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Performance evaluation of an IP voice terminal

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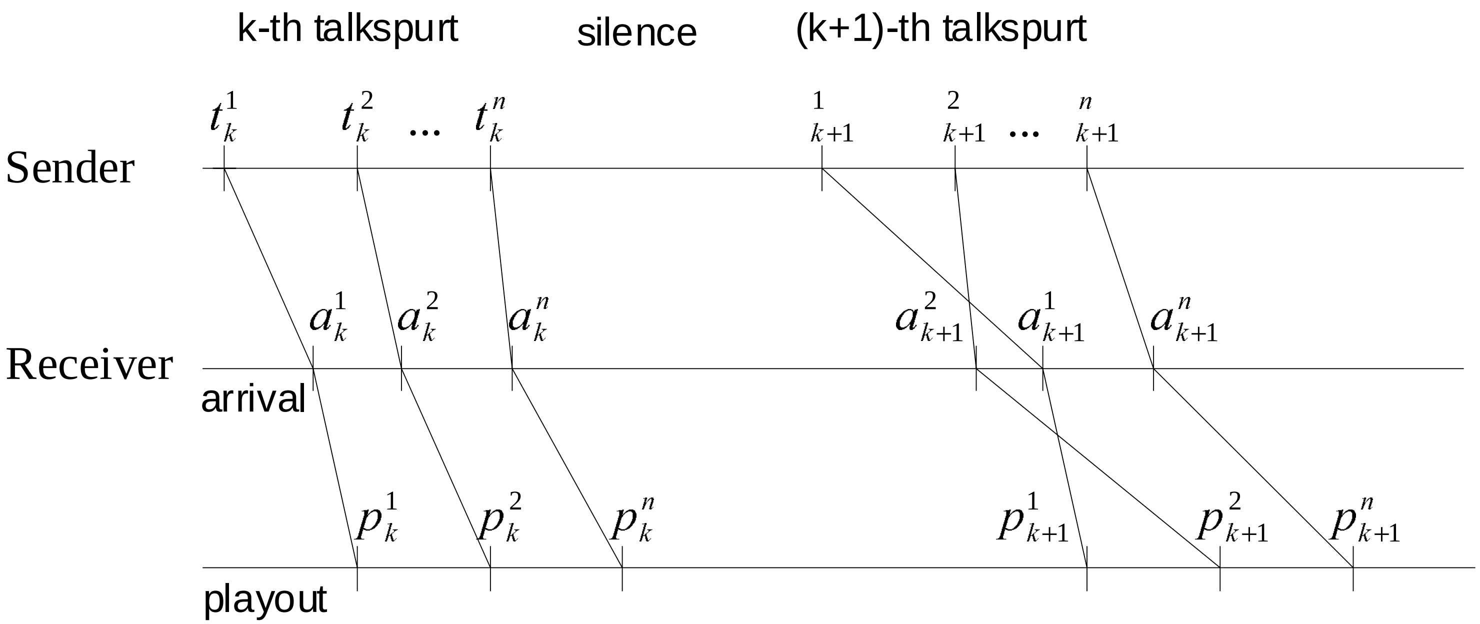
Delays in IP Voice

- Framing delay (e.g. 20 ms)
- Processing delay:
  Coding & decoding, Dependent on used algorithm
- HW delay: A/D & D/A transform
- Network delay: Jitter
- Buffering
- Operating system: Scheduling

Playout delay adjustment

- Fixed
- Adaptive: Per-talkspurt or Per-packet



Playout algorithms

Algorithm 1:

A linear predictor

$\alpha = 0{,}998002$

$$\hat{u}_k^i = \alpha * \hat{u}_k^{i-1} + (1-\alpha)\hat{d}_k^i$$

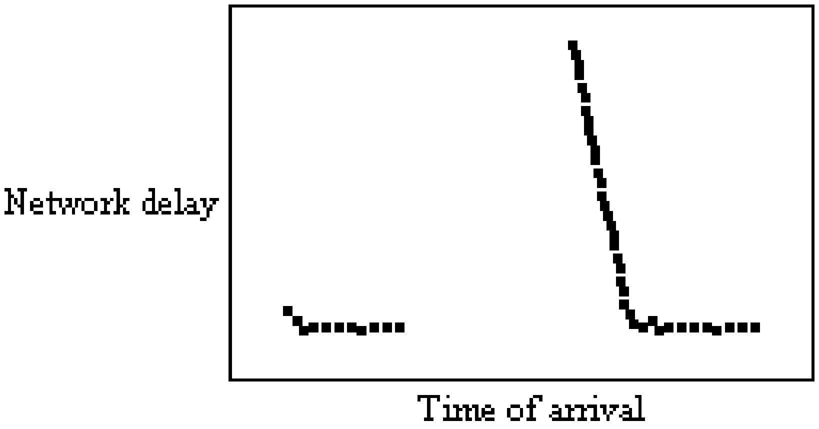
$$\hat{v}_k^i = \alpha * \hat{v}_k^{i-1} + (1-\alpha)\,|\,\hat{u}_k^i - \hat{d}_k^i\,|$$

$$\hat{p}_k = \hat{u}_{k-1}^{n_{k-1}} + \beta * \hat{v}_{k-1}^{n_{k-1}}$$

Algorithm 2:

Two operational modes

- Normal mode
- Spike mode



A typical spike

Playout algorithms

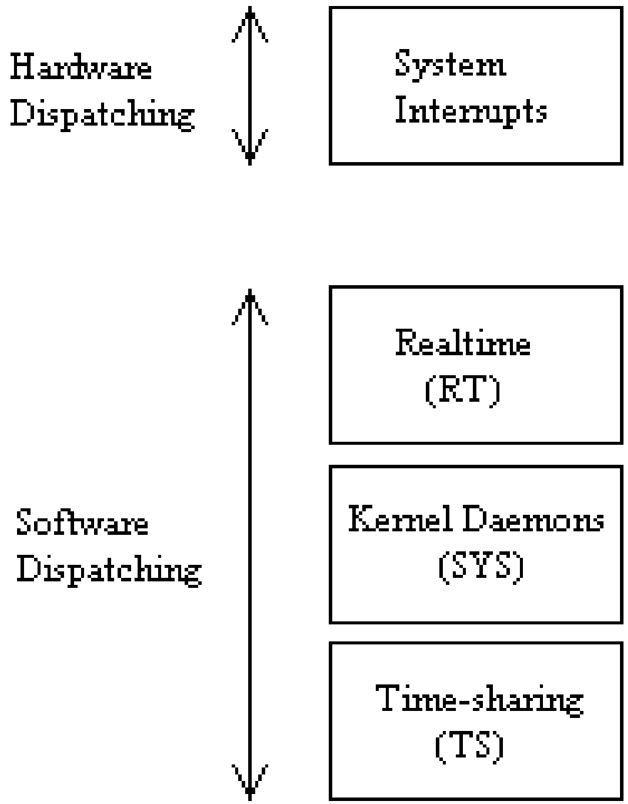
Algorithm 3:

- Playout delays are calculated by using collected delay statistics
- Normal mode & spike mode
- Takes some time to first collect the statistics

Algorithm 4:

- A combination of algorithms 1 and 3

Unix process scheduler



Dispatch priorities for scheduling classes

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Measurements and results

Used CPU time	*PCM*	*ADPCM*	*GSM*	*LPC*
in ms	0,26	0,49	1,14	1,83
in percent	1,3	2,5	5,7	9,1

Used CPU time in ms and % of used CPU time from total CPU time with different audio codings

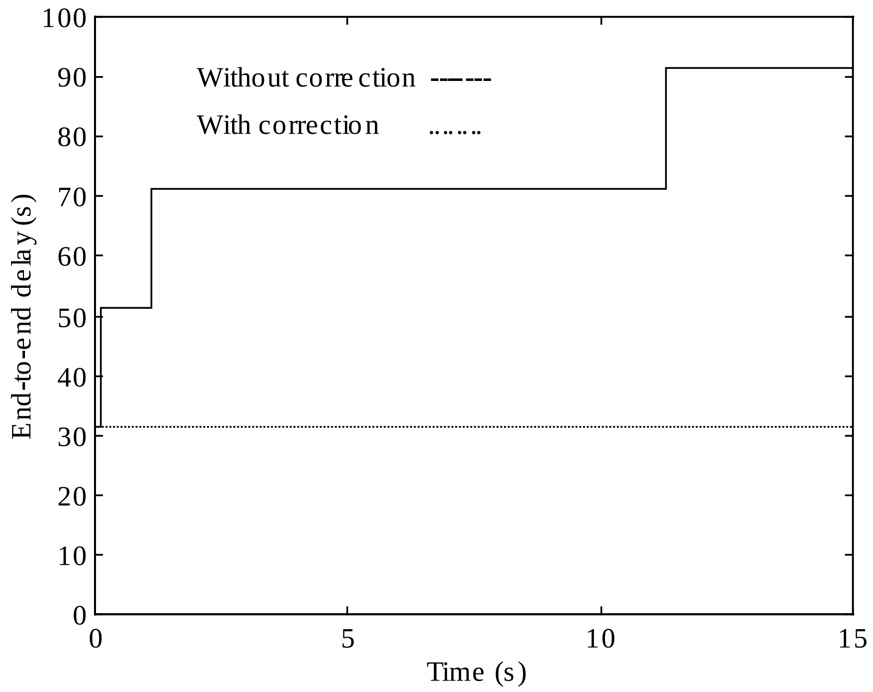
Delay component	*Delay in ms*
Framing delay	20,0
Processing delay	0,5 - 3,7
HW delay	2,2
Network delay	0,5
OS delay	0 – 2,9
Buffering delay	8,2 - 8,8

Components of the end-to-end delay

Used workstation:
Sun Ultra Enterprise 1
Operating system: SunOS 5.5.1

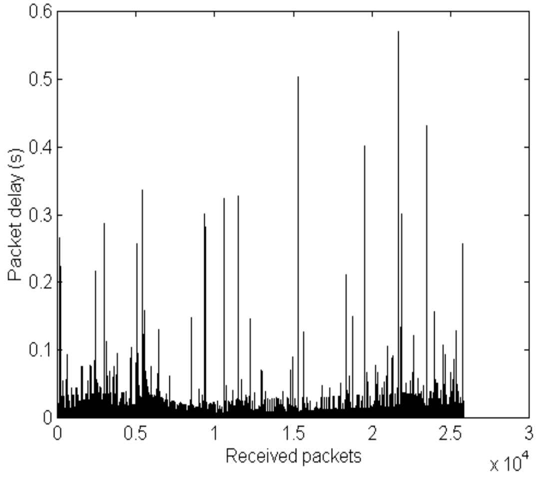
Used software:
Nevot v.3.35

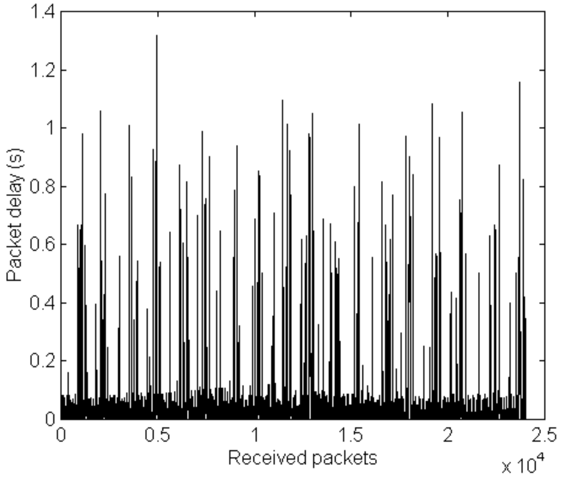
Measurements and results

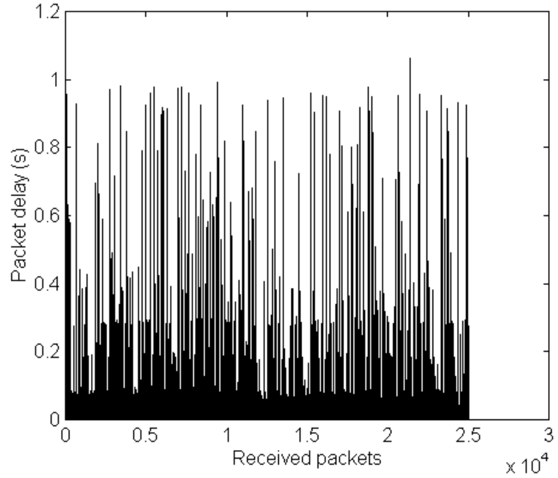


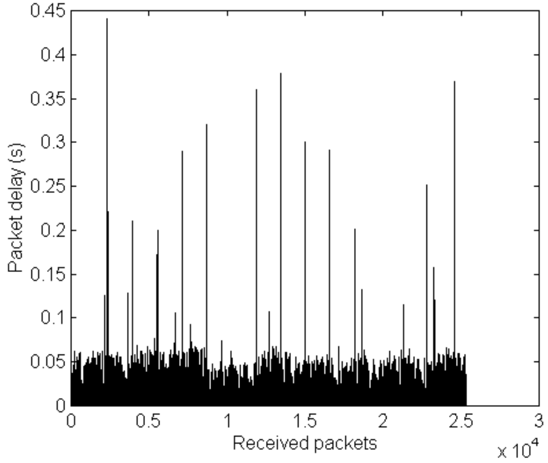
End-to-end delays with and without correction

Comparison of playout algorithms



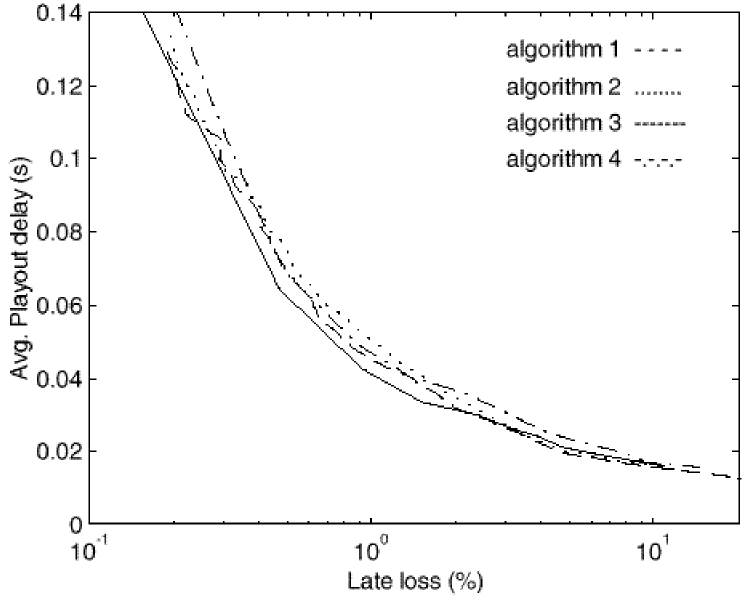




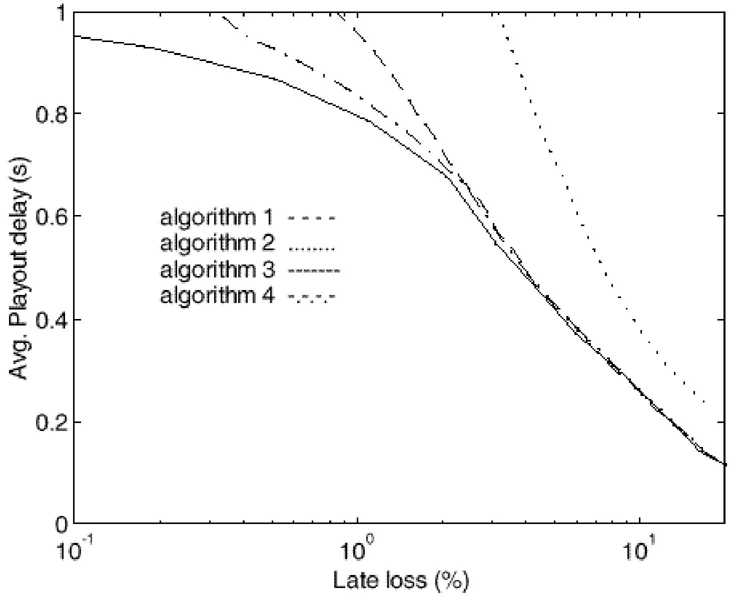


Trace	*Traffic description*	*Frames/s*	*Bytes/frame*	*Load/Mbps*	*Length/packets*
Trace 1	Small packets	3000-5000	160	3,936-6,560	25830
Trace 2	Small packets, high load	2000-3500	320	5,184-9,072	25023
Trace 3	Large packets, bursty load	100-860	1450	1,163-10,000	24048
Trace 4	Variable size packets, bursty load	200-860	160-1450	0,2624-10,000	25337

Comparison of playout algorithms



Algorithms 1-4 on trace 1



Algorithms 1-4 on trace 2

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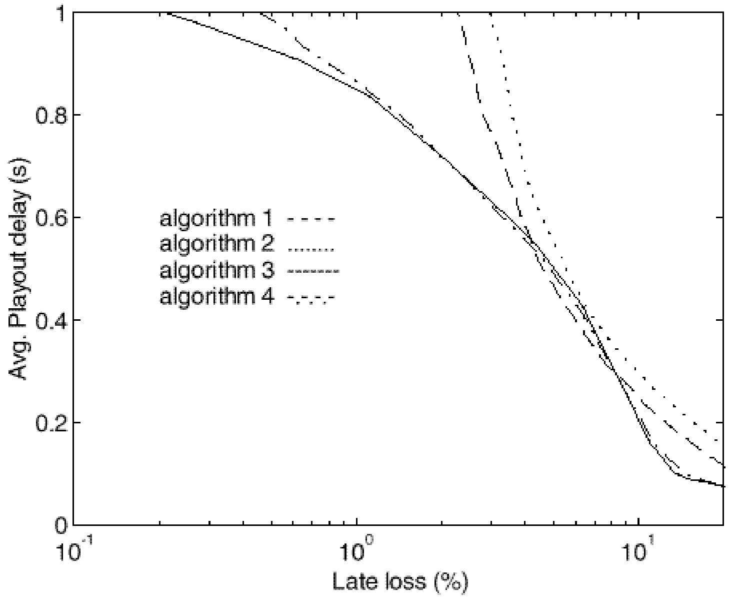
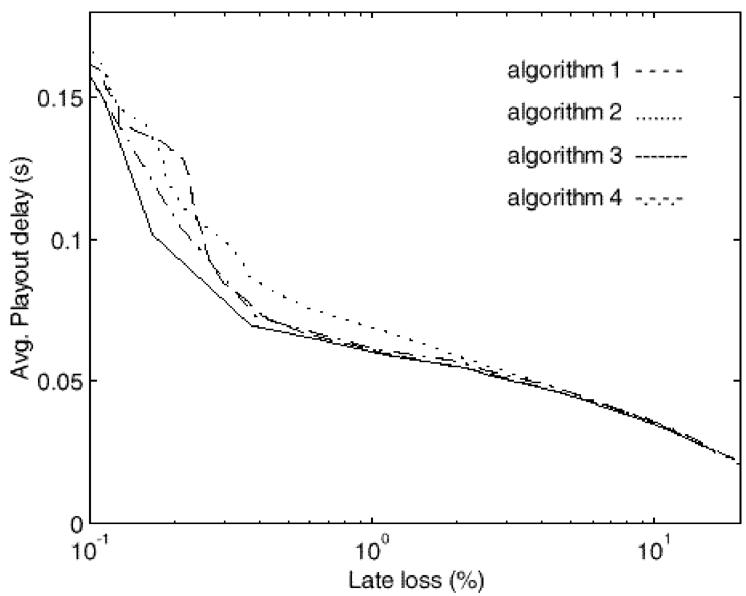
Comparison of playout algorithms



Algorithms 1-4 on trace 3



Algorithms 1-4 on trace 4

Conclusions

- Significant part of the delay generated by the VoIP client software (Nevot)
- Other delays quite small in an unloaded LAN
- A new playout algorithm was presented as a combination of two existing algorithms. Best performance is obtained during calls over 250 seconds

Future work:

- Simulations with actual network traces and comparison with results presented in this paper