Dimensioning Links for IP Telephony

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http://www.sics.se/~ianm/Talks/columbia.{ps,pdf}

Background

- Link dimensioning is in telephony/ATM domains
- Most research & results are *still* in this domain
- Research field is enormous (ICC - 628 papers)
- Often stated but not addressed, e.g. Diff-serv

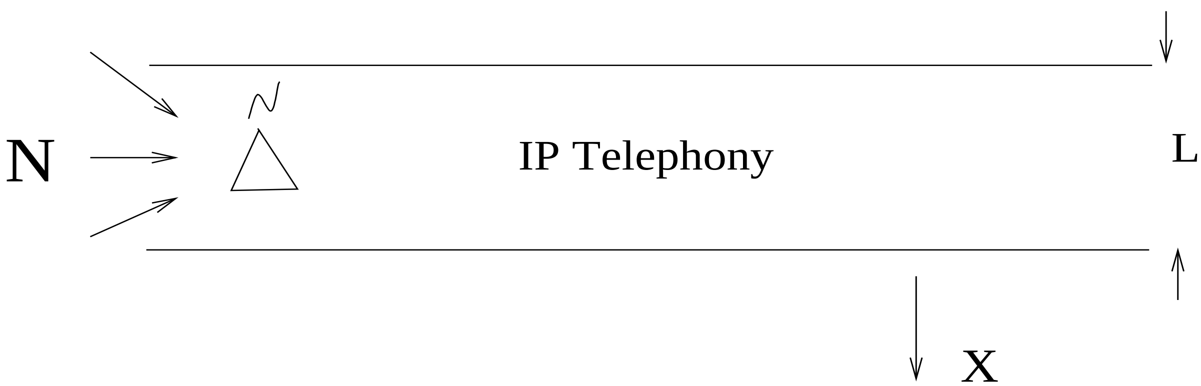
Goals

- Choose and verify appropriate models
- Establish mathematical, simulation and practical techniques for the task
- Stimulate cooperation between theoretical and experimental groups

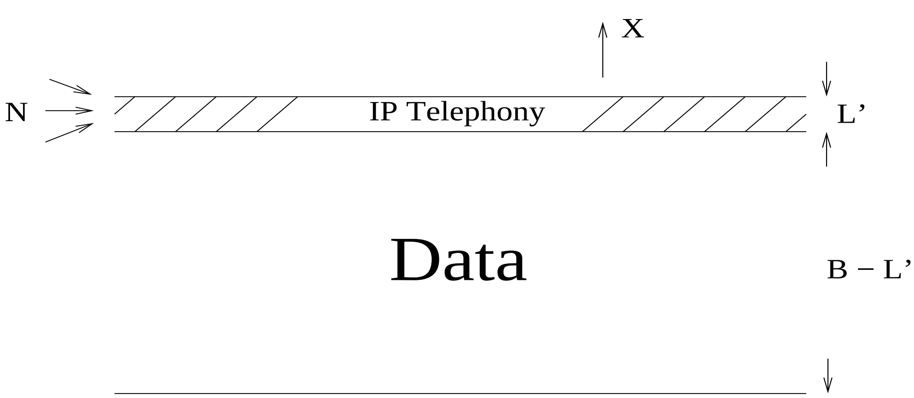
Classical dimensioning

- 1a. Want to know how many calls N can be routed over a link L for a given loss percentage X ?

- For a link (e.g. T1):

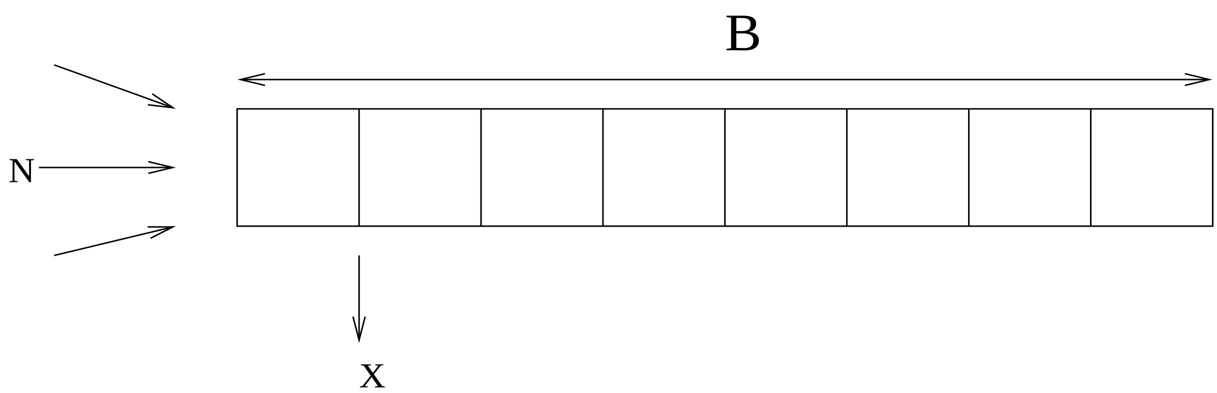


- 1b. Or a portion of a link L' (e.g. T3)



Buffer dimensioning

3. Want to know how large to make buffer B for N calls and a given loss percentage X ?



Or

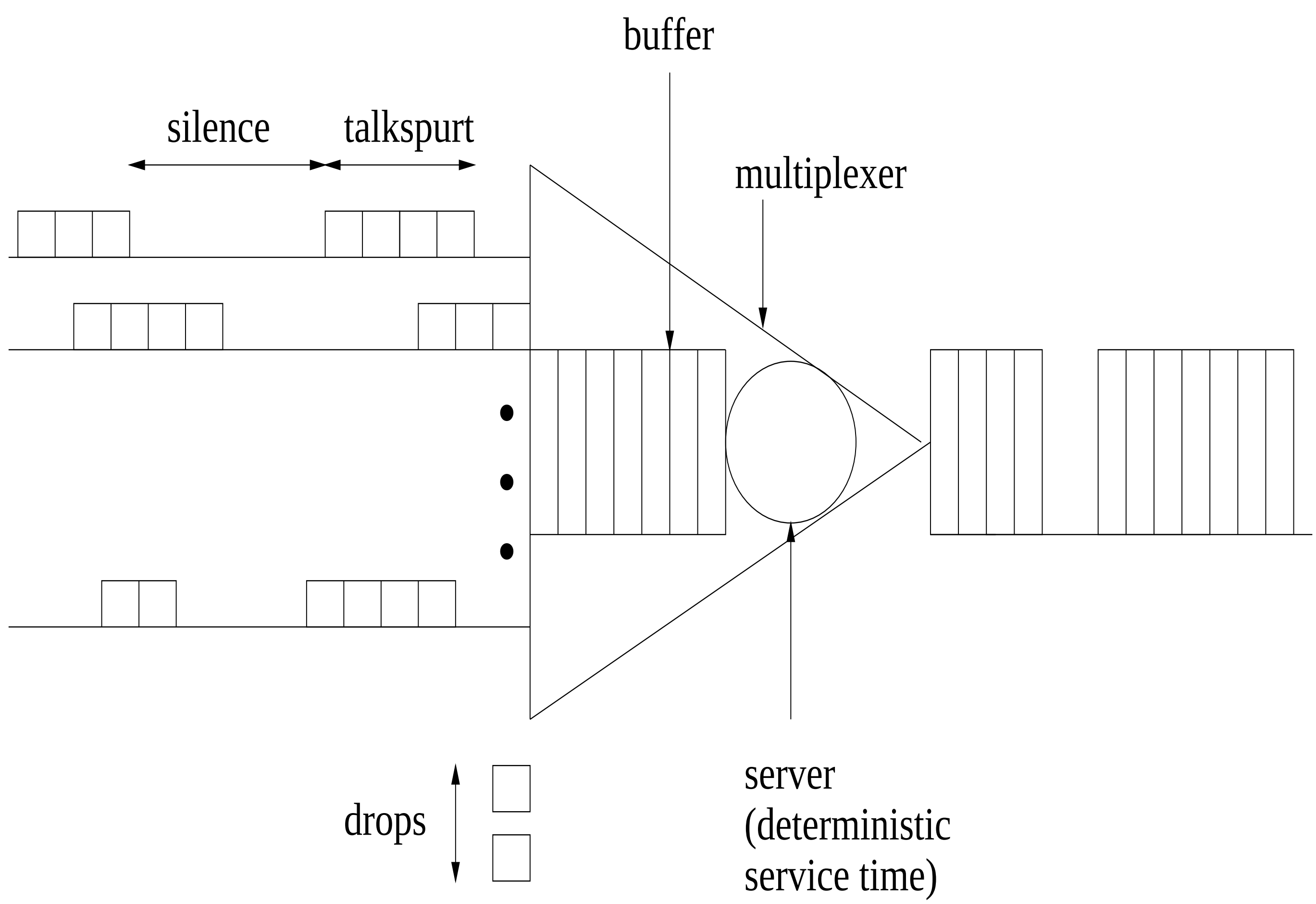
4. What properties should the sources have ?

- encoding
- packet size etc.

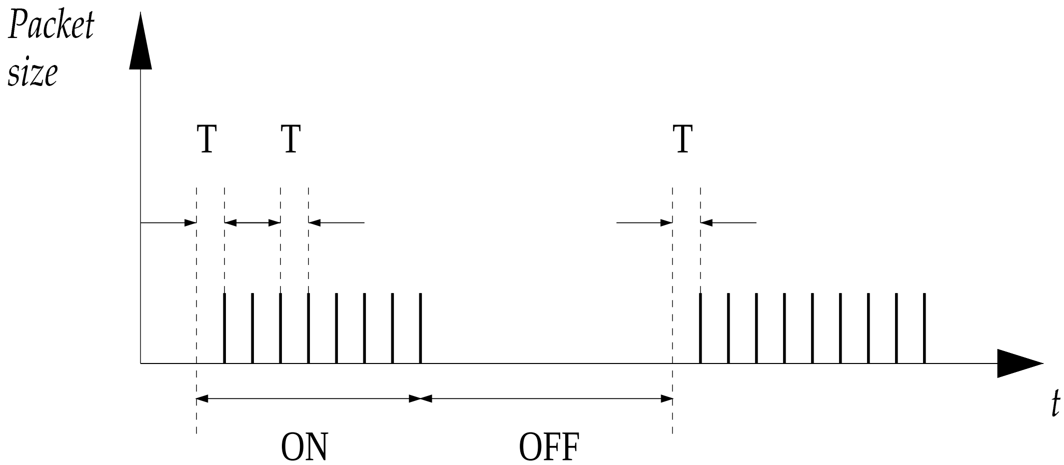
Core Architecture

Only audio traffic flows into this multiplexor

If normal traffic is mixed we have to separate them *before* this stage



Properties of a single source

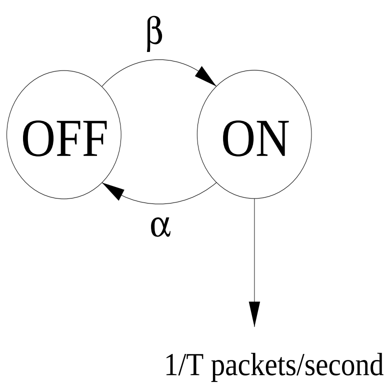


- All packets are the same size
- During ON periods packets are sent with the same inter-packet spacing
- No packets are sent during an OFF period
- ON and OFF periods are exponentially distributed

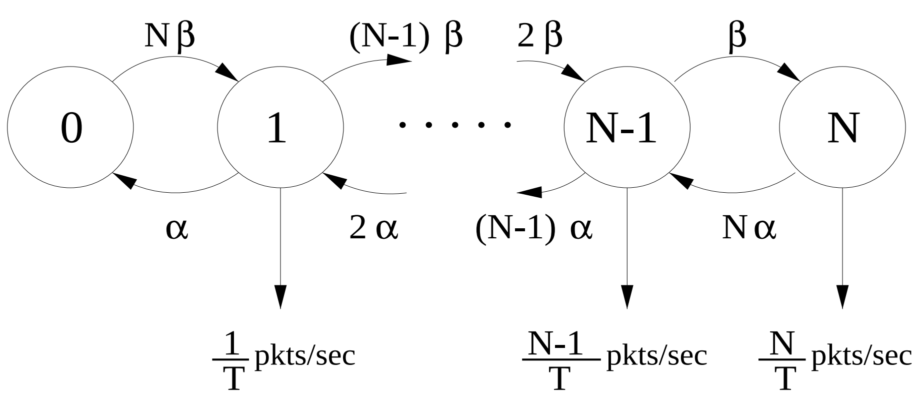
Arrival process as a Markov Process

Exponential distributed ON and OFF times means that we can describe the ON-OFF periods as a Markov process.

- A single source



- Arrival process for N sources



Problems

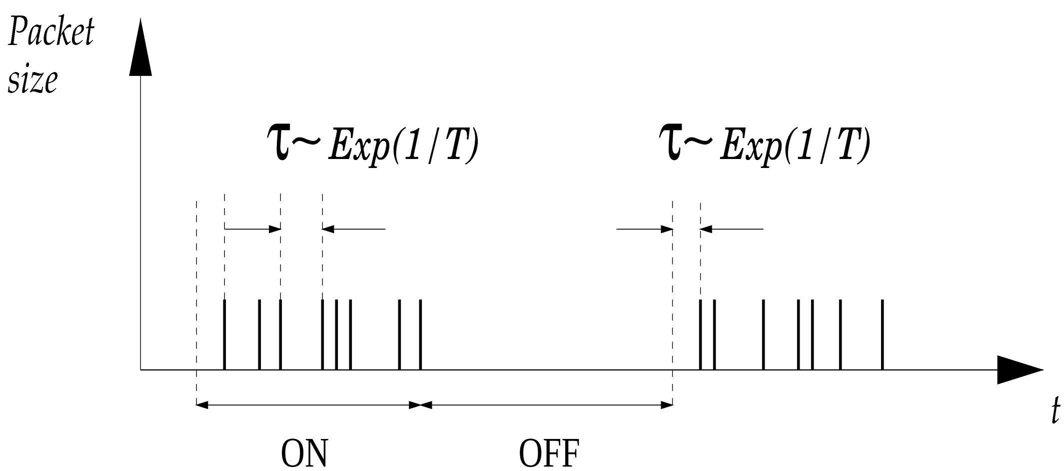
1. Determinate average arrival time hard to treat mathematically

2. Too many states in the process which alters the number of sources which are on

Solution to 1

"Determinate average arrival time hard to treat mathematically"

We assume we have an exponential distributed average inter-arrival times with the same average value as the inter-arrival times for the determinate case.

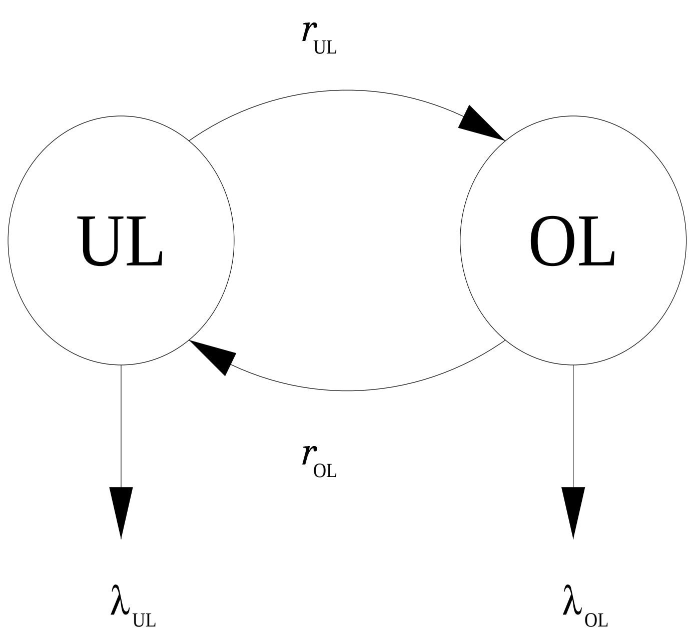


Now we have a Poisson process where one source is on. If we add 2 Poisson processes we obtain a new process. We can now use the mathematical theory for Poisson processes to help us further.

Solution to 2

"Too many states in the process which alters the number of sources which are on"

Combine the states into a 2 state model. One state constitutes the states where the arrivals under utilise the link capacity and the other where the arrivals over utilise the link capacity.



- This constitutes a Markov Modulated Poisson process (MMPP)

Simulations

We have simulated the multiplexor with NS-2 with the following parameters:

- Inter-arrival time for packets during an ON period is set to 16 ms
- OFF periods are exponential distributed with an average value of 650 ms
- Number of packets during a ON period are geometrically distributed with a mean of 22
- Packet size is set to 64 bytes
- The capacity of the outgoing link is 1.536 Mbit/s

Stability conditions

There is a maximum number of sources that can be multiplexed onto a link known as "*offered load*" or ρ

$$\rho = \frac{N F_p P_{on}}{C} < 1$$

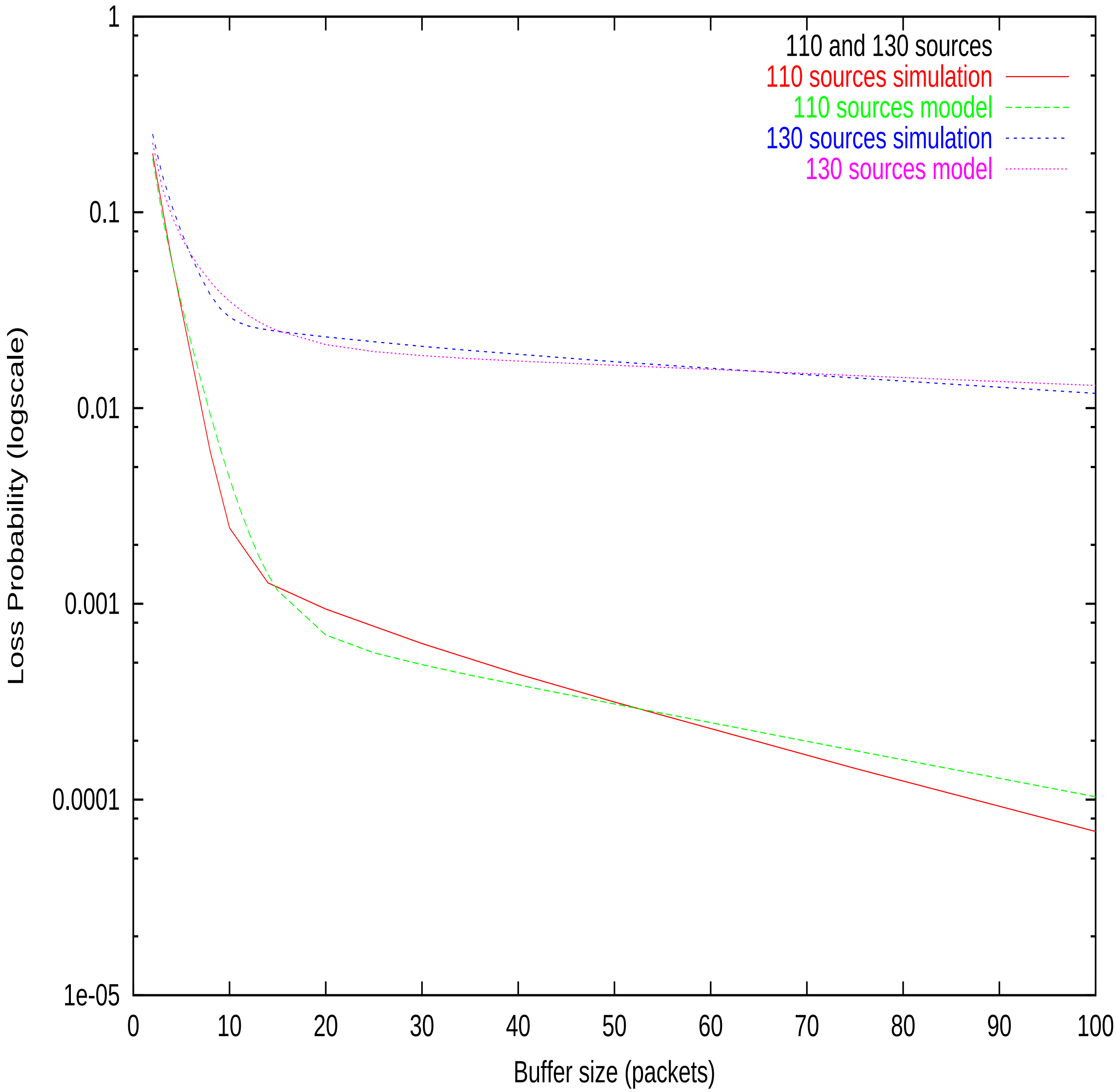
where:

N = number of sources
F_p = Max. rate of 1 source
P_{on} = Probability one source is on
C = link capacity

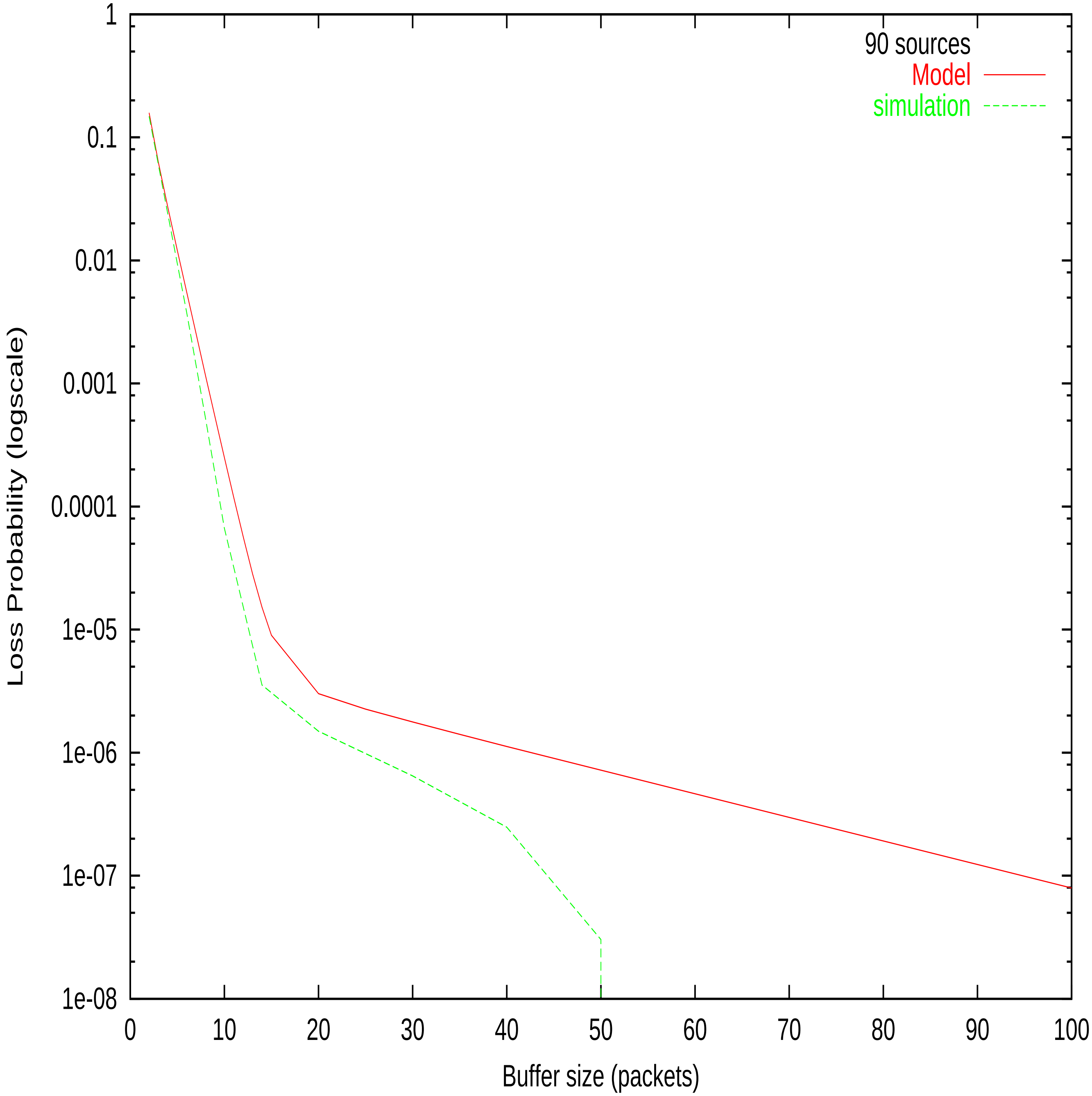
With our choice of parameters the maximum number of sources should not be more than 136.

Also note with peak rate allocation (i.e. $P_{on} = 1$) the maximum would be 48.

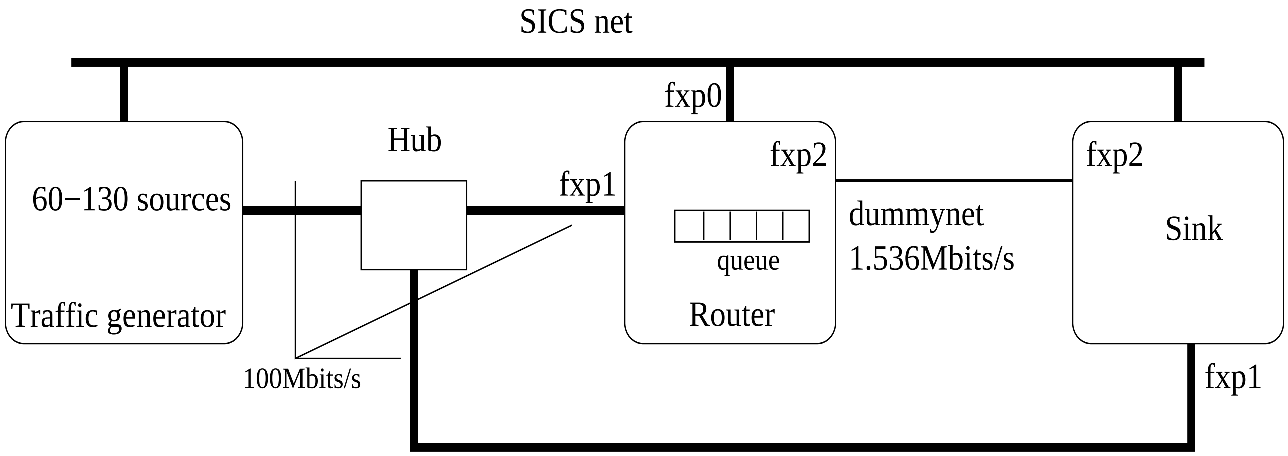
Loss probabilities 110 and 130 sources



Loss probabilities 90 sources (logscale)

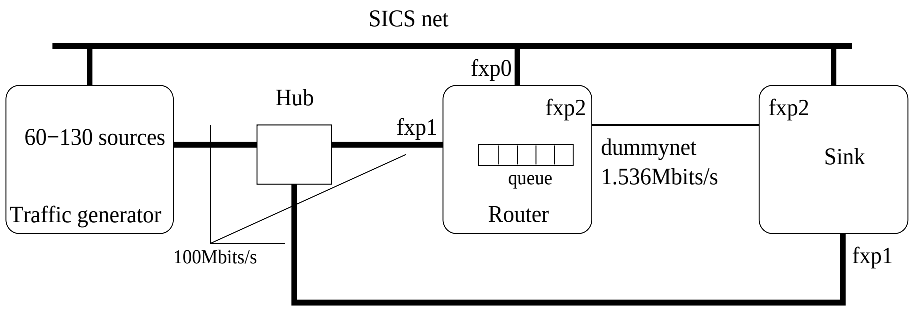


Laboratory experiments components



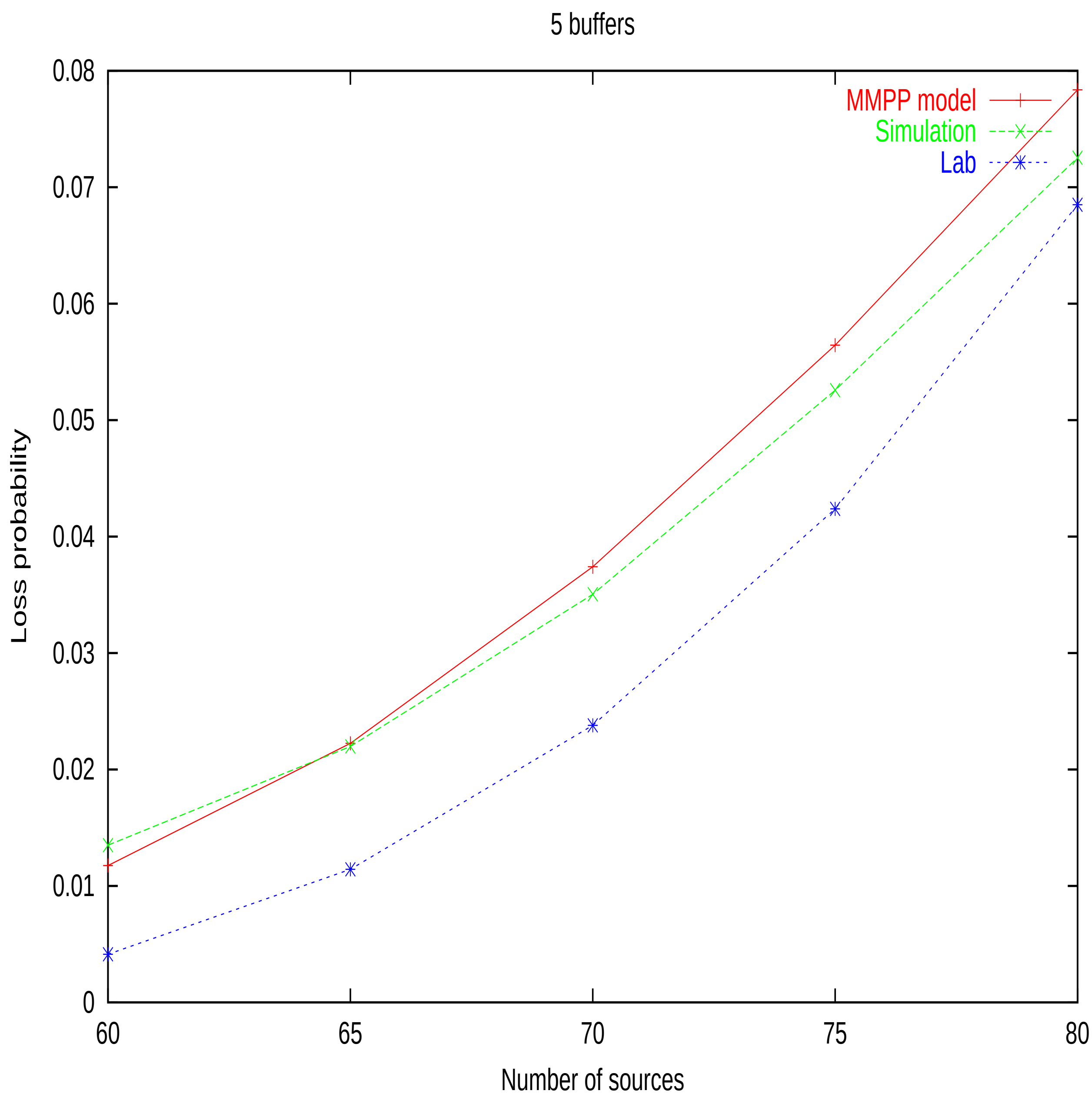
- Special traffic generator for IP telephony
- Router with constrained output link (Dummynet)
- Sink to receive and monitor original stream
- Pre-generate traffic patterns to save time (also for reproduceability)
- Goal is to simulate multiplexed telephony flows

Laboratory setup features

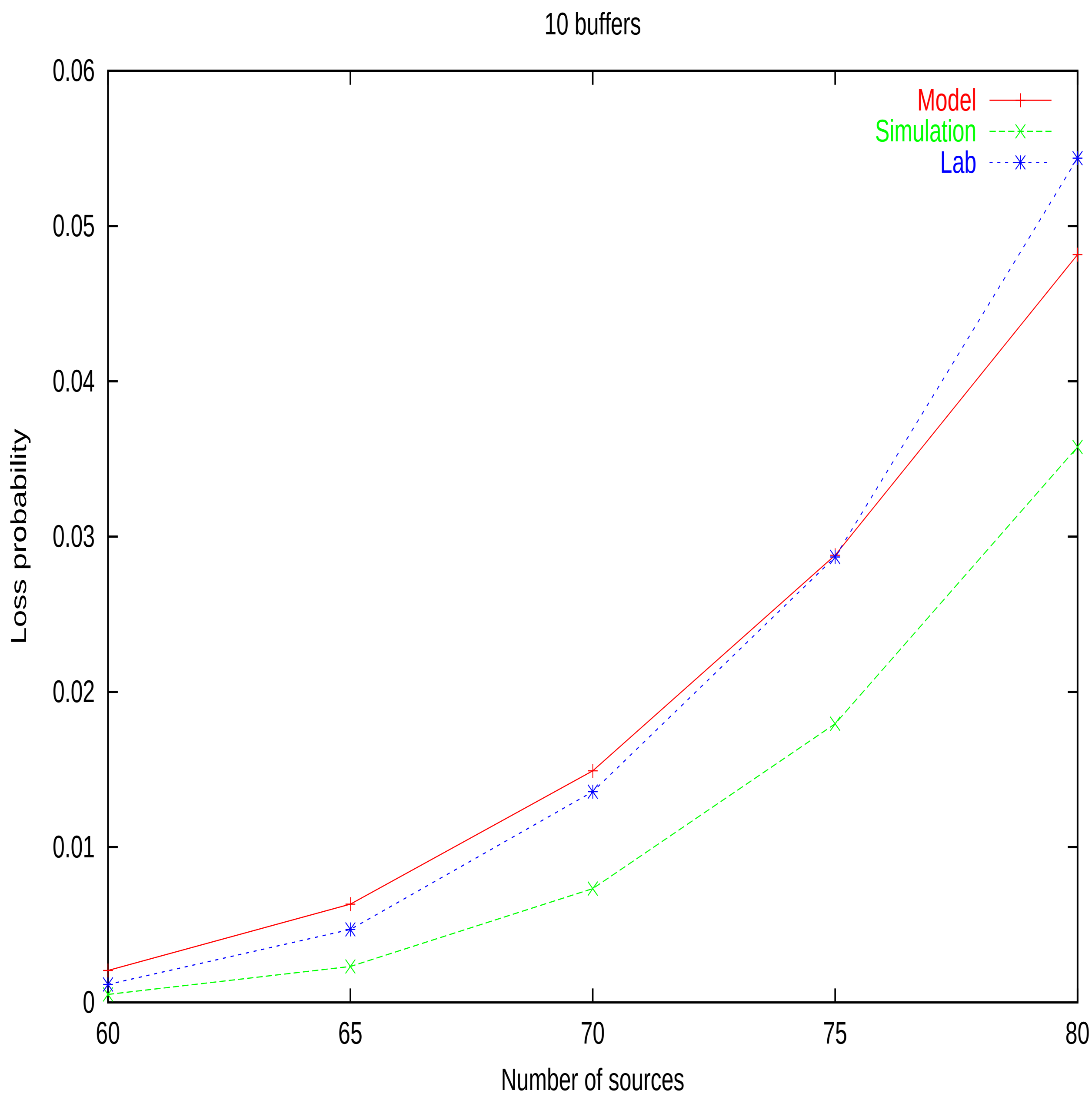


- Generator has internal ’timer’ to keep each flows timing strict
- Drops at queue fxp2 of router monitored
- Can be verified as difference of fxp1/fxp2 at sink
- RTP used to identify of each packet (seq no)
- Possible to calculate delay as well as loss
- Use Dummynet to change queue sizes in kernel without rebooting machine

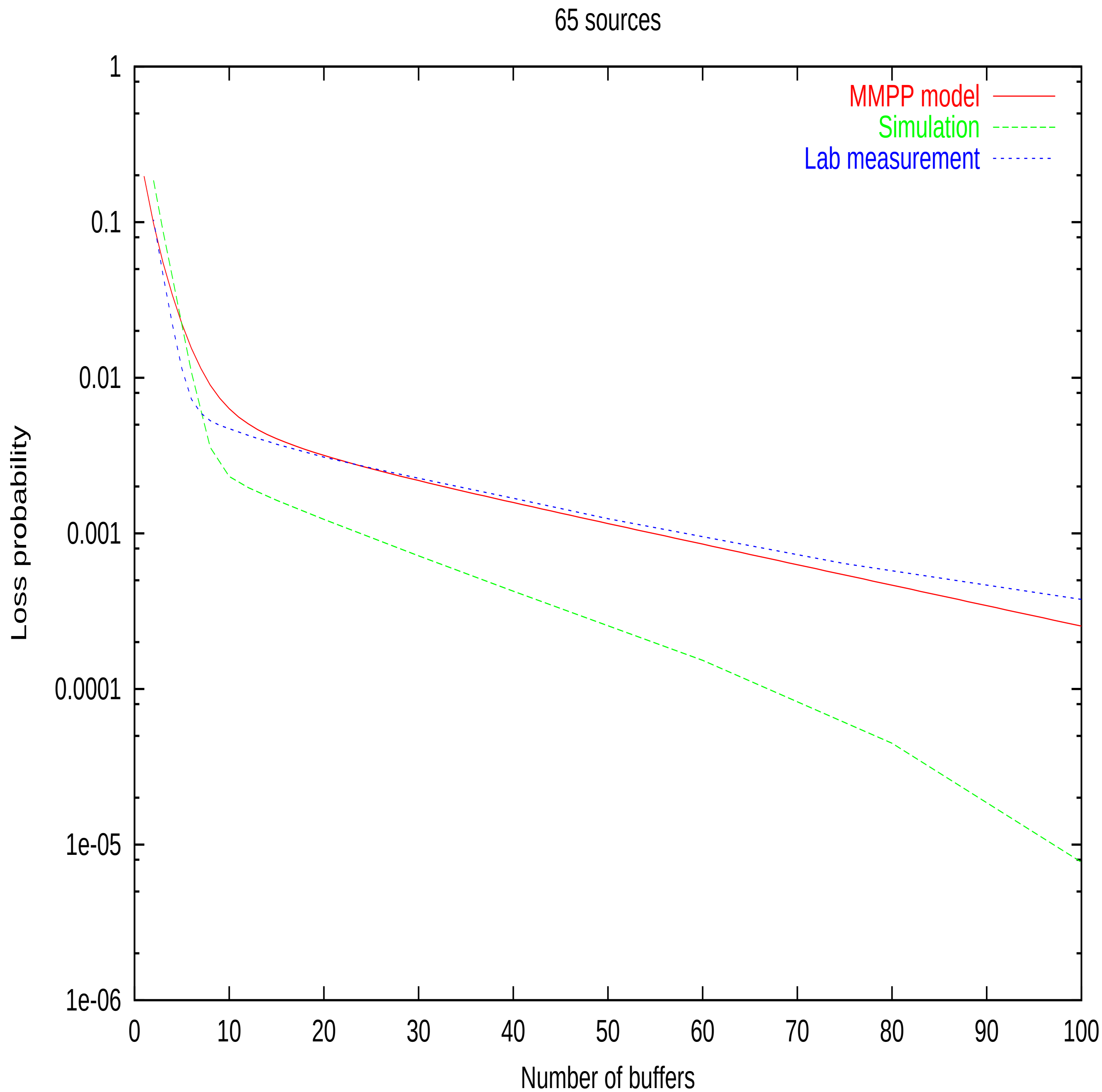
Lab. experiments 65 to 80 sources - 5 buffers



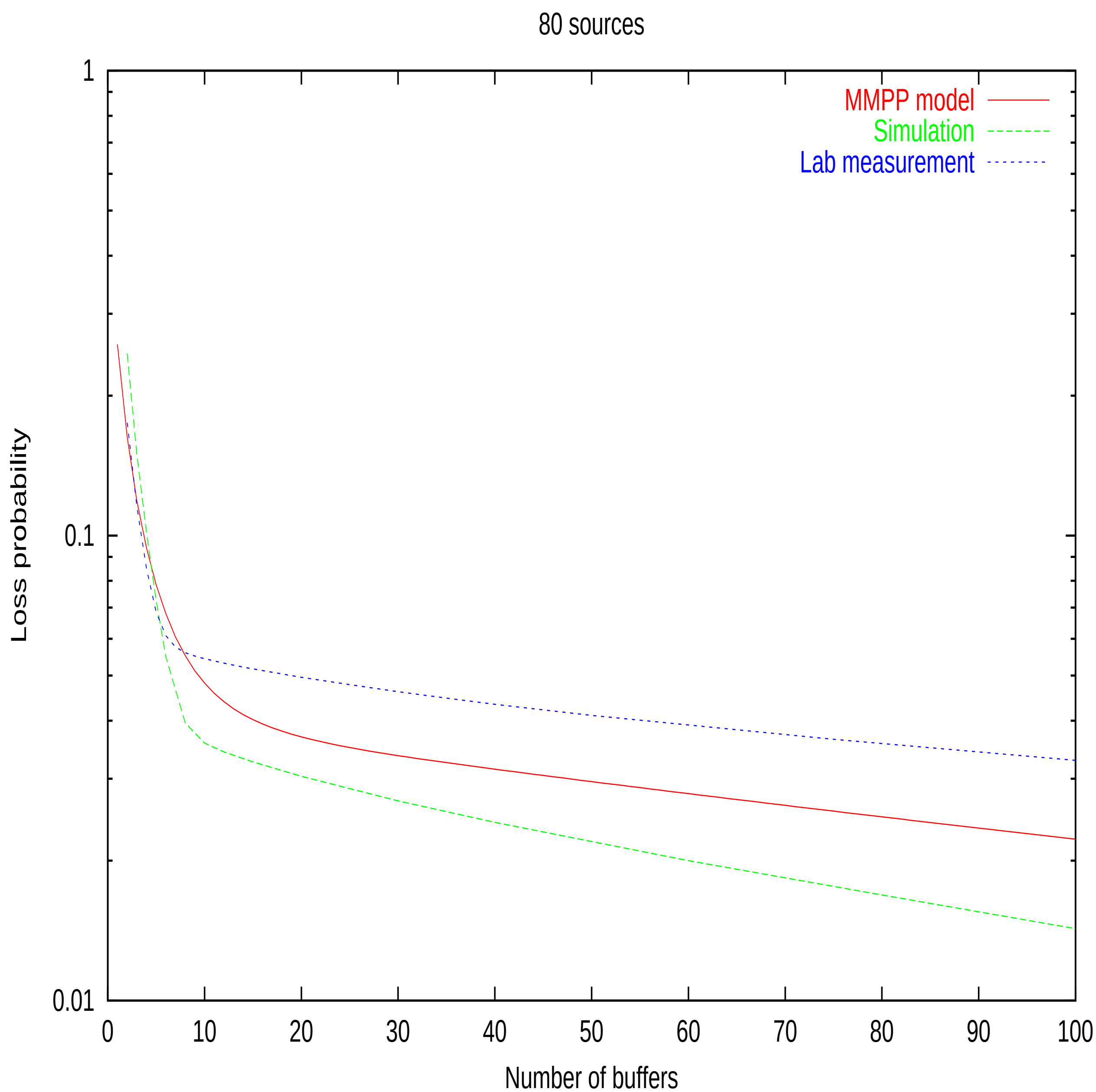
Lab. experiments 65 to 80 sources - 10 buffers



Lab Experiments 5 and 10 buffers with 65 sources



Lab Experiments 5 and 10 buffers with 80 sources



Related Work

- Anick/Mitra & Sondhi (82) studied infinite buffer with stochastic fluid flow (only under heavy load

- Heffes &Lucantoni (86) 2 state Markov modulated Poisson process quite successfully for infinite buffer multiplexor

- Tucker (88) looked at multiplexer with finite buffer using the fluid flow model (not good for small buffers)

- Nagarajan/Kurose and & Towsley (91) show the above does not work in the finite buffer case

- Baiocchi (91) approximate the arrival process with a two-state MMPP and use asymptotic matching to calculate parameters

Related Work 2

- Andersson (2000) uses above together with Baiocchi, Melazzi and Roveri's method to calculate loss probabilities

Discussion and differences

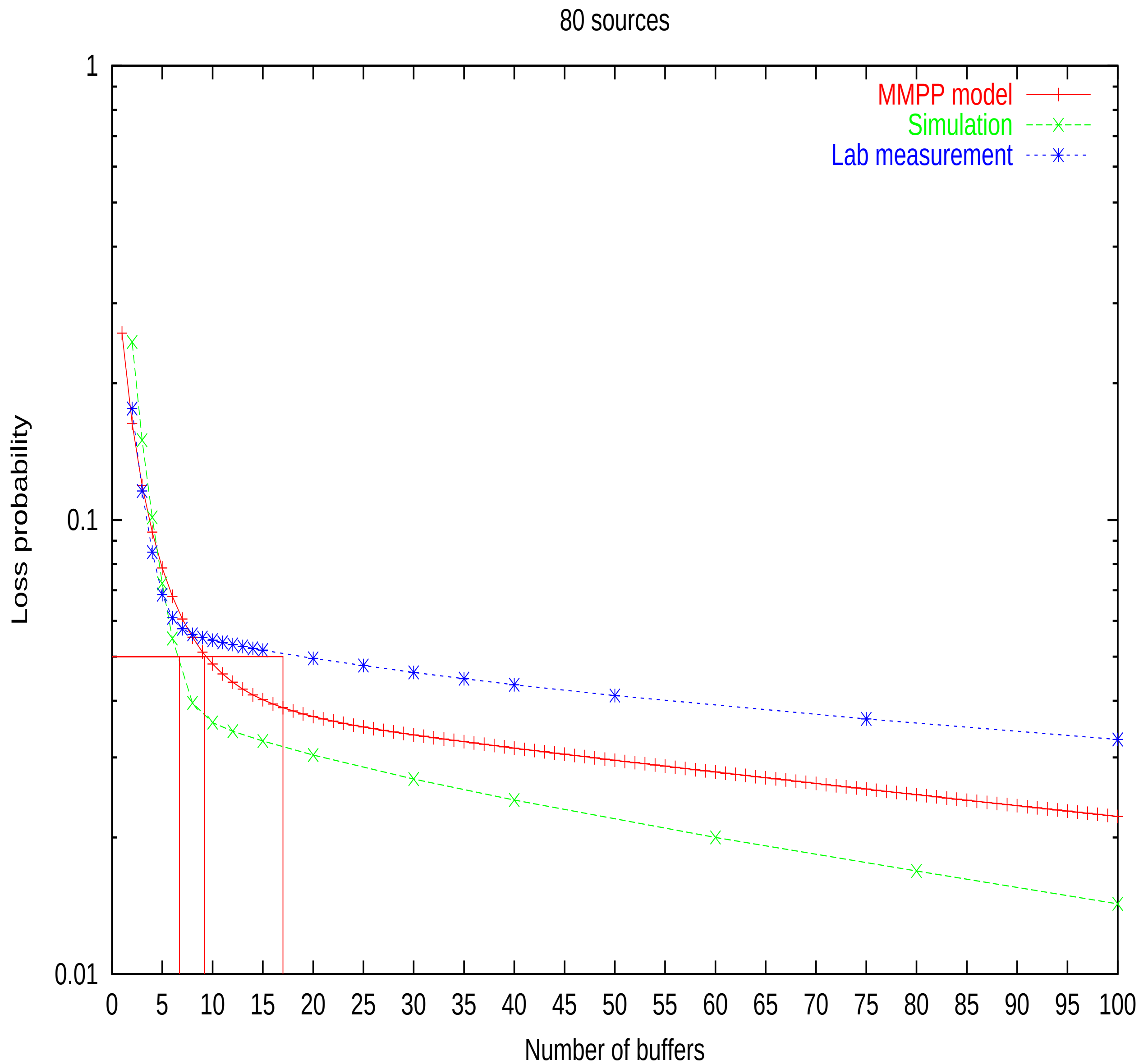
Why do we not get an *exact* match ?

- Model is an approximation

- Lab always has some inaccuracies

- The constrained link is not exactly 1.536Mbits/sec (verified with mgen and netperf)

80 sources with 5% loss



- Lab 17 buffer places, model 9 and sim 7
- If we chose 7% loss, all give 5 buffers

Conclusions

- Using approximations we can break the problem into something we can analyse

- Without quality degradation we can double the utilisation by using “statistical multiplexing” instead of “peak rate allocation”

- The model we studied (MMPP/D/1/K Baiocchi, Melazzi and Roveri ’91) seems well suited to dimensioning links

- Verified by both good simulation and lab results

- Very useful to do more than just model and sim, we can believe the theories work !!!