric: 1.425 (maxLossRun:143), ILDMetric:18.354 (maxGoodRun:200)
plotLossMetrics: Returned from procLossMetrics: PSR:0.000, TotalLR:-0.000, LR2:0.000, CorrCoeff:0.000, MBLM:1.425, MILDM:18.3
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Problem: Finding the Optimal (N,k)

- System parameters that come into play:
  - Number and location of users
  - Topology/propagation which defines the loss process characteristics (mean loss rate, correlation structure)
  - Video stream attributes (encoding rate, compression factor, decoder resiliency to loss, CBR/VBR delivery, client playback buffer. size

- Basic rules (given r=N-k)
  - We know r=p/(i/1-p))
  - As p approaches r/n the size of the required N gets large.