Adaptive Video Streaming: a Survey and Case Study

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Abstract

In the past decade, Internet traffic has seen a significant change from web browsing to video viewing. The ongoing trend raises a challenging problem: how to stream data to heterogeous peers?

The designer of such data streaming architecture should bear the following considerations in mind: QoE, server load, network resource efficiency, scalability, etc. The heterogeneous peer network condition makes the design more complicated. The underlying codec ranges from Multi Description Coding to Multi Layer Coding. The data deliver architecture ranges from unicast, multicast, to P2P network. Researchers have focused on different system settings and optimization objectives.

This paper will first sum up several works in the context of adaptive video streaming. At the same time, we do a case study on a commercial adaptive video streaming system, which combines Multilayer Codec and P2P technology. Possible improvements on this system are proposed with reasoning. Some of the conjectures are verified through a corresponding simulation platform based on NS2.

Contents

1 Introduction

- User perceived experience.
- Vendor cost.
- User cost.
- System cost.

2 General Model

3 Problem Scope

3.1 Codec

3.2 Networking

4 Design of Adaptive P2P VoD System

4.1 Codec Choice

4.2 Transimission Protocol Choice

4.3 Overlay Construction

4.4 Peer Selection

4.5 Buffer Management

4.6 Chunck Selection

MMKP, Knapsack
MCMF, Network Flow

4.7 Playback Decision

4.8 User Model

5 A Case Study and Simulation

5.1 Baseline Description

- Blue: Real deployment
- While: Simulation platform
- Green: This work
- Red dash: Equivalency

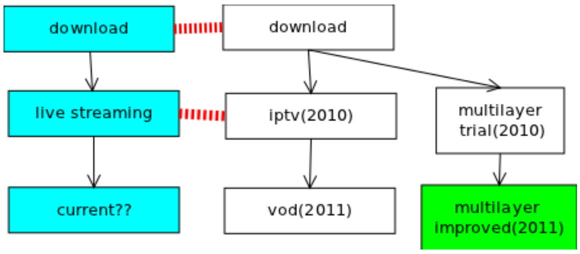
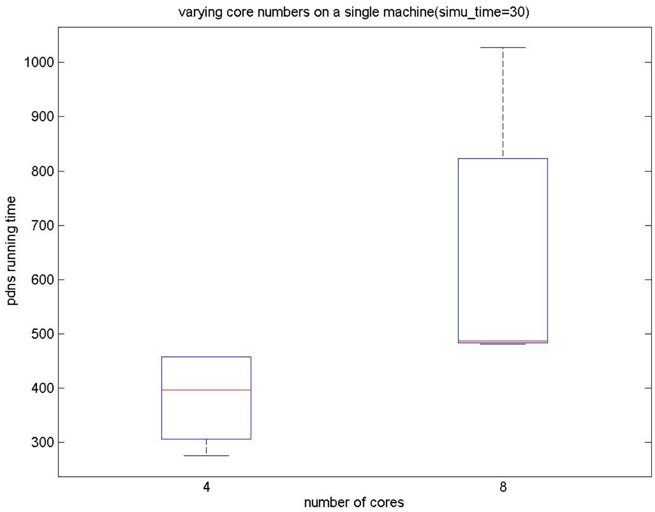


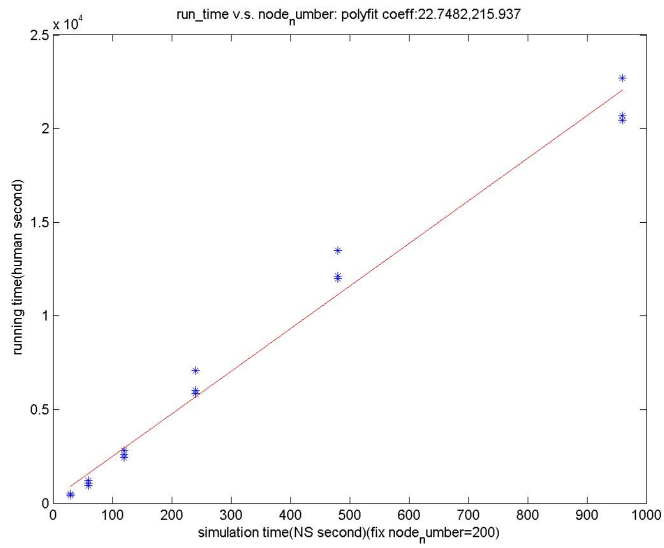
Figure 1: Version Tree of Real and Simulation

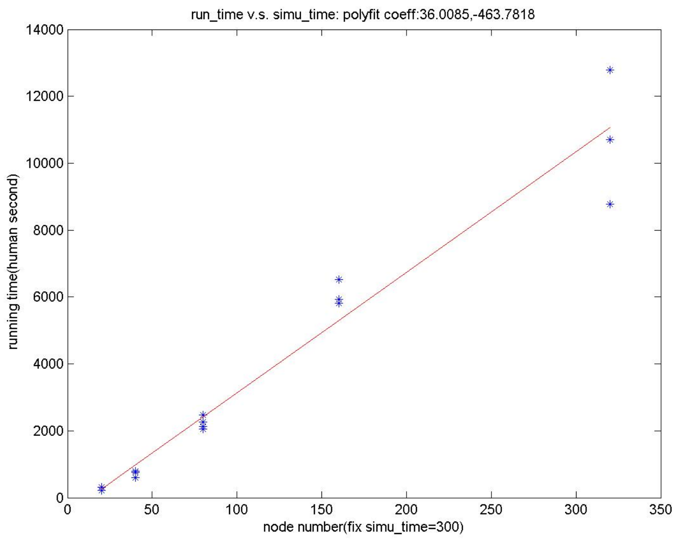


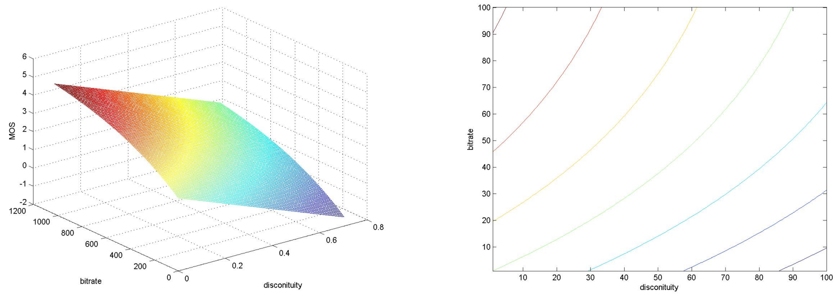
- Number of Nodes: 160
- Simulation Time: 300 (NS seconds)

Wen Zheng's configuration:

- Star like, 4 subnet.
- Subnet parameters:
  - Subnet1: down:10Mb; up:10Mb.
  - Subnet1: down:3Mb; up:0.5Mb.
  - Subnet1: down:3Mb; up:0.5Mb.
  - Subnet1: down:3Mb; up:0.5Mb.
- 3 Layers. Conform to [wang,2011] QoE study.
- Layer parameters:

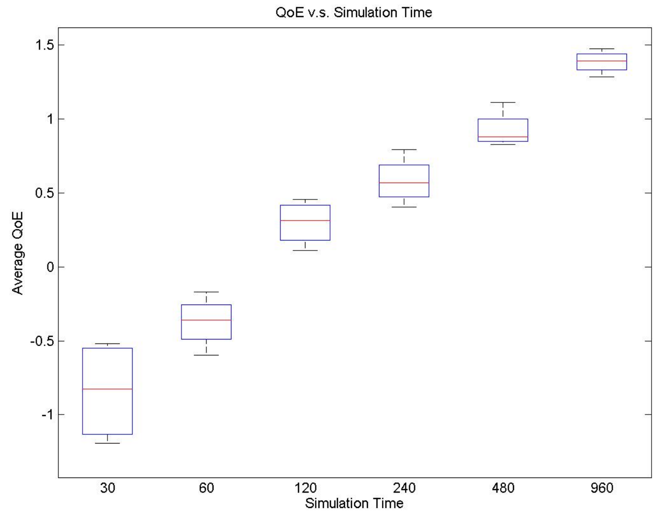

run_time v.s. node_number: polyfit coeff:22.7482,215.937
x 10^4
2.5
2
1.5
1
0.5
0
running time(human second)
0
100
200
300
400
500
600
700
800
900
1000
simulation time(NS second)(fix node_number=200)


run_time v.s. simu_time: polyfit coeff:36.0085,-463.7818
14000
12000
10000
8000
6000
4000
2000
0
running time(human second)
0
50
100
150
200
250
300
350
node number(fix simu_time=300)



(a) 3D (b) contour

Figure 2: Conclusion, QoE and Performance



- Layer1: 256Kbit. (per piece)
- Layer2: 256Kbit. (per piece)
- Layer3: 512Kbit. (per piece)

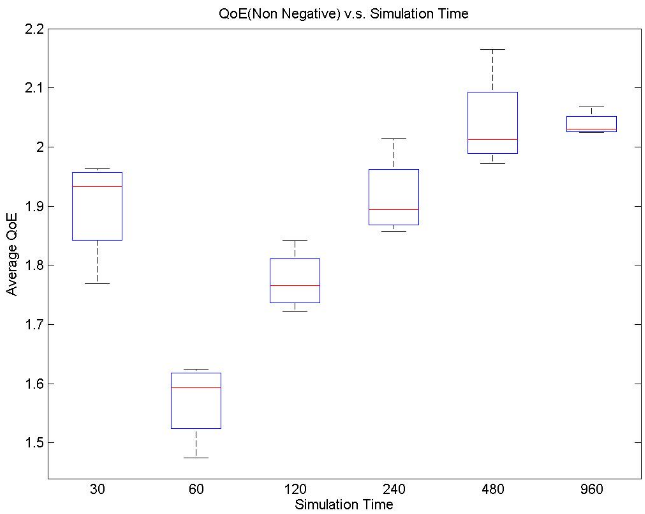
5.2 QoE Model Implementation

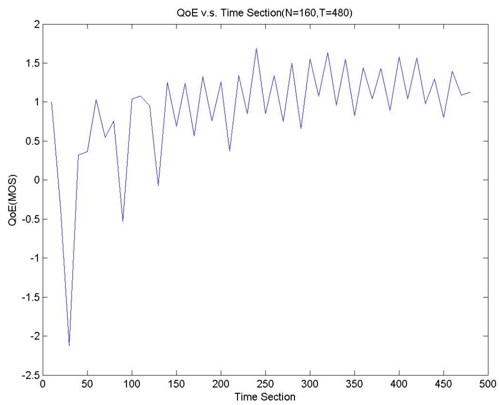
[wang, 2011], B-D tradeoff, continuous version.

$$MOS = c_1 \times d + \alpha \times (1 - e^{-b \times \lambda}) + c_2 \tag{1}$$

5.3 Baseline Test

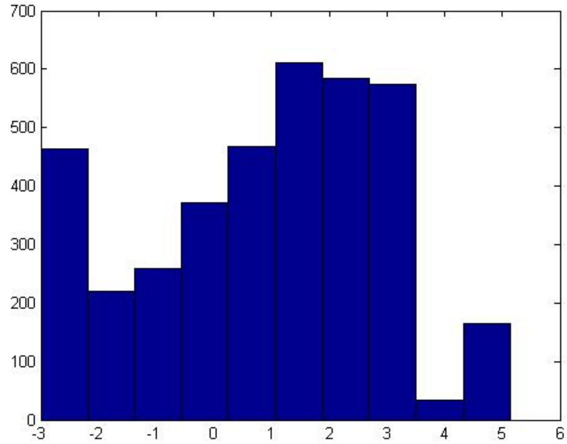
- $'count\_mr' => 3749$





- $'count\_mr\_nonneg' => 2601$
- $'avg\_qoe' =>' 0.871540677419684'$
- $'avg\_qoe\_nonneg' =>' 2.01996612593628'$
- $'node\_num' =>' 160'$
- $'simu\_time' =>' 480'$
- $'core\_num' =>' 4'$
- $'task\_duration' => 8399$
- $'pdns\_duration' => 8302$

Observations:



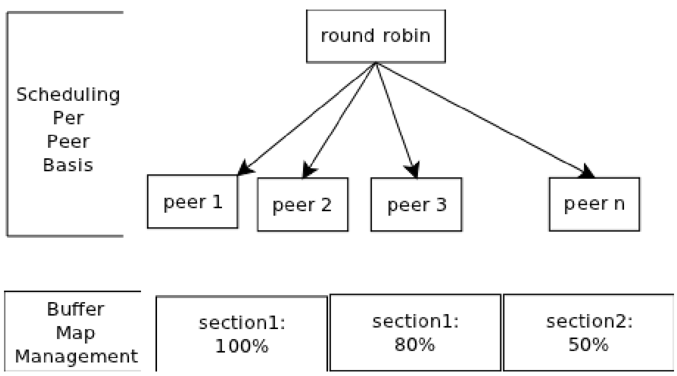


Figure 3: Original Architecture

- System bootstraping stage.
- Steady after about 250 seconds.

5.4 Chunk Selection Architecture Reconstruction

Effect:

- QoE: $0.7 \rightarrow 3.3$

5.5 Priority Based Upgrade

Result:

- QoE: nearly the same.
- Performance: decrease slightly.

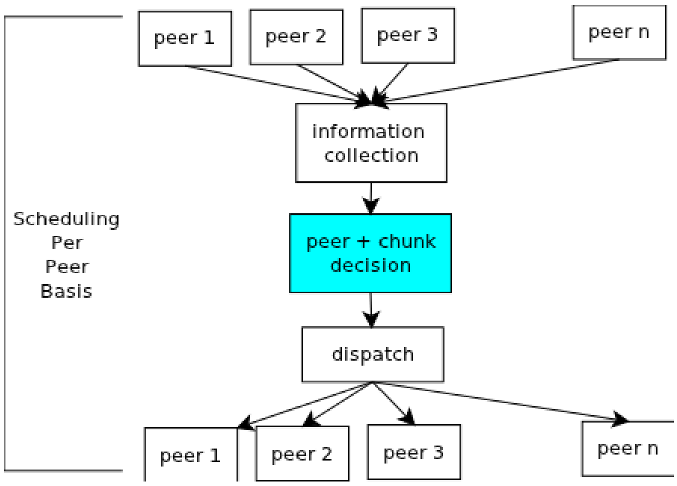


Figure 4: Improved Architecture

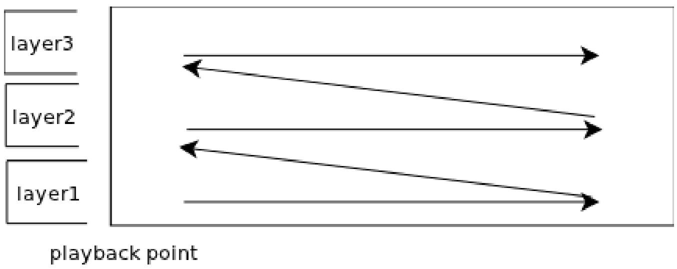


Figure 5: Improved Architecture

Table 1: A Sample Priority Table with Window Size = 5

	t1	t2	t3	t4	t5
layer3	11	12	13	14	15
layer2	6	7	8	9	10
layer1	1	2	3	4	5

Table 2: A Sample Priority Table with Window Size = 5+5

	t1	t2	t3	t4	t5	t6-t10
layer3	11	12	13	14	15	...
layer2	6	7	8	9	10	...
layer1	1	2	3	4	5	...

Table 3: A Sample Priority Table with Window Size = 5+5

	t1	t2	t3	t4	t5	t6-t10
layer3	11	12	13	14	15	...
layer2	6	7	8	9	10	...
layer1	1	2	3	4	5	...

5.6 Scalable Window Size

Reason:

- From trace, many powerful peeers can get full 3 layers in the whole window.
- Give them a chance to download more, and their data far from playback pointer can server others.

5.7 Performance Optimization

Result:

- QoE: nearly the same.
- Performance: 4.5h $\rightarrow$ 3.5h.

5.8 Introduce Randomness in Second Window Section

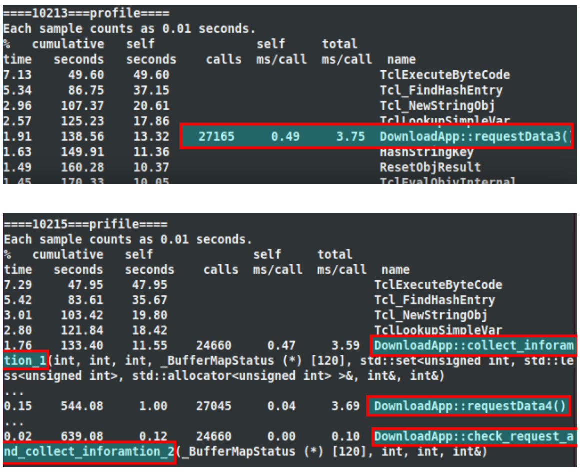
Result:

- QoE: worse.
- Performance: worse.

5.9 Conclusion of the Case Study

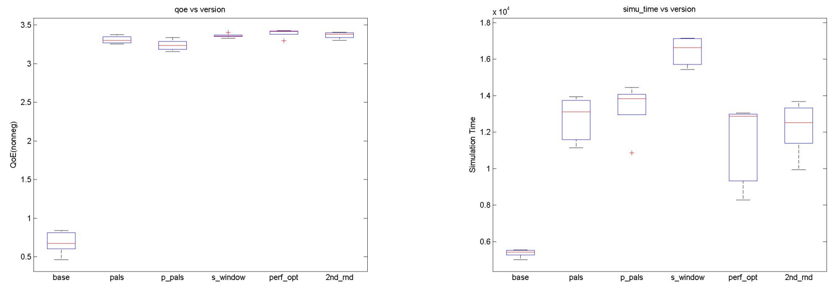
6 Conclusion

- Engineering approach v.s. academic approach:
  where is the biggest cake?
- Time distribution:



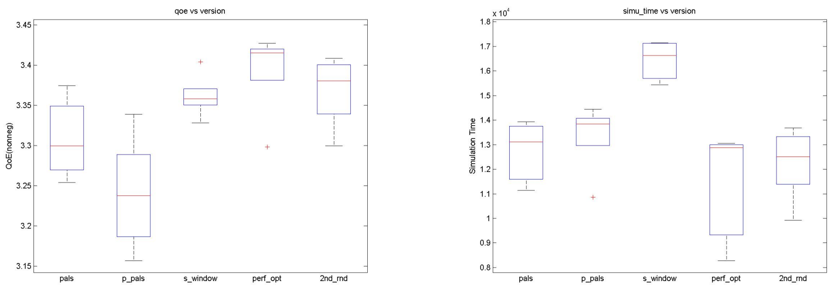
```
====10213===profile====
Each sample counts as 0.01 seconds.
%   cumulative   self              self     total
time   seconds   seconds    calls  ms/call  ms/call  name
7.13     49.60    49.60                             TclExecuteByteCode
5.34     86.75    37.15                             Tcl_FindHashEntry
2.96    107.37    20.61                             Tcl_NewStringObj
2.57    125.23    17.86                             TclLookupSimpleVar
1.91    138.56    13.32    27165     0.49     3.75  DownloadApp::requestData3(
1.63    149.91    11.36                             HashStringKey
1.49    160.28    10.37                             ResetObjResult
1.45    170.33    10.05                             TclEvalObjvInternal

====10215===prifile====
Each sample counts as 0.01 seconds.
%   cumulative   self              self     total
time   seconds   seconds    calls  ms/call  ms/call  name
7.29     47.95    47.95                             TclExecuteByteCode
5.42     83.61    35.67                             Tcl_FindHashEntry
3.01    103.42    19.80                             Tcl_NewStringObj
2.80    121.84    18.42                             TclLookupSimpleVar
1.76    133.40    11.55    24660     0.47     3.59  DownloadApp::collect_inforam
tion_1(int, int, int, _BufferMapStatus (*) [120], std::set<unsigned int, std::le
ss<unsigned int>, std::allocator<unsigned int> >&, int&, int&)
...
0.15    544.08     1.00    27045     0.04     3.69  DownloadApp::requestData4()
...
0.02    639.08     0.12    24660     0.00     0.10  DownloadApp::check_request_a
nd_collect_inforamtion_2(_BufferMapStatus (*) [120], int, int, int&)
```

Figure 6: GNU Profile, Output



(a) qoe (b) time

Figure 7: Conclusion, QoE and Performance



(a) qoe (b) time

Figure 8: Conclusion, QoE and Performance

  - 70%, literature survey.(30+ papers)
  - 15%, bugfix of the platform, environment setup.
  - 5%, first unified version(QoE:0.7→3.3, biggest improvement in this study)
  - 10%, scalable window, performance optimization, random 2nd section. (little outcome)

- 6 big versions / 240 runs.
- Auxilary Scripts:
  - .sh:298 lines
  - .pl:791 lines
  - .m:133 lines
- Simulation Code Difference:
  - download_agent.cc: 1940 lines
  - download_agent.h: 301 lines
  - labtesting.tcl: 84 lines

7 Future Works

Acknowledgements

Appendix

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