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Playout Control for Streaming Applications by Statistical Delay Analysis

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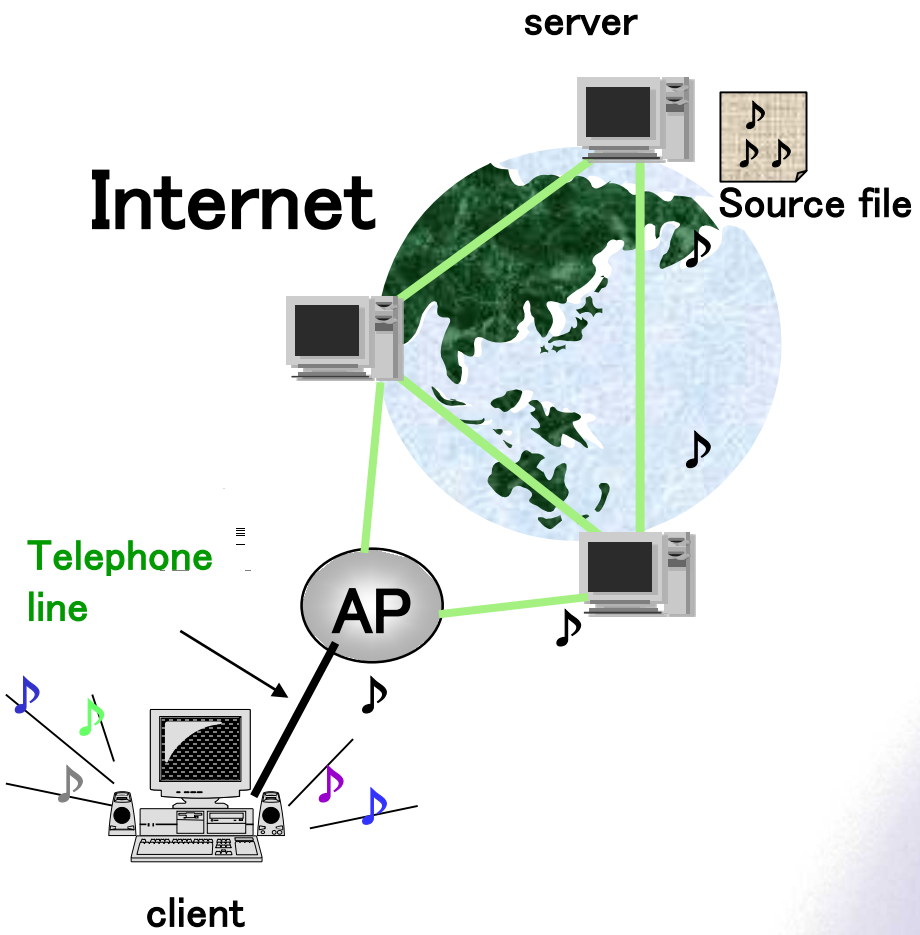
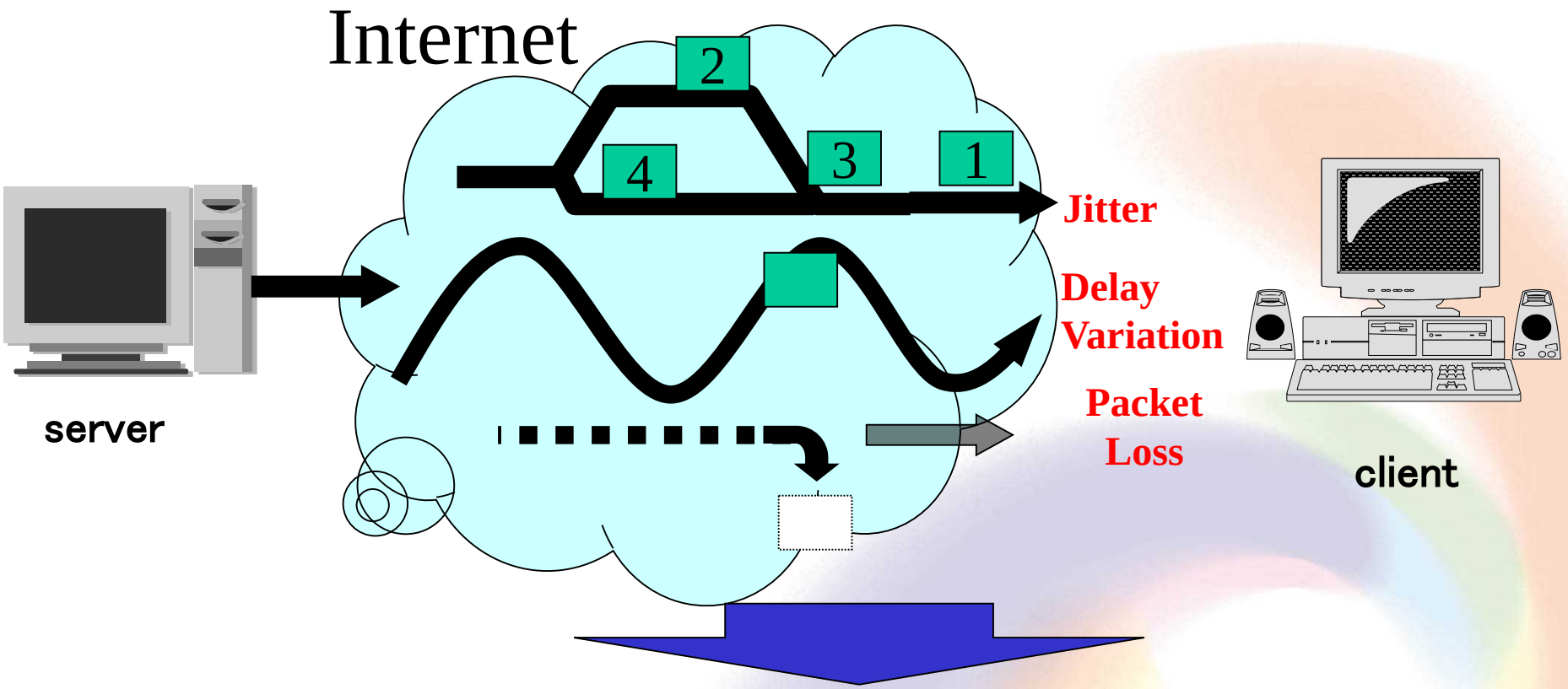
Real-time Applications



- The applications which playback audio data as soon as download
  - Interactive Voice, Voice conference （vat、NeVoT..）
  - Radio （Winamp, RealPlayer..）
  - etc

Issues on Real-time Applications in the Internet



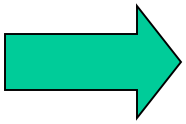
Playout buffer algorithm

Playout Buffer Algorithm

- Jitter
  reorder the packet in the buffer
- Delay Variation
  absorbed by buffering
- Packet Loss
  detect packets which will not arrive

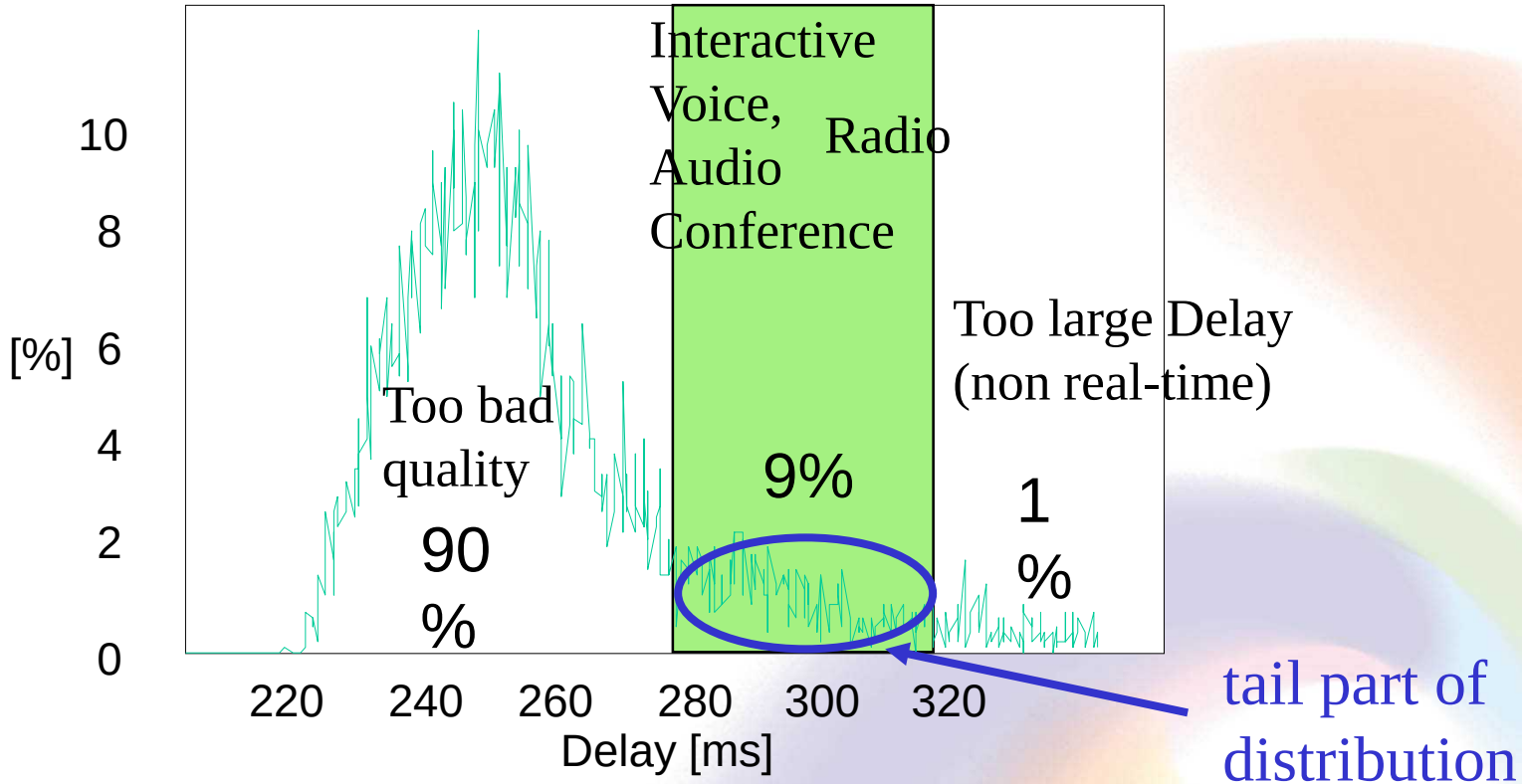
Playout Delay

- Playout delay
  = buffer size + delay
- Playout delay affects the quality of the real-time application
  - small buffer size
    the client treats packets to be lost even if those packets eventually arrive in a short time
    real-time > high quality
    for interactive voice, voice.conference
  - Large buffer size
    playout more packets, but cannot playout in real-time
    real-time < high quality
    for internet radio



we need carefully determine the playout delay which satisfies the application's characteristics

Delay Distribution and Target Value



Target value = the ratio of packets which will be playouted required by application

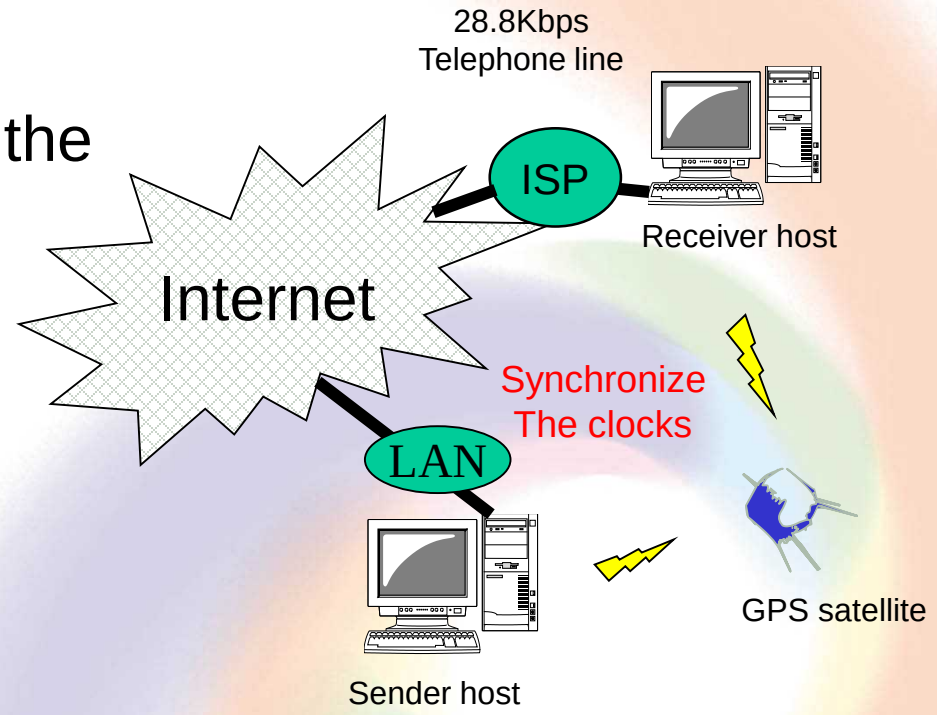
Objectives

1. Analyze the packet delay characteristics
   - Model the tail part of delay distribution
2. Apply the analytic results to the real-time application
   - Propose a new playout buffer algorithm which can control the packet loss ratio
   - Evaluate the performance of new algorithm
   - Implementation test

The Analysis of Packet Delay Characteristics

Measurement Method of One-way Delay

- Developed a measurement tool
  1. the sender records the current time into the packet
  2. the delay is calculated by the receiver host
  - – Synchronize the sender and receiver hosts clocks
  - – Packet size : 160 byte
  - – Interval : 80 ms



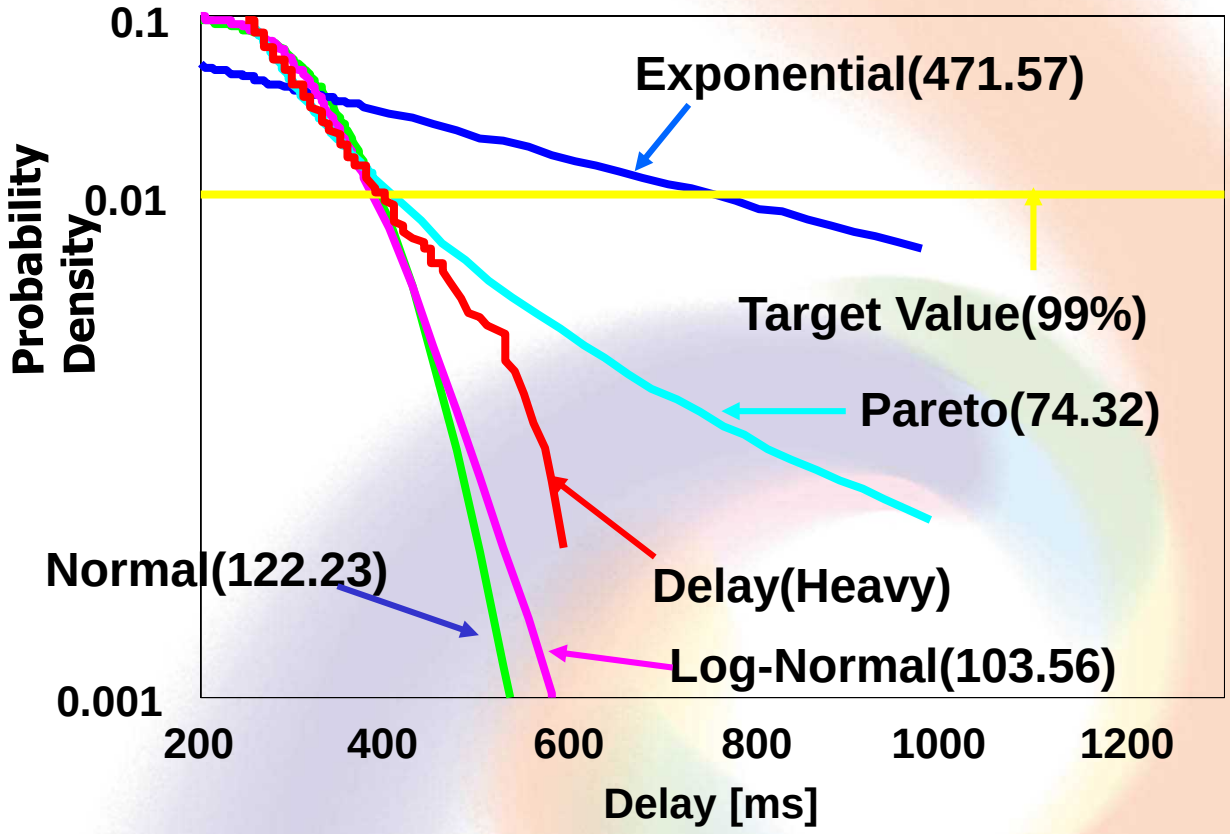
Modeling Method

- Pick up four distribution functions as candidates to adequately represent delay distribution
  - Normal, LogNormal, Exponential, Pareto
- Select Adequate function as the model
  - Estimate parameters of each functions from the delay at the tail part of distribution
  - Determine the most appropriate function by χ-squared test in the tail part of distribution

Comparisons among Delay Distribution and Candidate Functions

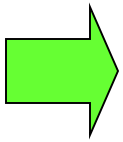
function	*X*-squared
Normal	122.23
Exponential	471.57
LogNormal	103.56
Pareto	74.32

- Busy hour
- Measurement for 40 min
- 13,000 data



X-squared Test Results

Hour	*X*-squared Test			
	Normal	**Exponential**	**LogNormal**	**Pareto**
9PM	83.82	602.56	71.96	**19.56**
11PM	53.86	470.90	49.67	**30.10**
1AM	55.06	426.46	49.99	**24.01**
5AM	94.45	500.91	85.77	**25.16**
9AM	107.76	754.09	98.74	**45.33**
12PM	108.66	1218.95	101.09	**30.61**
3PM	109.07	336.49	85.41	**21.21**



The Pareto distribution is the most appropriate as the model regardless of time of day

Application of the Analytic Results to Real-time Applications

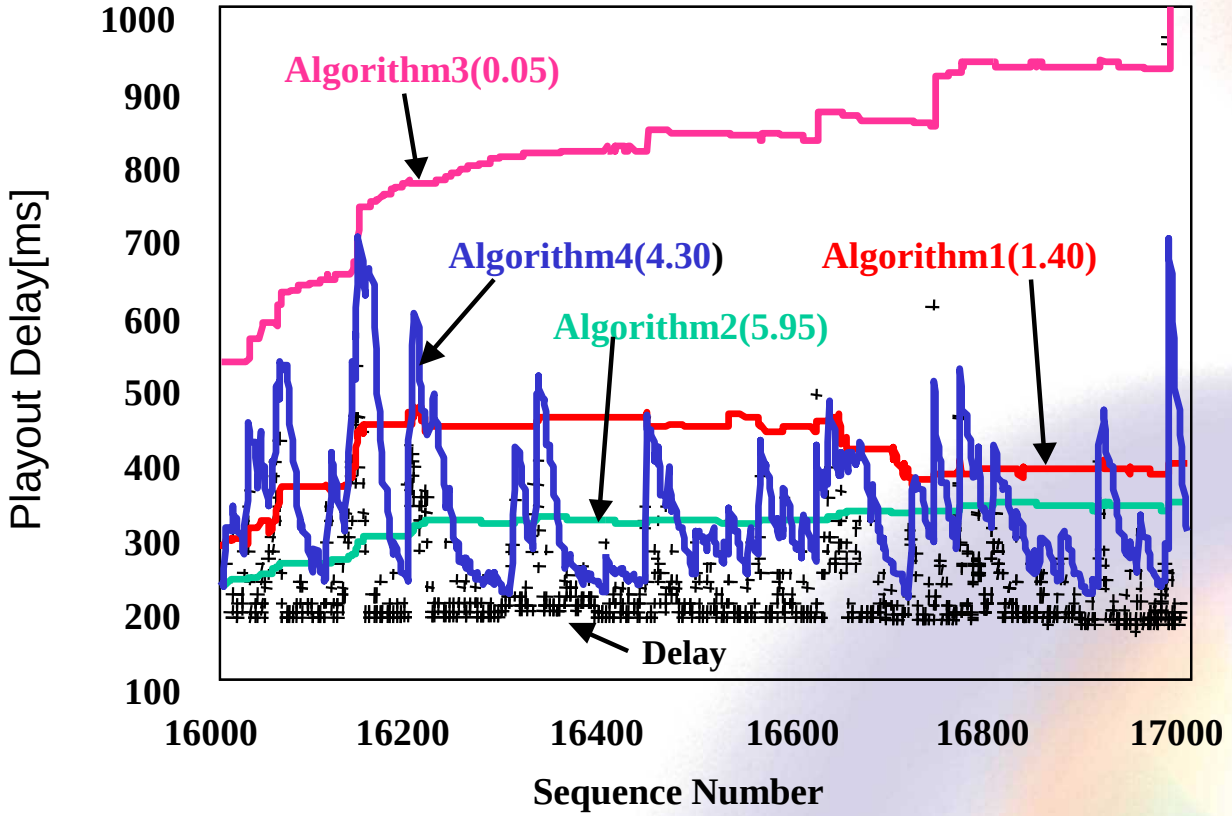
Proposed Playout Buffer Algorithm

- Use the model to determine the adequate playout delay which satisfy the quality required by the applications

1. Record the delays of last n packets
2. Estimate parameters of Pareto distribution function from the distribution of recorded delays
3. From estimated Pareto distribution, calculate the playout delay which keep the packet loss ratio to satisfy the target value

Simulation - Playout Delay Variation

- Test the performance of proposed algorithm by tracing measured packet delay



Target value = 99%

(11PM)

[1] R.Ramjee, J.Kurose, D.Towsley, and H.Schulzrinne, "Adaptive playout mechanisms for packetized audio applications in wide-area networks," in Proceedings of IEEE INFOCOM'94, pp.680-688, April 1994

Performance Evaluation

Hour	Algorithm	Target Value[%]	Packet Loss Ratio[%]	Avg. Playout Delay[ms]
11PM	1	95	5.13	221.17
		99	1.37	265.12
		99.9	0.14	855.38
	2	-	2.46	237.16
	3	-	0.24	392.64
	4	-	3.95	230.72

Proposed algorithm can control the playout delay with satisfying the target loss probability

Implementation

- Apply proposed playout buffer algorithm to the real-time application (input plug-in of winamp)
- Test the performance of the algorithm

Target Value[%]	Packet Loss Ratio[%]	Recorded audio data
90	8.5	
99	1.8	
99.9	0.2	

Conclusion

- From statistically analytic method, I have found that the Pareto distribution is most appropriate as the model of the one-way delay's distribution
- I have proposed a playout buffer algorithm based on the analytic results in order to control the quality of the applications.
- Numerical examples have shown that the proposed algorithm can control the playout delay satisfying the target packet loss probability.

Simulation

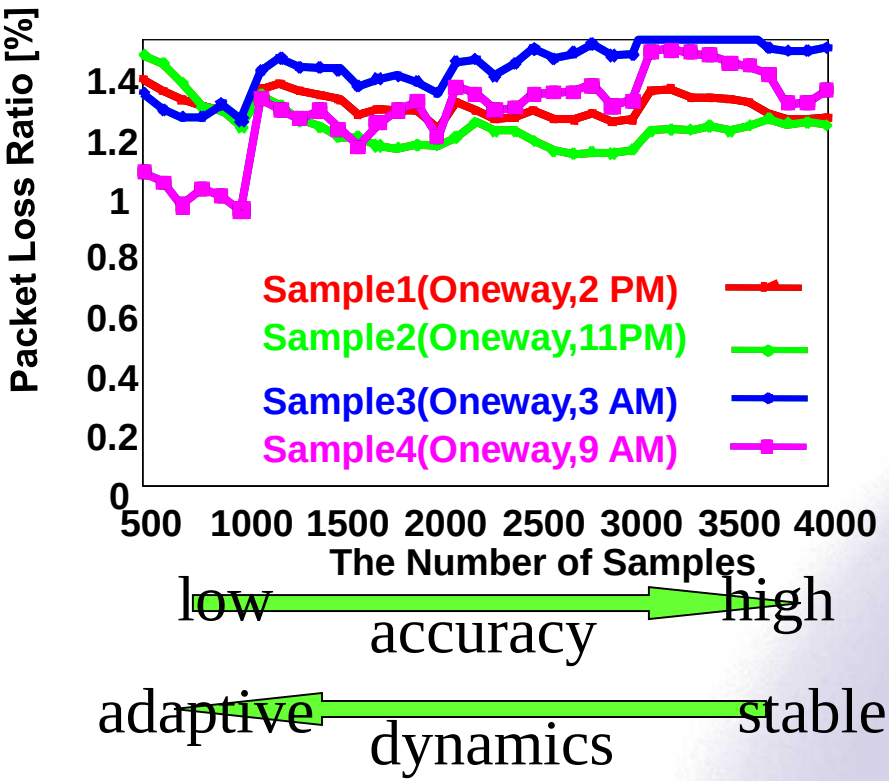
- Test the performance of proposed algorithm by tracing measured packet delay
  - Keep the required quality?
- compare the performance of proposed algorithm with those of well-known algorithms shown in paper[1]

[1] R.Ramjee, J.Kurose, D.Towsley, and H.Schulzrinne, “Adaptive playout mechanisms for packetized audio applications in wide-area networks,” in Proceedings of IEEE INFOCOM’94, pp.680-688, April 1994

Factor Affecting Modeling Delay Distribution

- Time of day
  - Busy time
    heavy traffic
    intensive variation of delay,
    increase of the packet loss ratio
  - Day time, midnight
    opposite to busy time characteristic

Required Number of Packets for Reliable Parameter Estimation



No drastic variation by changing sample number

Nunber = 500

Performance Evaluation(2/3)

Hour	Algorithm	Target Value[%]	Packet Loss Ratio[%]	Avg. Playout Delay[ms]
8AM	1	95	5.42	247.66
		99	1.08	270.11
		99.9	0.10	386.23
	2	-	1.08	277.88
	3	-	0.12	353.08
	4	-	2.96	258.53

Performance Evaluation(3/3)

Hour	Algorithm	Target Value[%]	Packet Loss Ratio[%]	Avg. Playout Delay[ms]
2PM	1	95	5.32	242.67
		99	1.34	267.29
		99.9	0.10	414.48
	2	-	1.37	260.62
	3	-	0.26	339.79
	4	-	3.08	252.50