



802.17 Performance modeling

Preliminary performance results from a simple Java model

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RPR performance modeling

- ◆ A simple RPR model written in the programming language Java:

Class Node // single direction node

Class DualNode

Class Buffer // several needed in each node

Class Link // one (out) for each single Node

Class Packet // new one for each packet sent

Class Application // generating system load, etc

Class Kernel Class Unit // simulation environment



RPR performance modeling

◆ RPR model status as of May 14. 2001:

Dual rings with shortest path forwarding

Two priority levels with two set of buffers

Absolute priority for the highest (provisioned)

Choice of preemption (without packet loss ($1/2$ K))

Cut-through (store&forw. very easy to implemet)

Parameters:

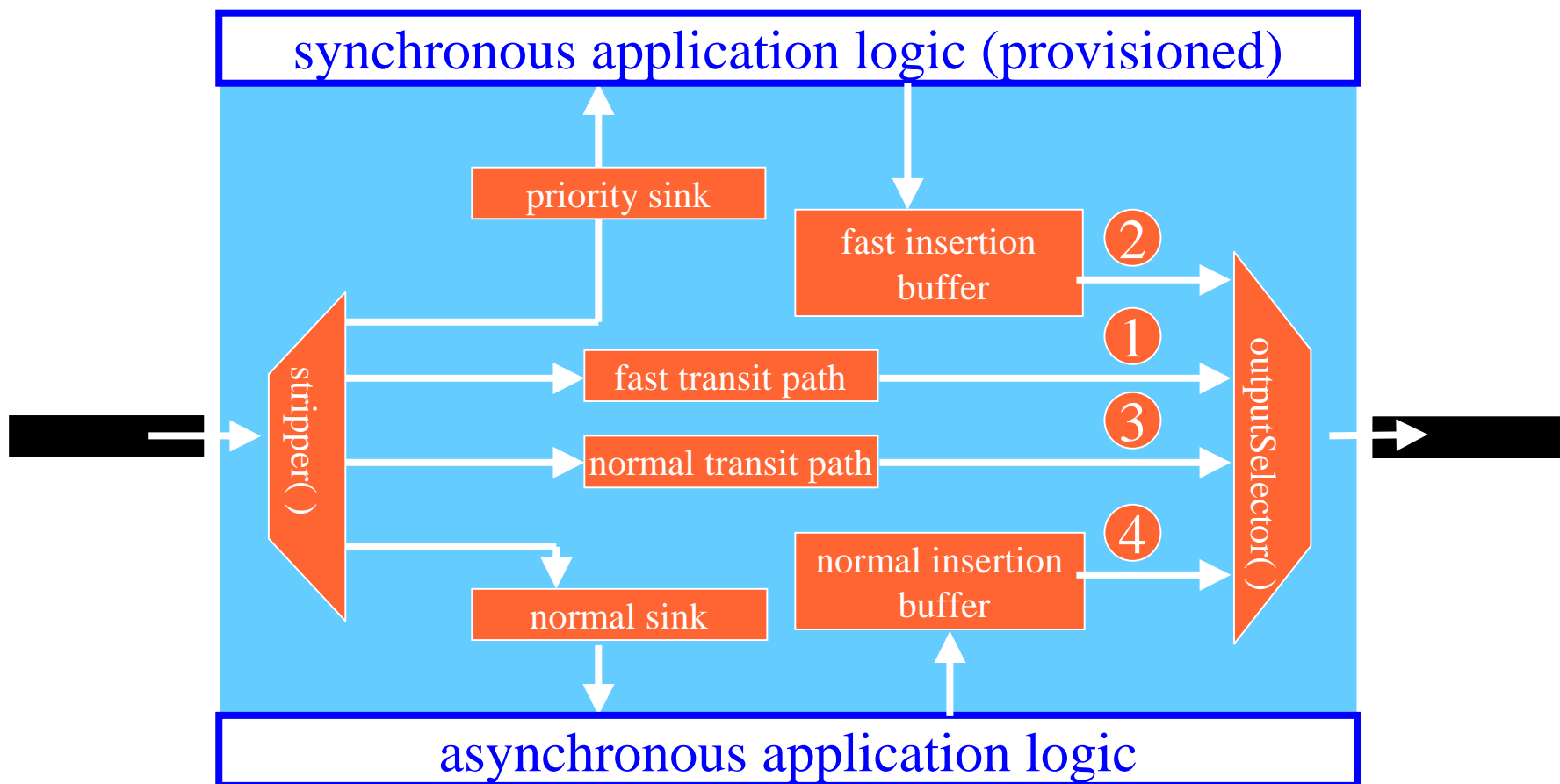
No. of nodes, wire length/wire latency, bandwidth

Programmable (in Java) load (Class Application) with destination and packet size set individually for each packet sent

Simple statistics (Class Reporter)

No flow control yet

Single Direction Node Model



Traffic put into correct single node depending on shortest path



Simulation Topology

- ◆ 16 nodes (numbered 0 – 15), dual rings
- ◆ 250 microsec. cable between each node
includes one node bypass latency
(~ 50 km between each node)
- ◆ 1Gbyte/sec bandwidth (= 10Gbit/sec)

Two basic Scenarios

- ◆ Scenario A – Random receiver

 - Overloaded system – 10Gbit/sec/link

 - Three background packet sizes:

 - 1600 , 16K and 520 bytes

- ◆ Scenario B – Hot receiver

 - Partly highly loaded system – 10Gbit/sec/link

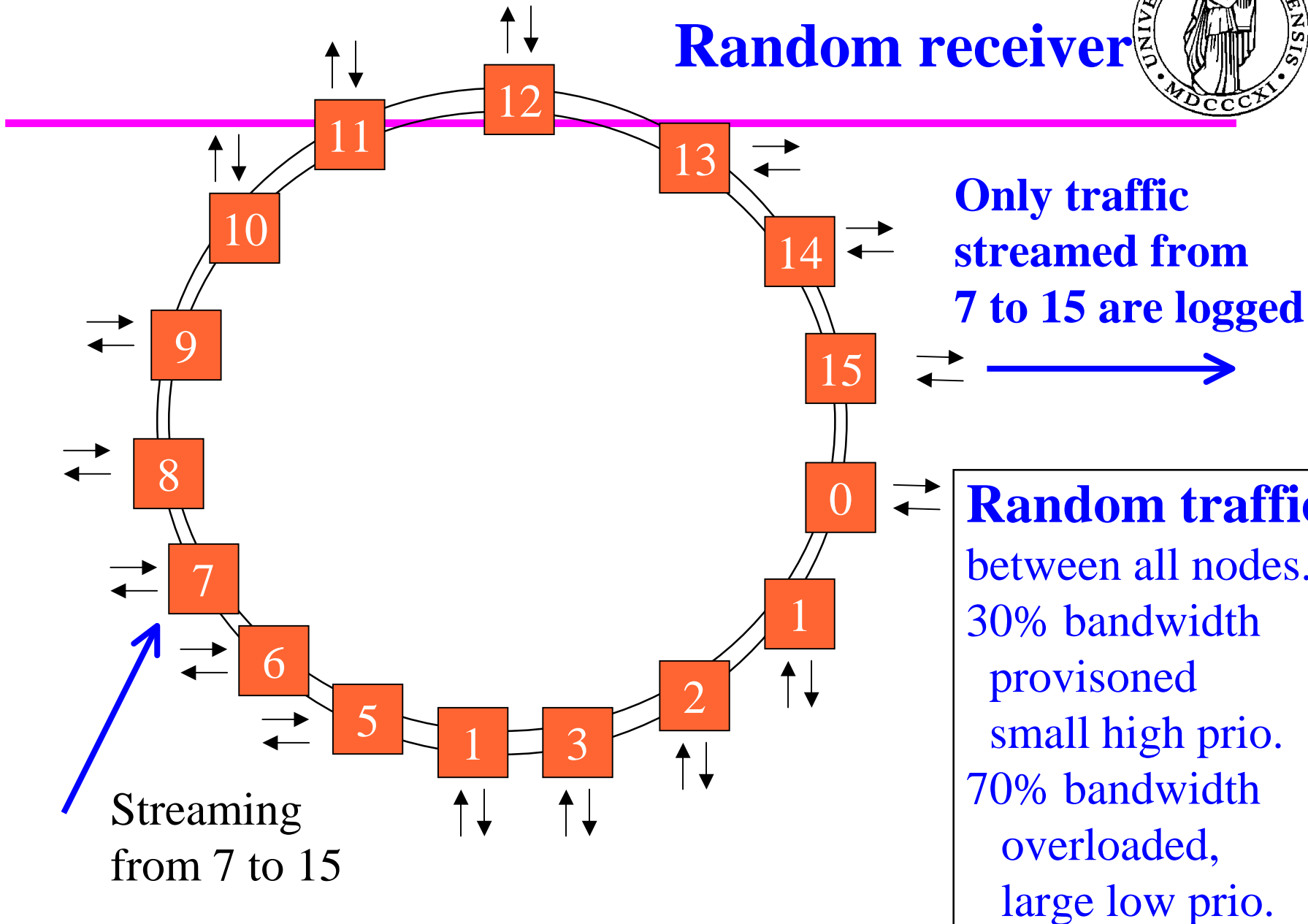
 - Three background packet sizes:

 - 1600, 16K and 520 bytes

Simulation Scenario - A



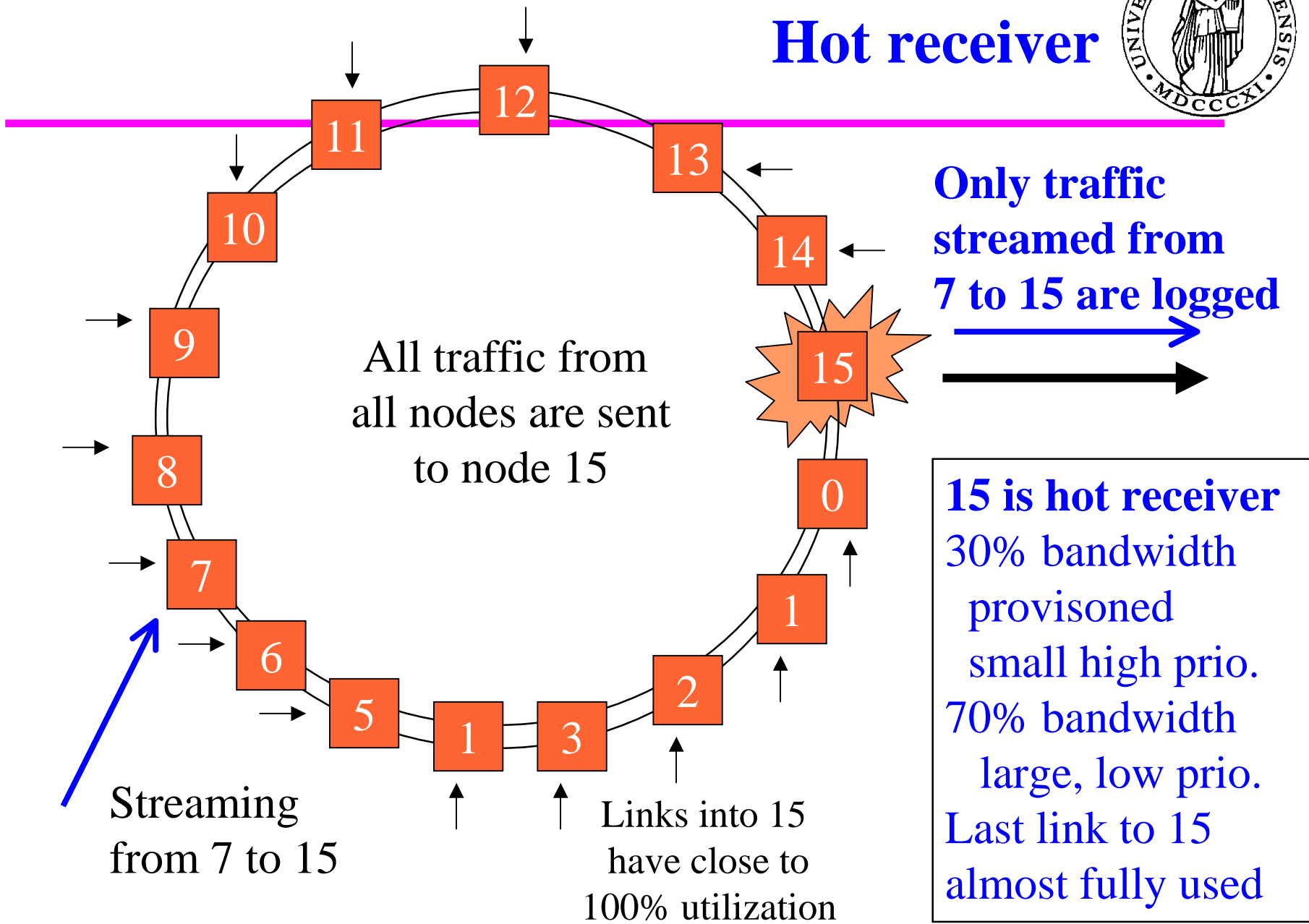
Random receiver



Simulation Scenario - B



Hot receiver





Measured traffic

- ◆ Latency / jitter
- ◆ Streaming small high priority packets (80 bytes including header) from node 7 to node 15
 - 8 hops, ~ 400 km distance = 2ms min. latency
- ◆ 2 us. between packets
- ◆ 125 us. between packets (TDM frame interval)

Background traffic

◆ Load distribution

30 % bandwidth high priority small packets

70% bandwidth low priority

- "IP-packets" (1600 bytes)
- Jumbo-packets (16K)
- Jumbo-packets with preemption (1/2 K)

□ A. Random receiver

network overloaded

□ B. Hot receiver (node 15)

Almost full utilization of last link into hot receiver
(i.e. lighter loaded system than A, but not easy to get comparable load in all cases)

Results

- ◆ Packet Latency (and Jitter) in a stream of small (80 byte) high priority packets
- ◆ How much delay/jitter are caused by other packets blocking ?
- ◆ Delay caused by
 - Low priority packets on their way out (mostly)
 - Other high priority packets (also)
- ◆ Single runs of 20 ms
(statistics from 10,000 packets)
- ◆ No confidence intervals etc.

Scenario A: Random traffic – overloaded



- ◆ Traffic from all nodes to all nodes (random destination)
- ◆ All links full all the time
- ◆ Measuring high prio. stream from 7 to 15 with 2 us. or 125 us between packets
- ◆ Background traffic is
 - 30% high prio 80 bytes packets (provisioned) and 70% low prio packets:
 - 3 sub-scenarios with 3 packet sizes:
 - A1. 1600 bytes "IP-packets" or
 - A2. 16K jumbo packets or
 - A3. 16K jumbo packets with preemption (1/2 K)

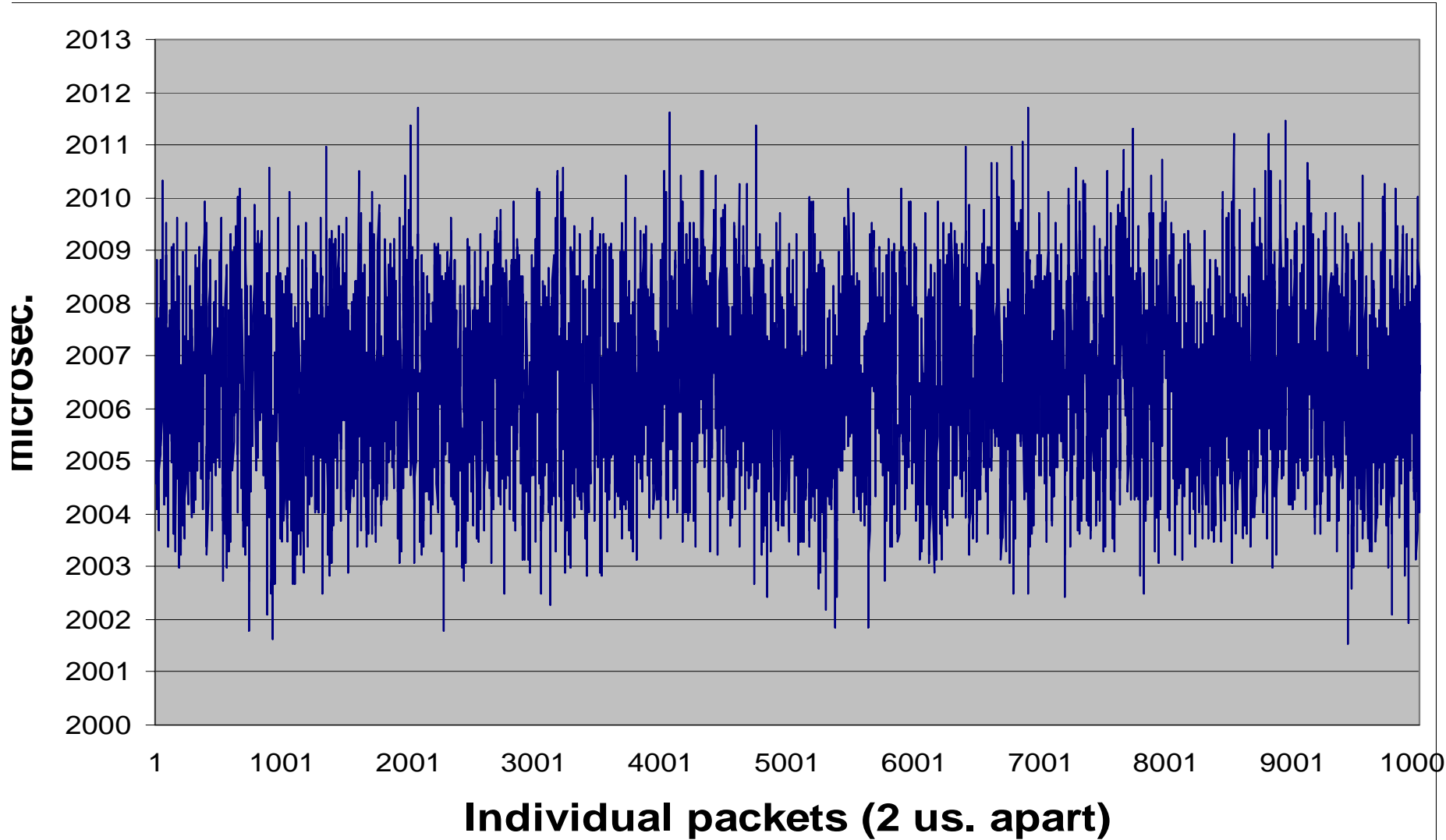


Scenario A1: Random "IP-packets" background

- ◆ Random background traffic with
 - 30 % bandwidth high prio small packets
 - overloaded with "IP-packets" (1600 bytes)
- ◆ Streaming from node 7 to node 15
 - 8 hops, ~ 400 km distance = 2ms min latency
 - 2 us between packets
 - 125 us. between packets

A1. Latency

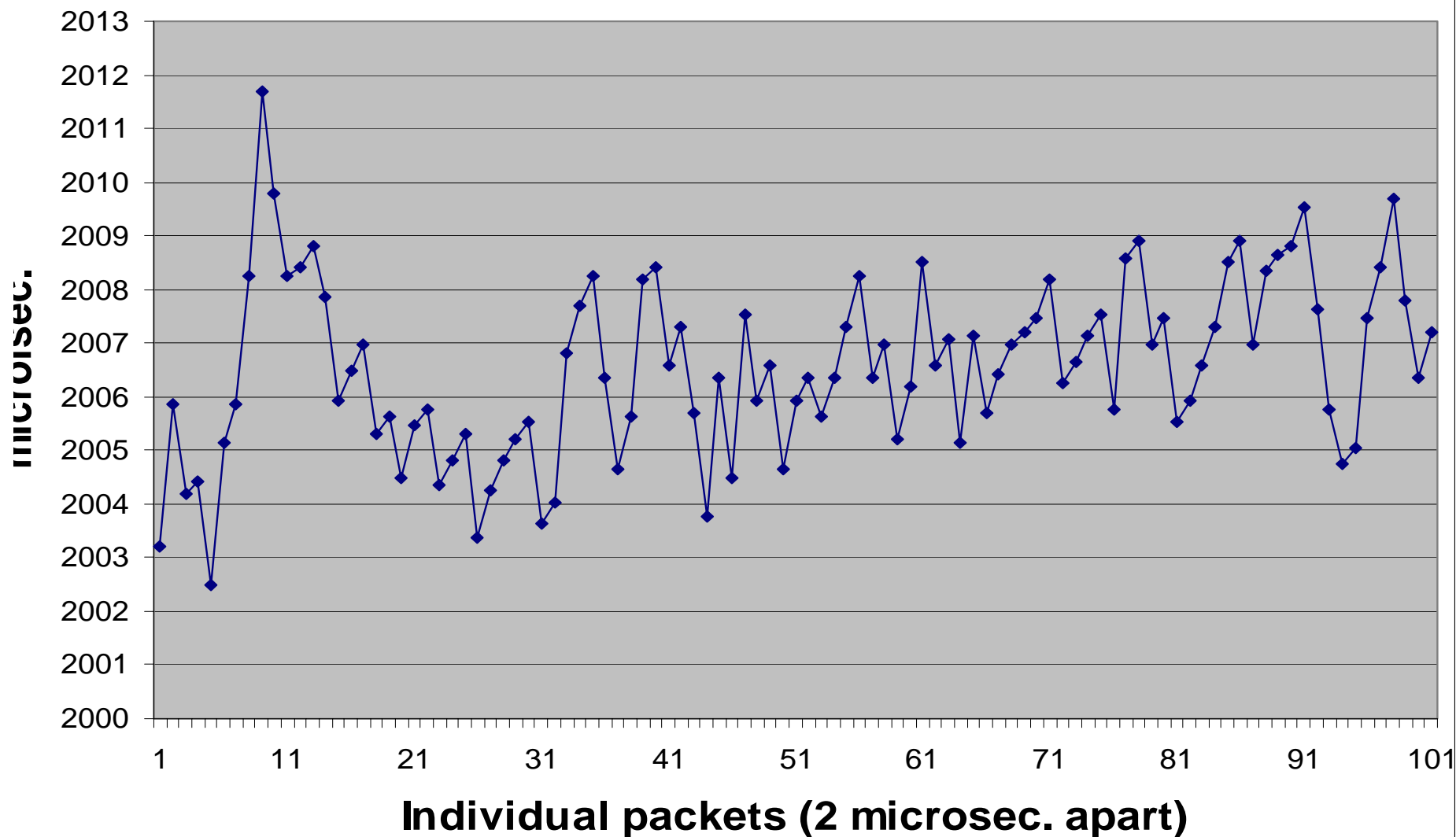
Streaming high prio. small packets 8 hops (400 km., 2ms.)
with random overloaded "IP-packets" (1600 byte) background





A1. Latency

Streaming small packets 8 hops with overloaded "IP-packets" background. [More detailed sample.](#)

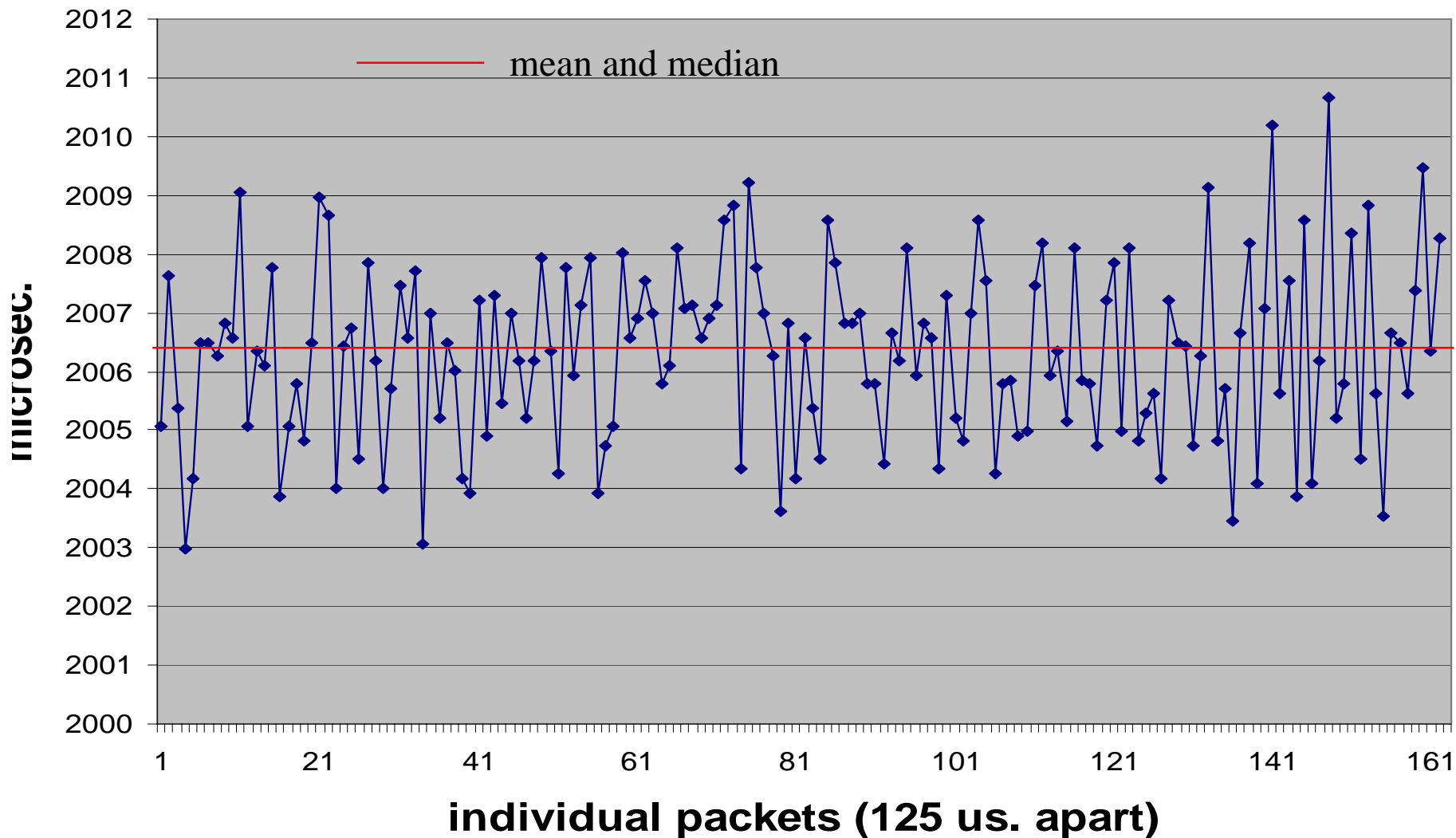




A1. Latency

Streaming small packets 8 hops with overloaded

"IP-packets" background. 125 us. between packets.





A1. Conclusion: Streaming small high prio. packets with "IP packets" overloaded background

- ◆ Added latency between 2 and 12 us.
(going 8 hops, 400 km., 2 ms.)
- ◆ Theoretically added latency between 0 and 13us.
- ◆ Max 11.7 us. Min. 1.5 us. added latency
- ◆ 0.1 %: more than 11us. added latency
- ◆ 1%: more than 10us. added latency
- ◆ Mean and median is 6.4 us. added latency
- ◆ Max jitter almost as large as total latency variation

Scenario A2:

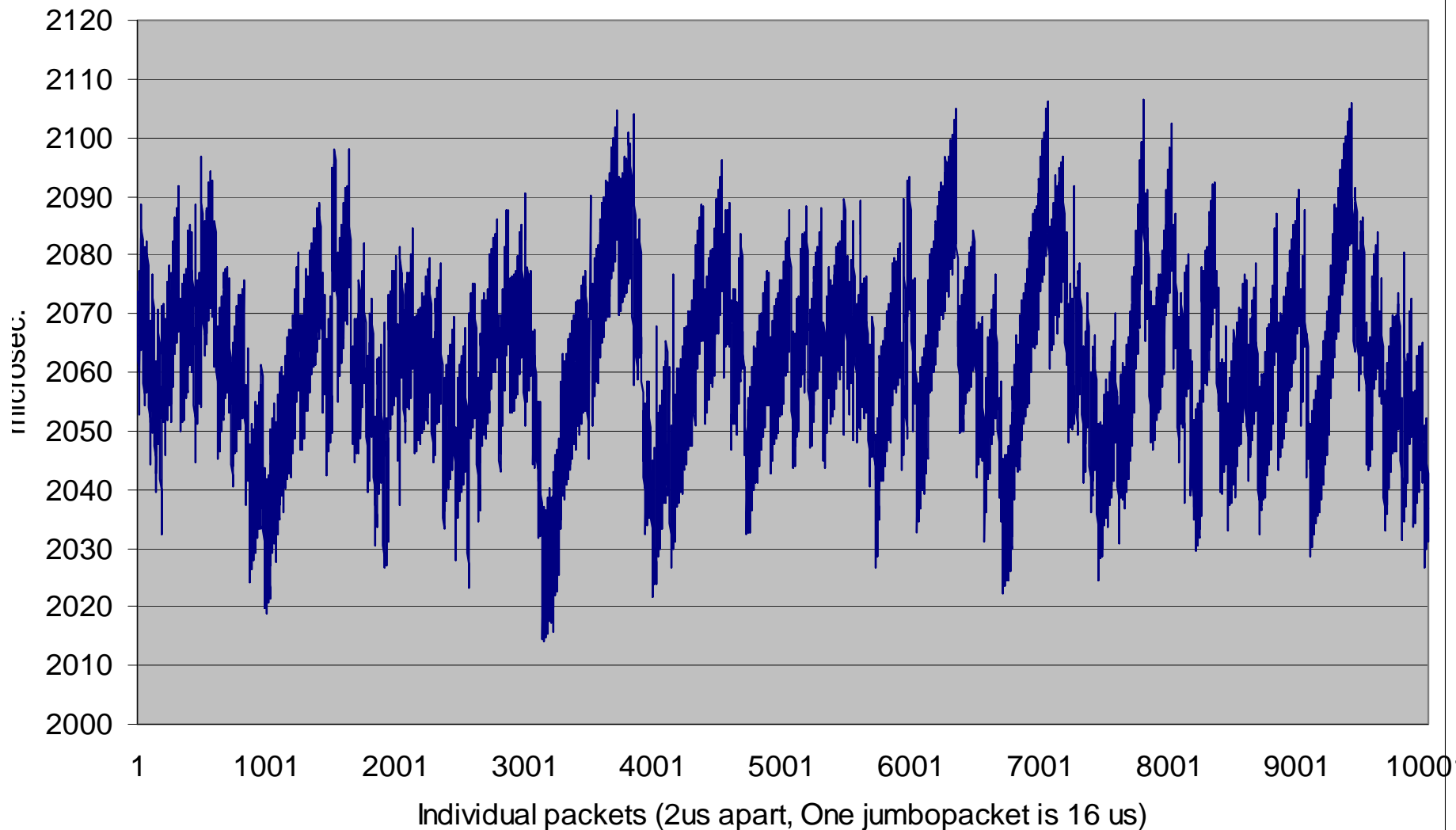
Random Jumbo packets background



- ◆ Random background traffic with
 - 30 % bandwidth high prio small packets
 - overloaded with Jumbo packets (16K bytes)
- ◆ Streaming from node 7 to node 15
 - 8 hops, ~ 400 km distance = 2ms min latency
 - 2 us between packets
 - 125 us. between packets

A2. Latency

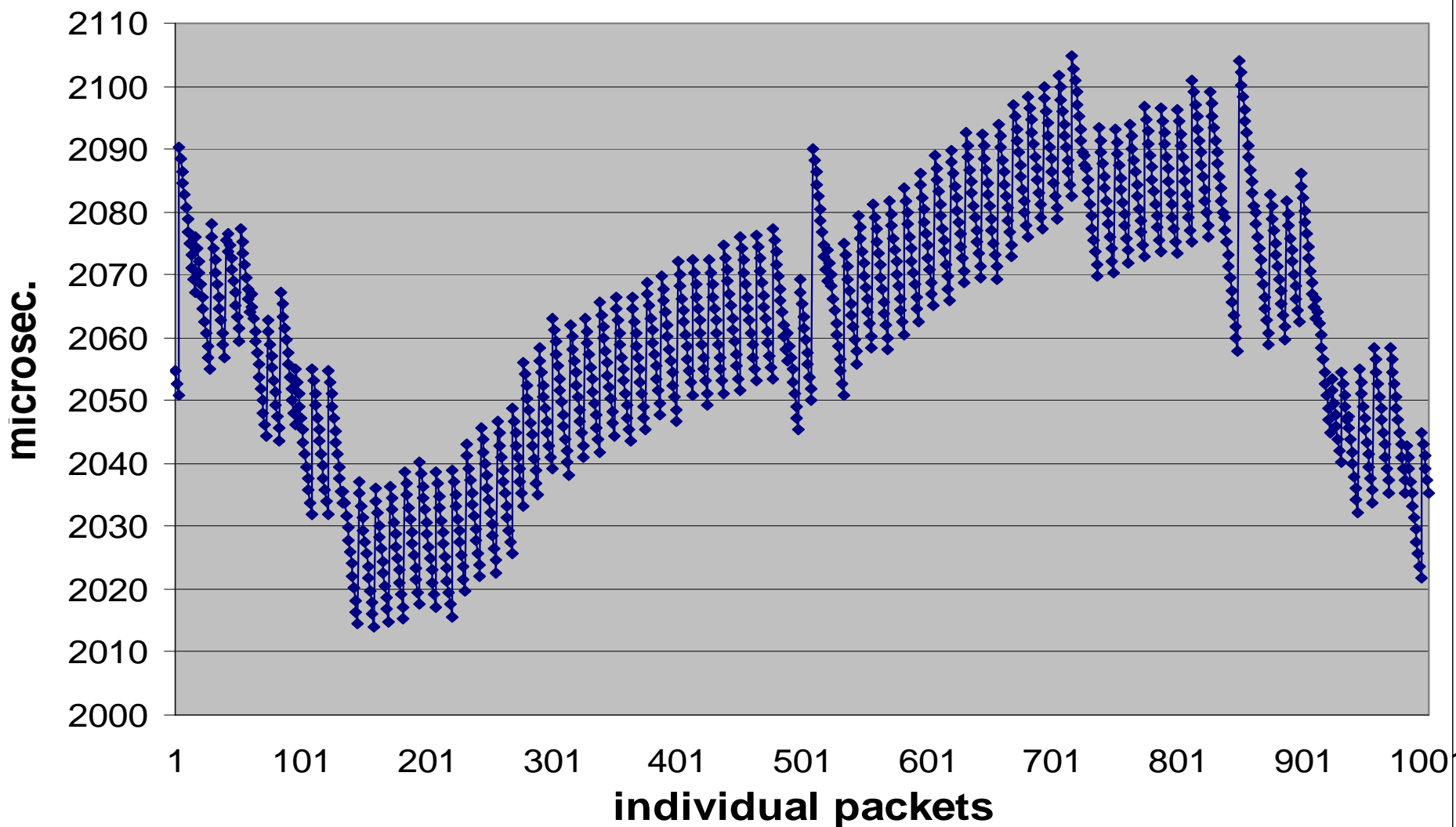
Streaming small high prio. packets 8 hops (400 km., 2 ms.)
with random overloaded **Jumbo-packets** (16K) background





A2. Latency

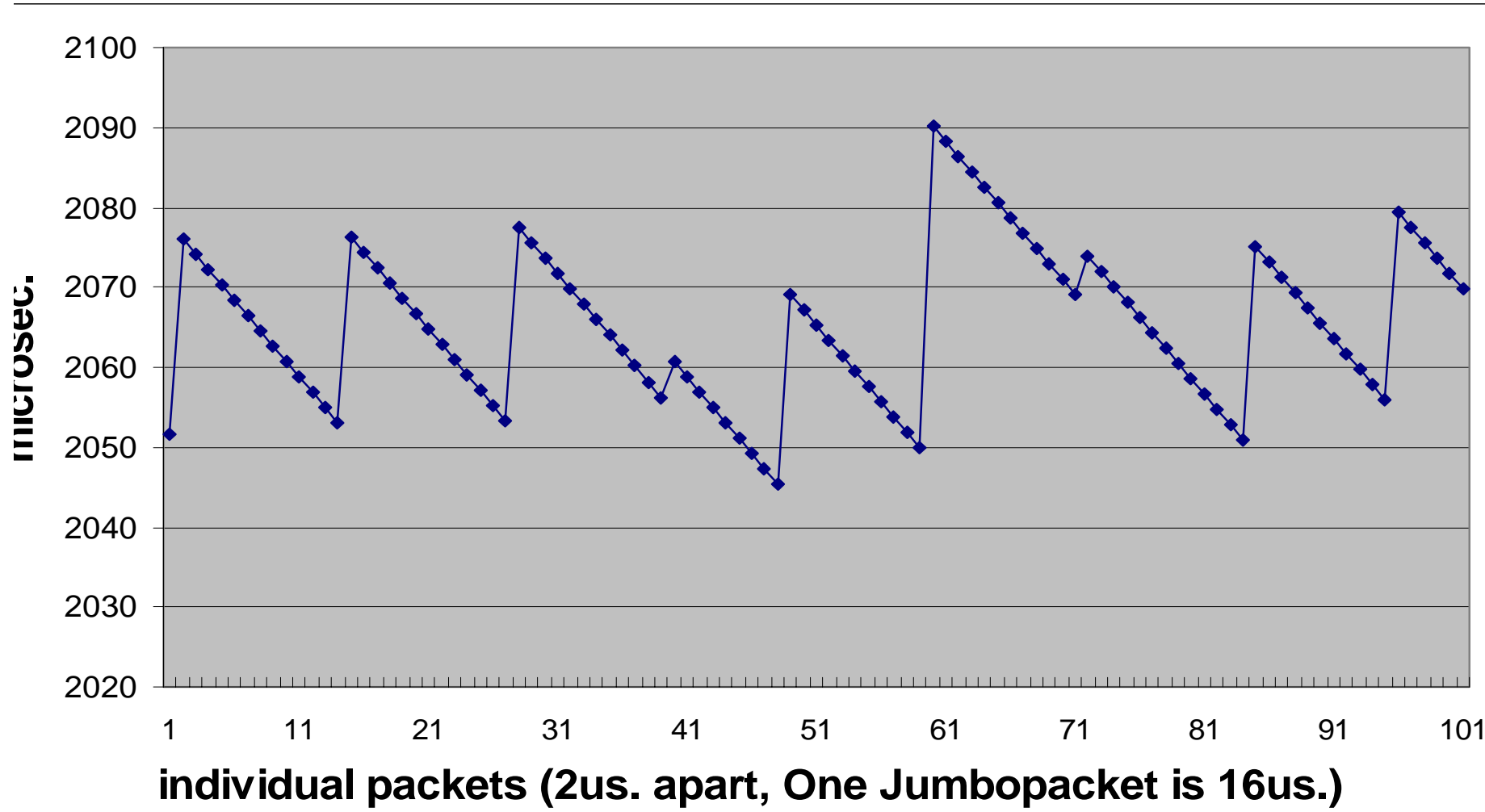
Streaming small high prio. packets 8 hops with
random overloaded **Jumbo-packets** (16K) background [\(details\)](#)





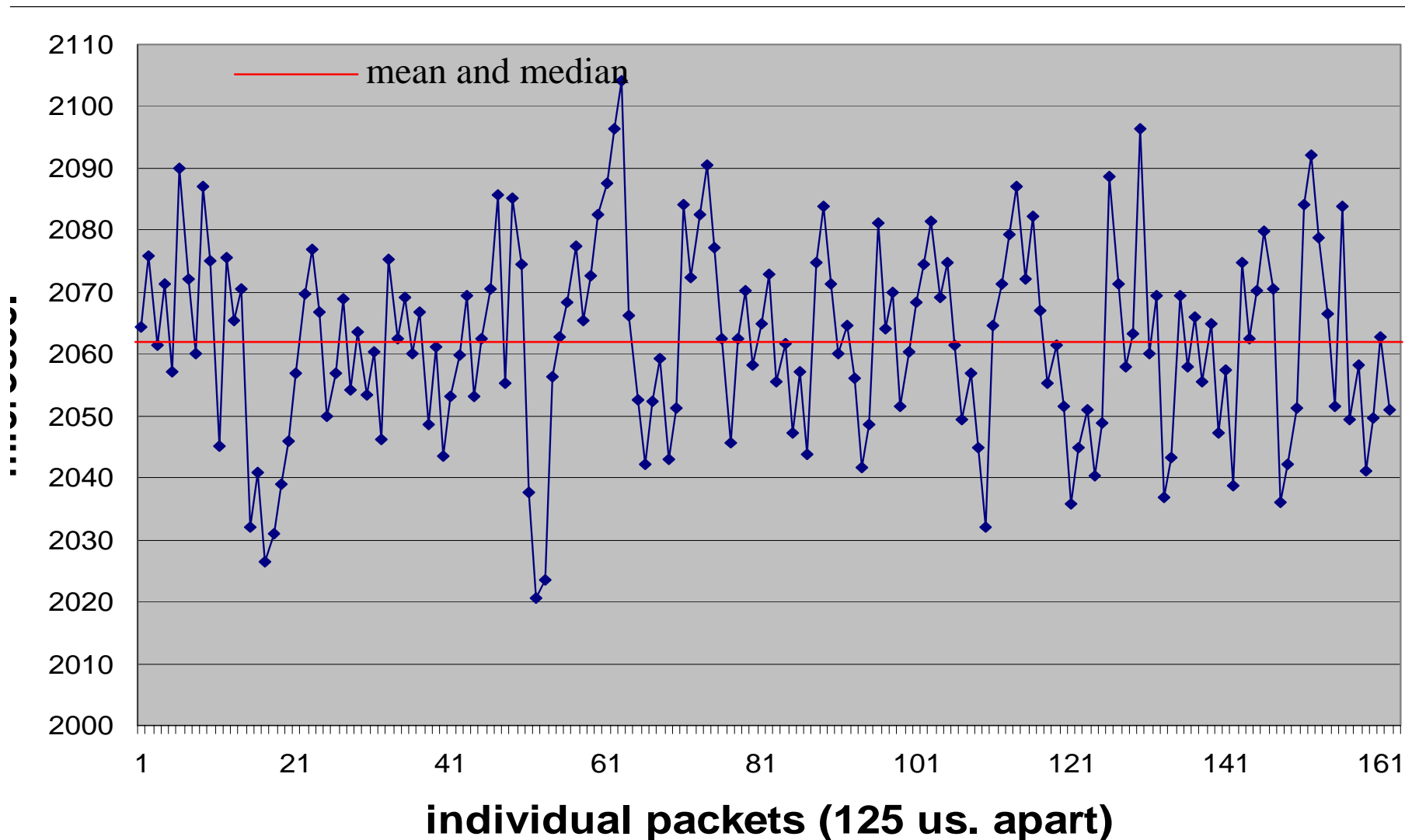
A2. Latency

Streaming small high prio. packets 8 hops with random overloaded **Jumbo-packets** (16K) background [\(more details\)](#)



A2. Latency

Streaming small high prio. packets 8 hops with random overloaded **Jumbo-packets** (16K) background. **125 us. stream**





A2. Conclusion: Streaming small high prio. packets with Jumbo packets overloaded background

- ◆ Added latency between 20 and 100 us.
- ◆ Theoretically between 0 and 128 us.
- ◆ Min: 14 us. Max: 106.5 us.
- ◆ 0.1 % larger than 104 us.
- ◆ 1% larger than 96.2 us.
- ◆ 10% larger than 81.4 us.
- ◆ Mean and median: 62 us.
- ◆ Max jitter about half of total latency variation



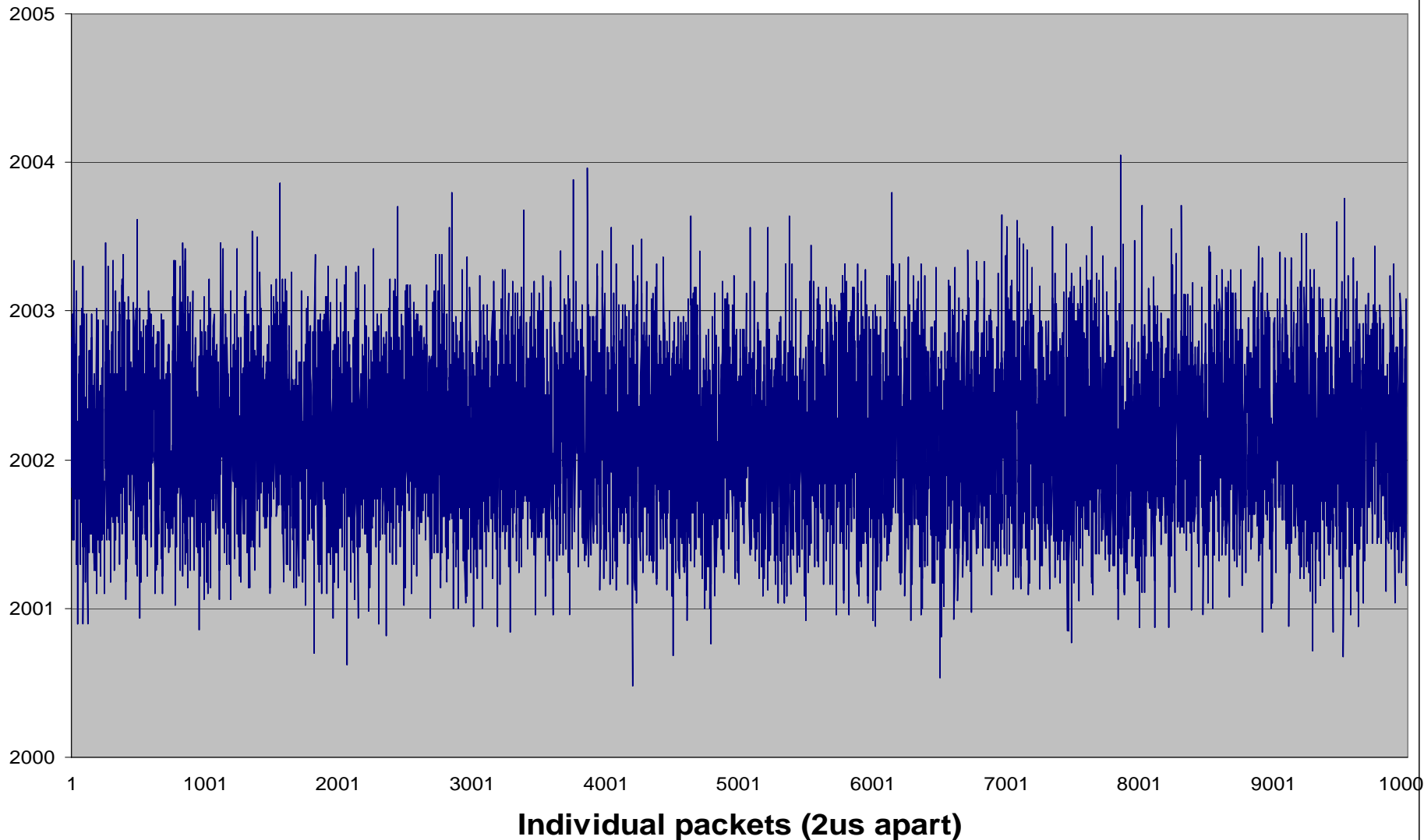
Scenario A3.

Background traffic with Preemption

- ◆ Random background traffic with
 - 30 % bandwidth high prio small packets
 - 70 % (overloaded) with Jumbo packets with preemption (slide in at every $\frac{1}{2}$ K)
- ◆ Streaming from node 7 to node 15
 - 8 hops, ~ 400 km distance = 2ms min latency
 - 2 us between packets
 - 125 us. between packets

A3. Latency

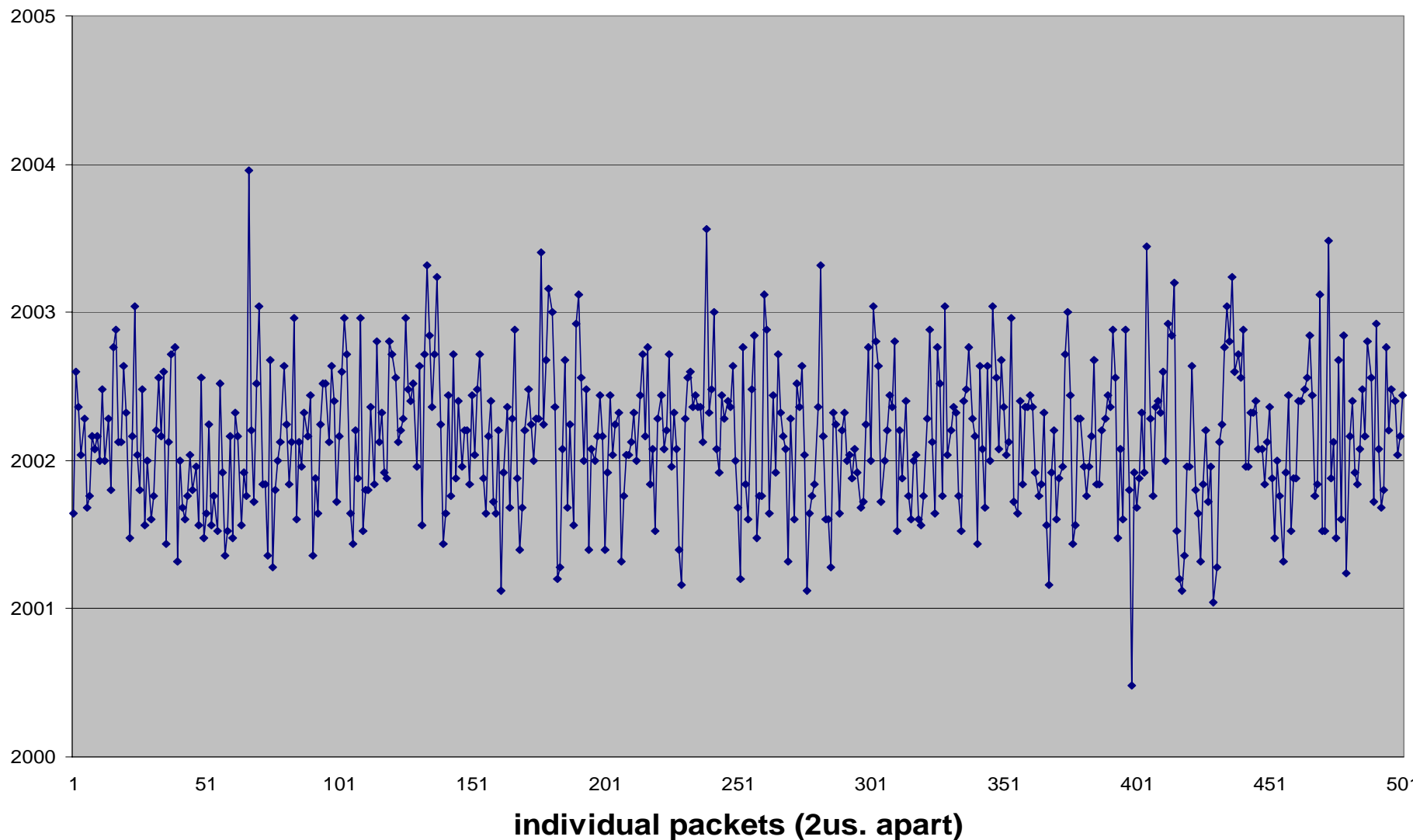
Streaming small high prio. packets 8 hops (400 km., 2 ms.) with overloaded random background **preemptable** (1/2 K) Jumbo-packets





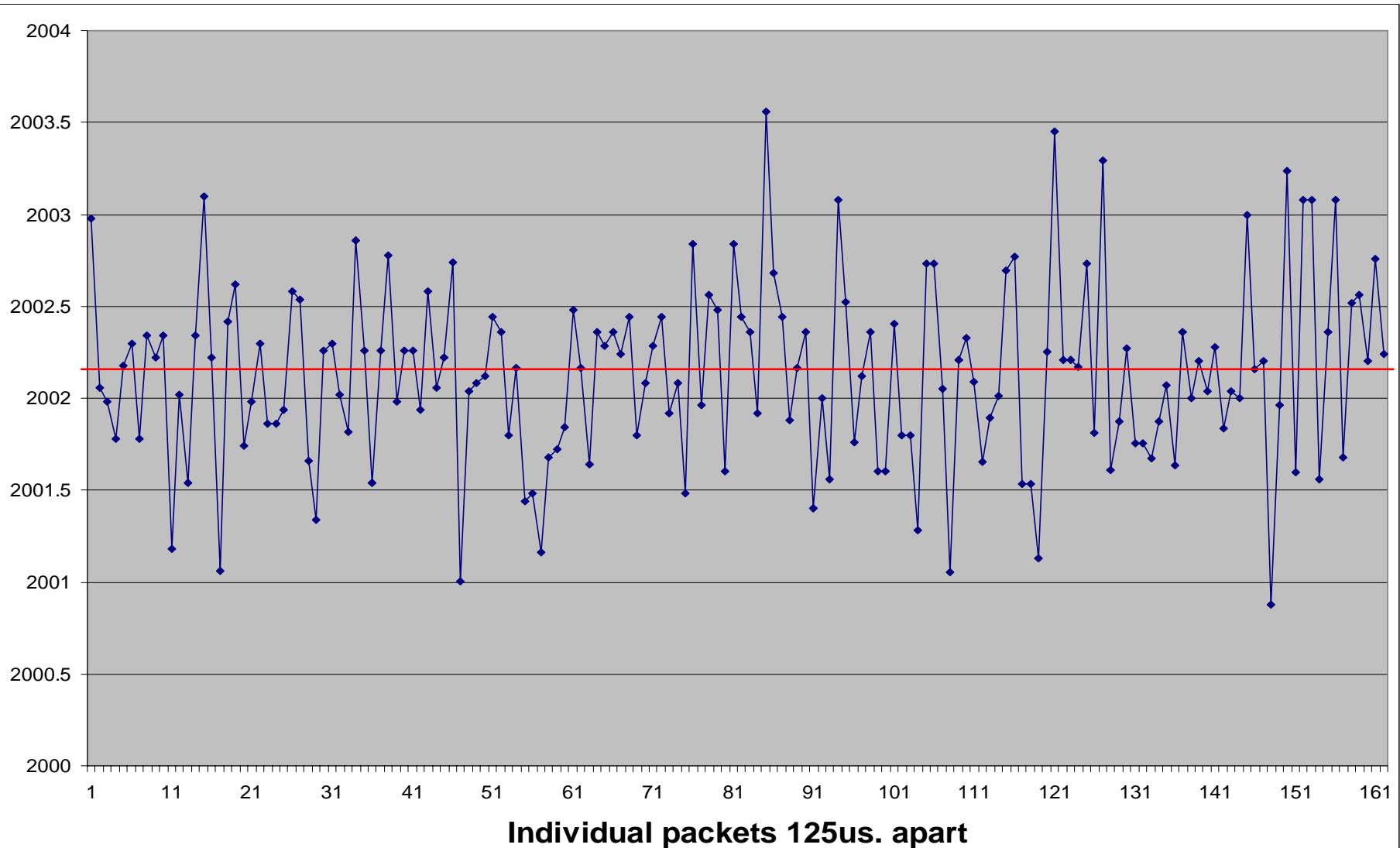
A3. Latency

Streaming small high prio. packets 8 hops with overloaded background preemptable (1/2 K) Jumbo-packets (details)



A3. Latency

Streaming small high prio. packets 8 hops with overloaded background preemptable (1/2 K) Jumbo-packets. 125 us. stream.





A3. Conclusion: Streaming small high prio. packets with preemptable overloaded background

- ◆ Added latency between 0.5 and 4 us.
- ◆ Theoretically between 0 and 4.1 us.
- ◆ Min: 0.5 us. Max: 4.05 us.
- ◆ 0.1 % larger than 3.7 us.
- ◆ 1% larger than 3.3 us.
- ◆ 10% larger than 2.8 us
- ◆ Mean and median: 2.15 us.
- ◆ Max jitter almost as large as total latency variation



B. Hot receiver – lighter load

- ◆ Traffic from all nodes to hot receiver, node 15
Last links to receiver is almost fully utilized
(but can be different in the three cases B1, B2 and B3)
- ◆ Measuring high priority stream from 7 to 15
with 2 us. or 125 us between packets
- ◆ Background is
 - 30% high prio 80 bytes packets (provisioned) and
70% low prio packets.
 - 3 sub-scenarios with 3 different packet sizes
 - B1. 1600 bytes "IP-packets" or
 - B2. 16K jumbo packets or
 - B3. 16K jumbo packets with preemption (1/2 K)

Scenario B1.

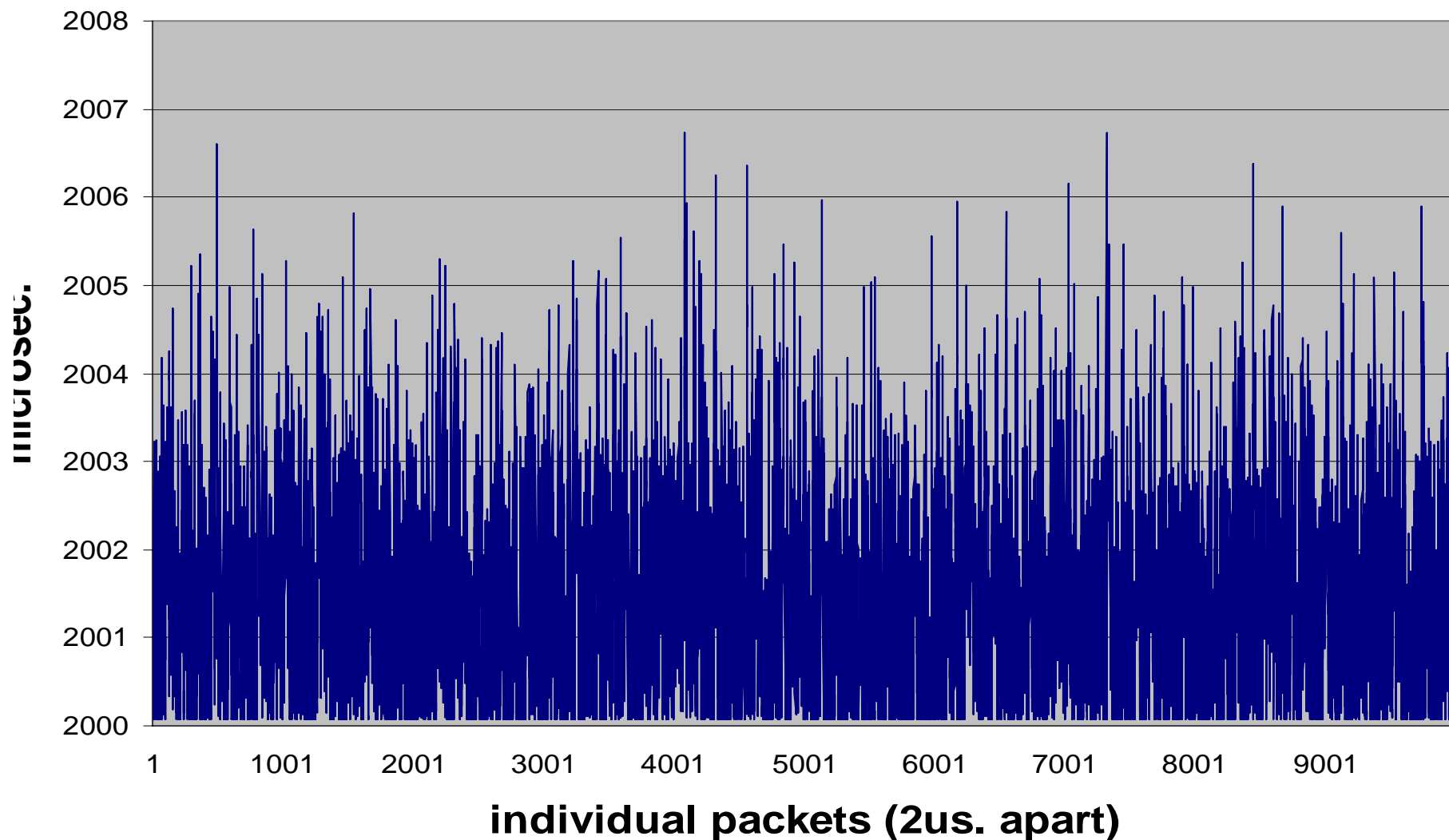
Hot receiver, "IP-packets" background



- ◆ Hot receiver (15) background traffic with
 - 30 % bandwidth high prio small packets
 - 70% "IP-packets" (1600 bytes)
 - Almost full utilization of last links to 15
- ◆ Streaming from node 7 to node 15
 - 8 hops, ~ 400 km distance = 2ms min latency
 - 2 us between packets
 - 125 us. between packets

B1. Latency

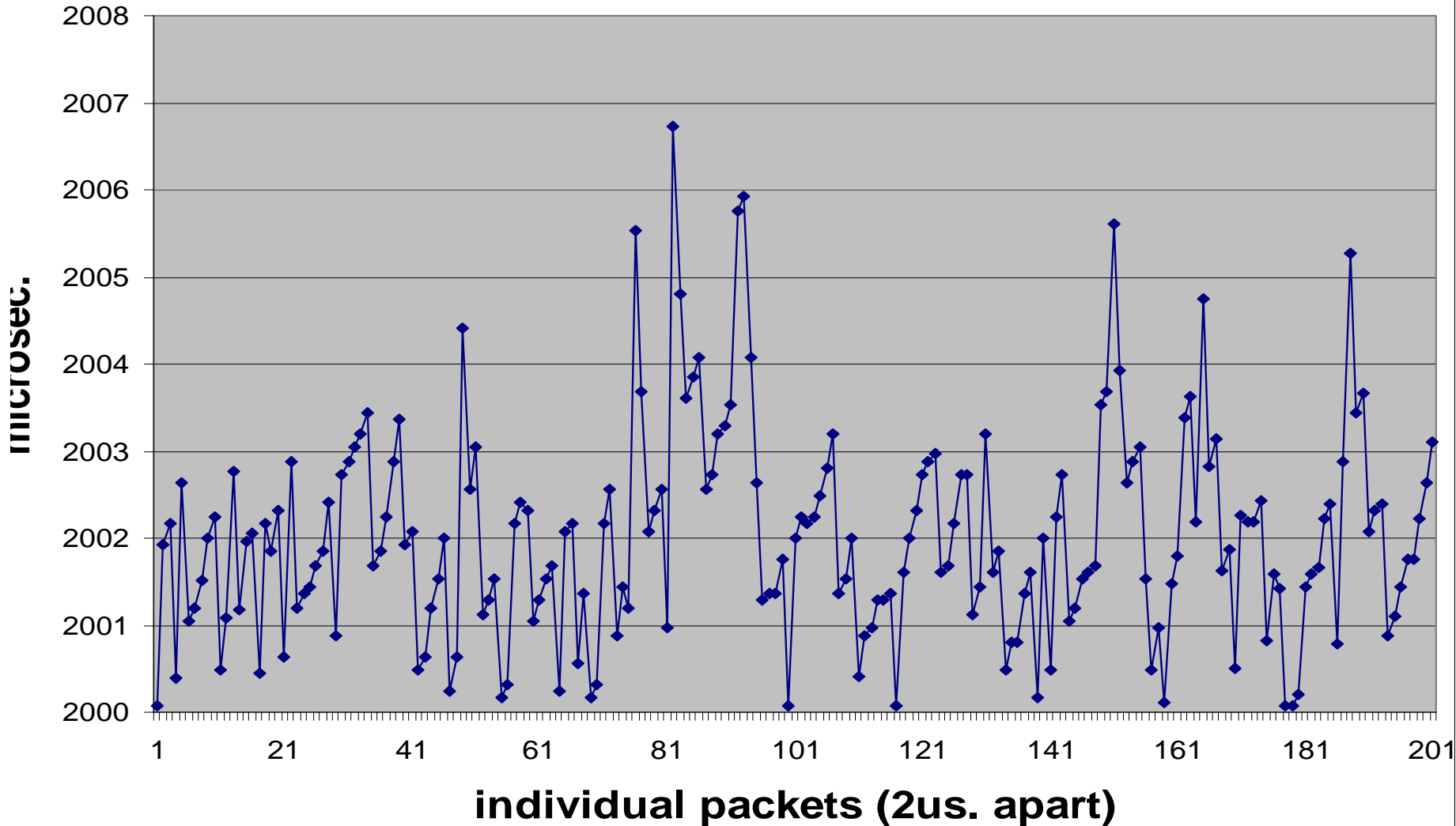
Streaming high prio. small packets 8 hops (400 km., 2ms.)
with hot receiver "IP-packets" (1600 byte) background



B1. Latency

Streaming small packets 8 hops (2ms.)

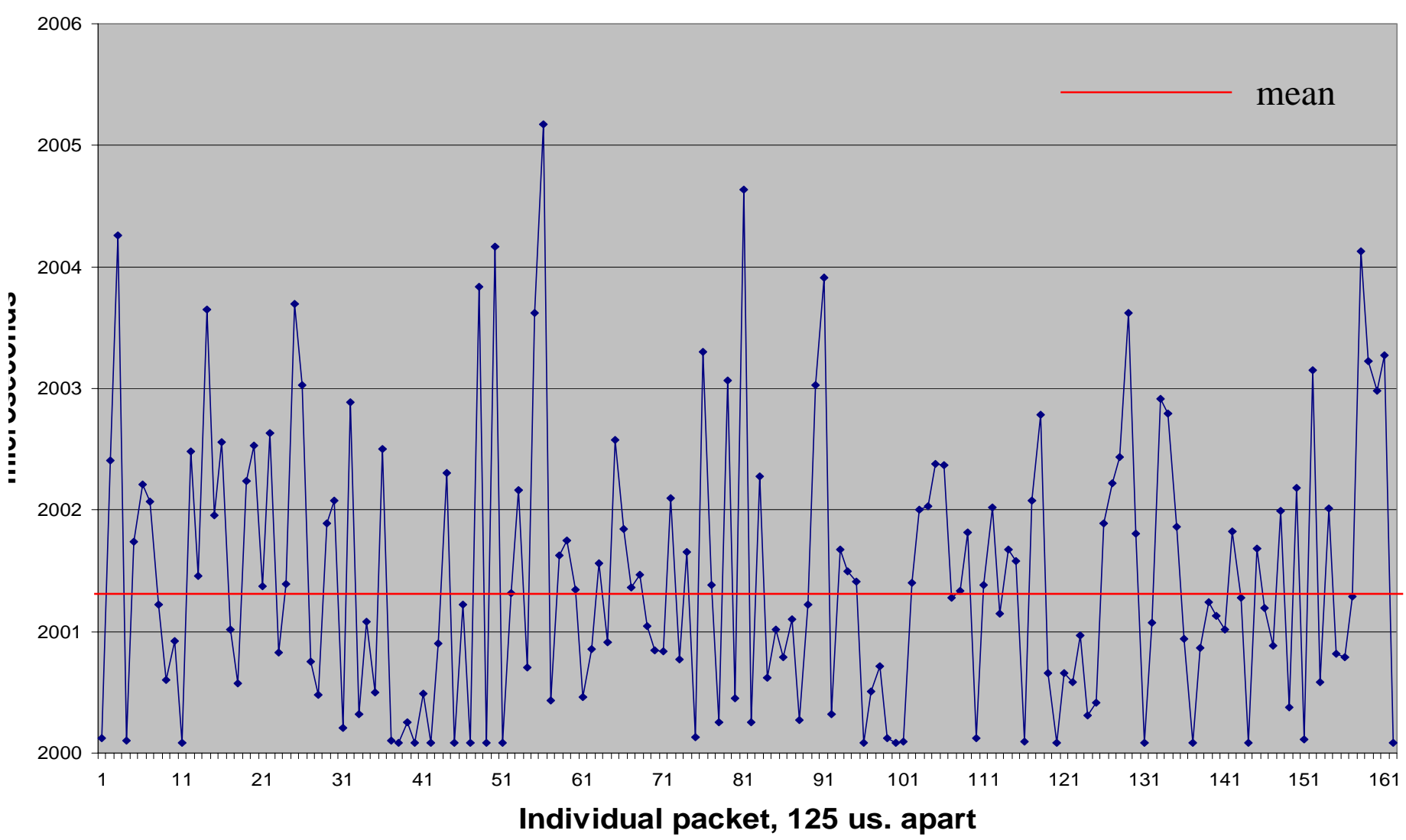
Hot receiver . "IP-packets" background (details)



B1. Latency

Streaming small packets 8 hops (2ms.)

Hot receiver . "IP-packets" background. 125 us. stream





B1. Conclusion: Streaming small high prio. packets with hot receiver and "IP-packets" background

- ◆ This is not a fully overloaded system
- ◆ Added latency between 0 and 6.5 us.
- ◆ Theoretically between 0 and 13 us.
- ◆ Max observed added latency is 6.74 us.
- ◆ 0.1% added latency greater than 5.9 us.
- ◆ 1% added latency greater than 4.6 us.
- ◆ Median 1.36 us. Mean 1.47us.
- ◆ 10% went through with no added latency
- ◆ Max jitter as large as total latency variation



Scenario B2.

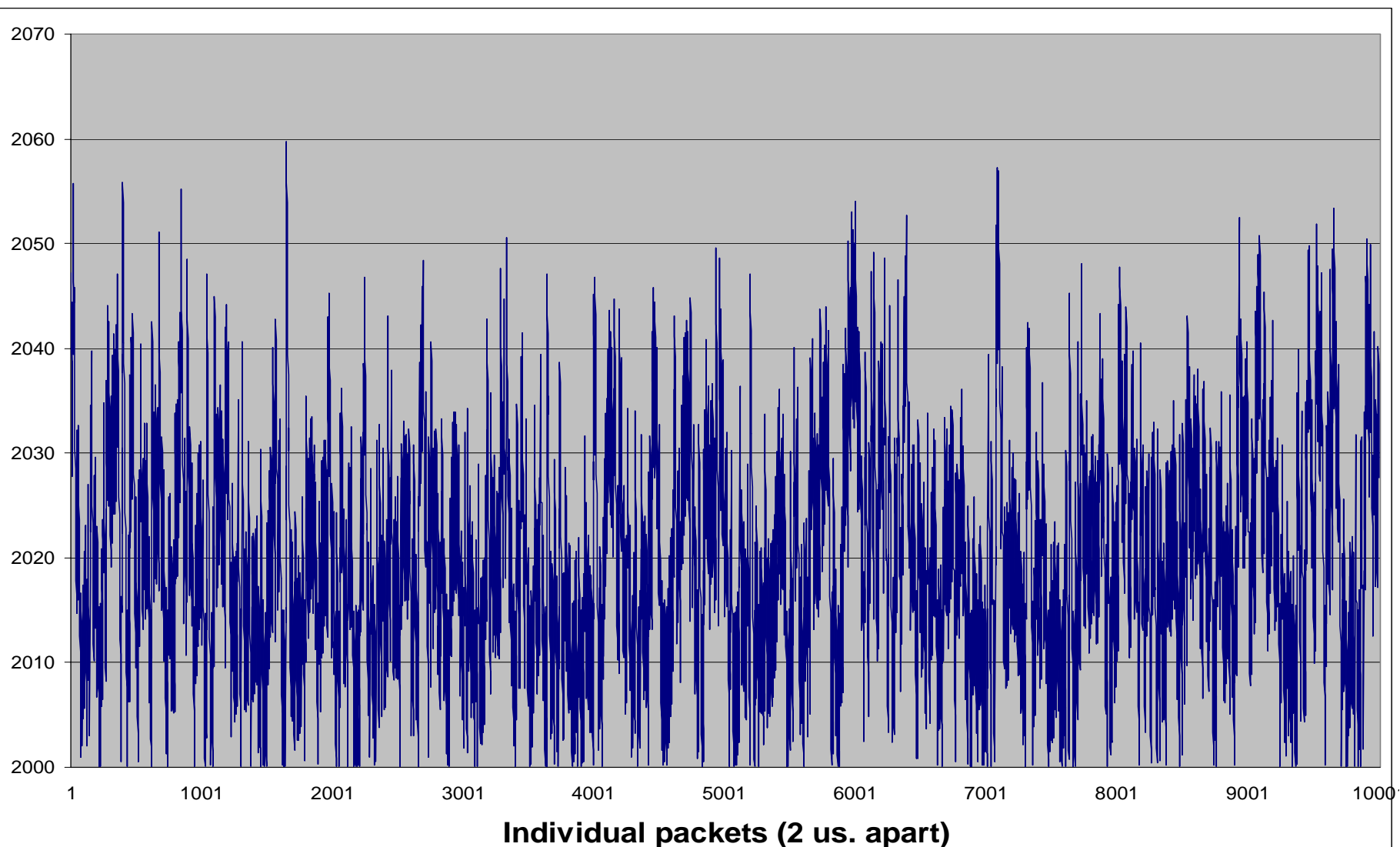
Hot receiver, Jumbo packets background

- ◆ Hot receiver (#15) background traffic with
 - 30 % bandwidth high prio small packets
 - 70% Jumbo packets (16K bytes)
 - Almost full utilization of last links to 15
- ◆ Streaming from node 7 to node 15
 - 8 hops, ~ 400 km distance = 2ms min latency
 - 2 us between packets
 - 125 us. between packets



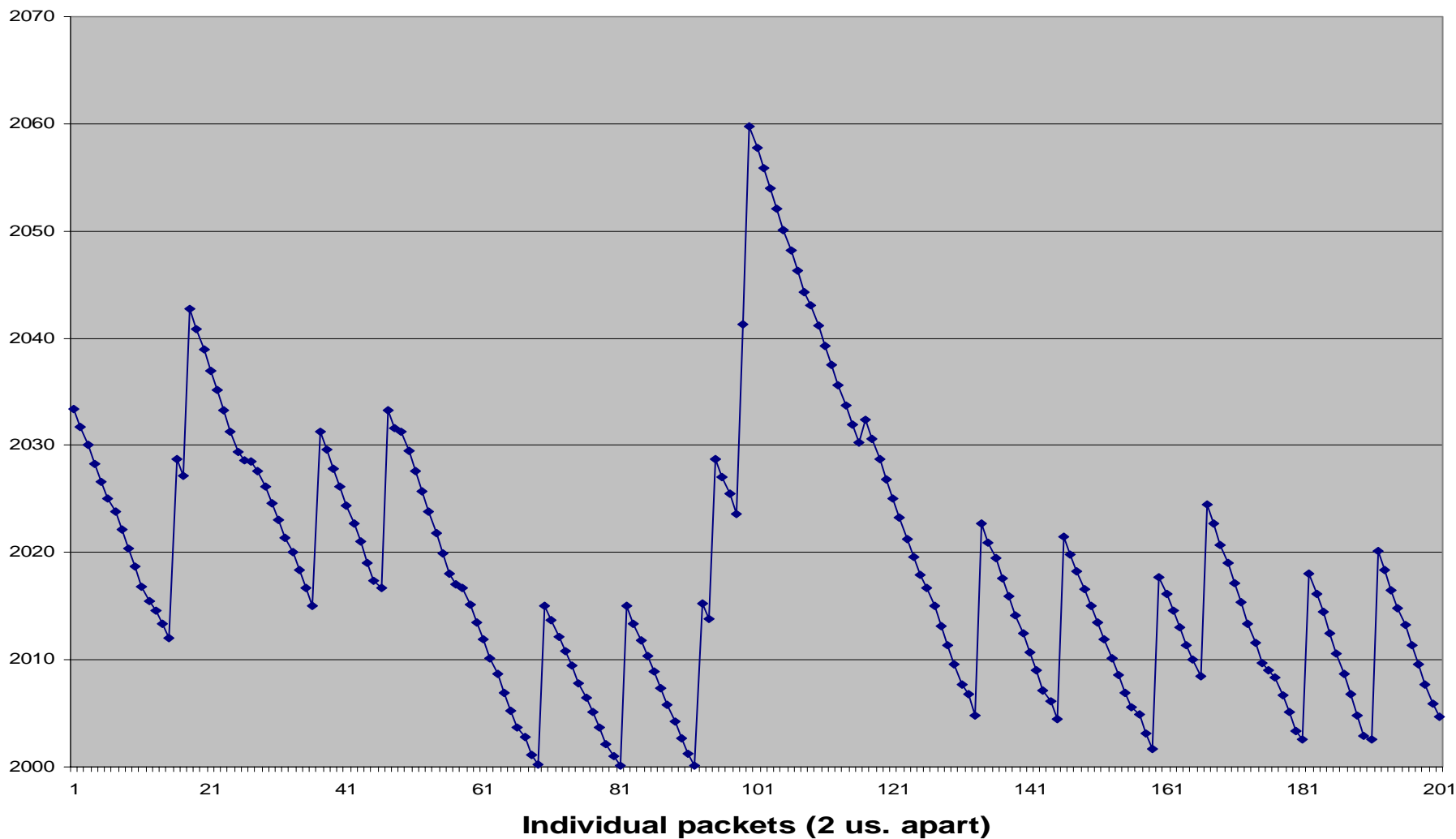
B2. Latency

Streaming high prio. small packets 8 hops (400 km., 2ms.)
with hot receiver **Jumbo packets** (16K byte) background



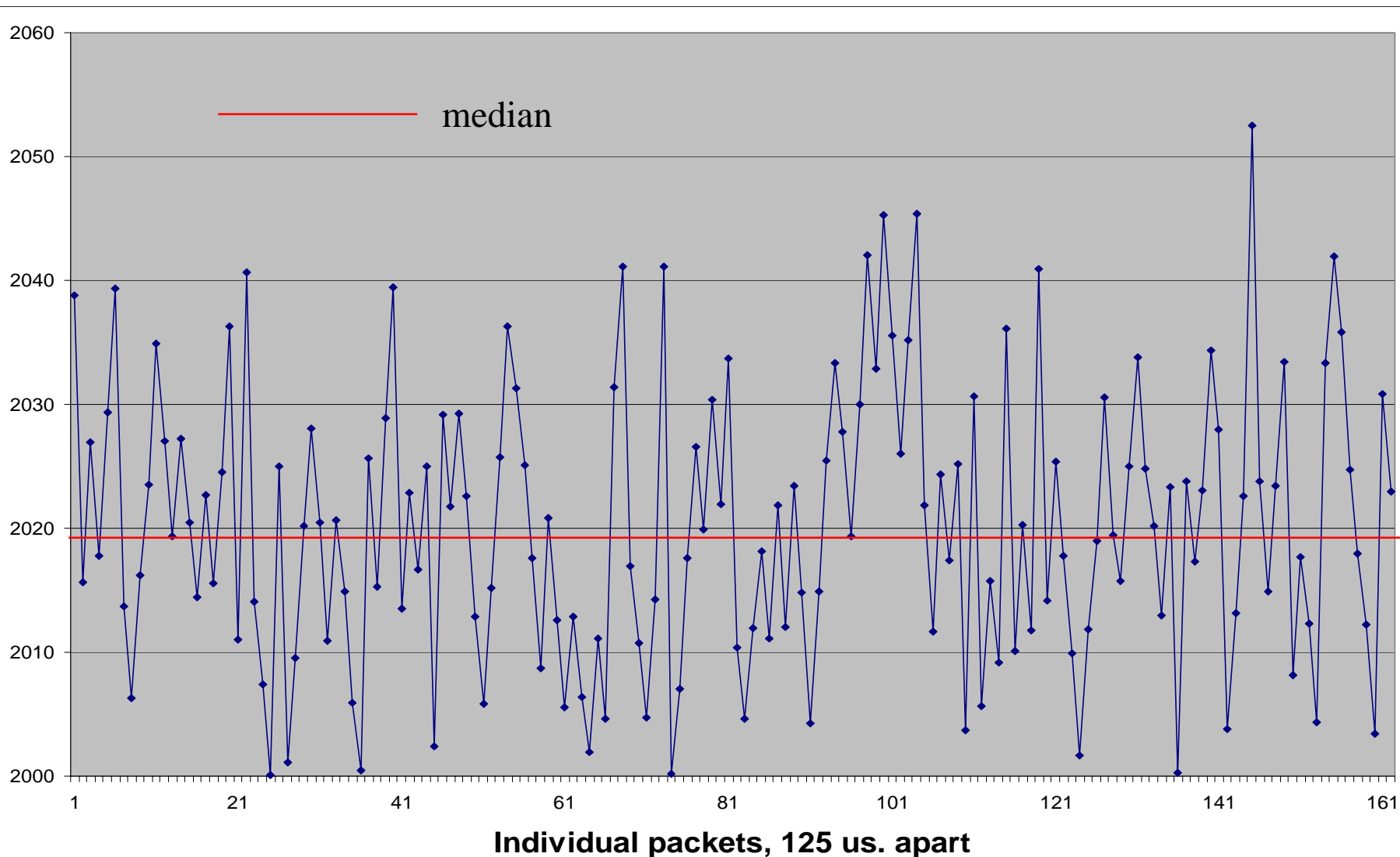
B2. Latency

Streaming high prio. small packets 8 hops with hot receiver **Jumbo packets** (16K byte) background (Details)



B2. Latency

Streaming high prio. small packets 8 hops with hot receiver **Jumbo packets** (16K byte) background. **125 us. stream**



B2. Conclusion:

Streaming small high prio. packets with hot receiver and Jumbo packets background



- ◆ This is not a fully overloaded system
- ◆ Added latency between 0 and 55 us.
- ◆ Theoretically between 0 and 128 us.
- ◆ Max observed added latency is 59.7 us.
- ◆ 0.1% added latency greater than 55 us.
- ◆ 1% added latency greater than 47 us.
- ◆ Median 18.8 us. Mean 19.9 us.
- ◆ 1% went through with no added latency
- ◆ 10% less than 6 us.
- ◆ Max jitter about half of total latency variation

Scenario B3.

Hot receiver, preemptive background

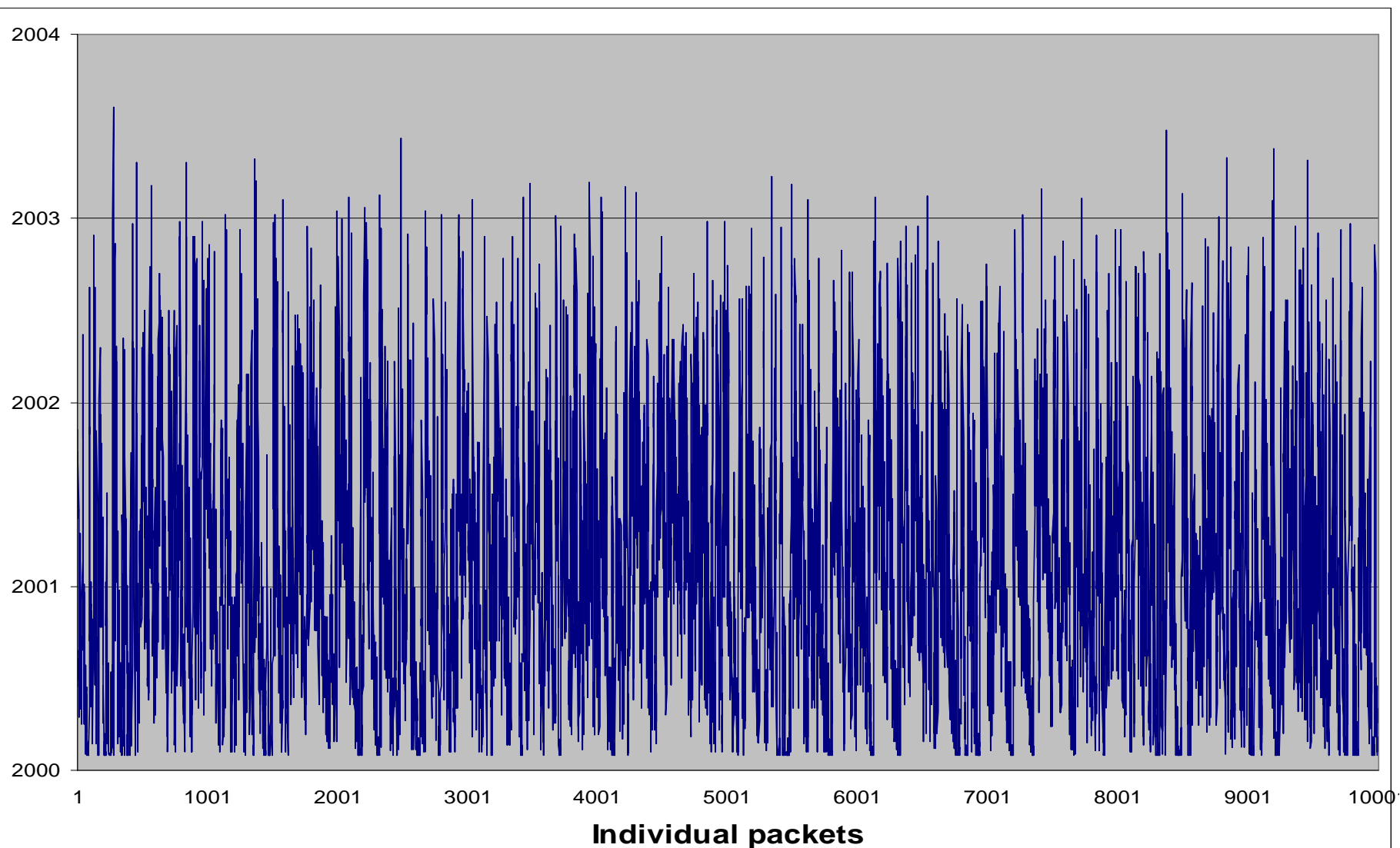


- ◆ Hot receiver (15) background traffic with
 - 30 % bandwidth high prio small packets
 - 70% Jumbo packets with preemption ($\frac{1}{2}$ K)
 - Almost full utilization of last links to 15
- ◆ Streaming from node 7 to node 15
 - 8 hops, ~ 400 km distance = 2ms min latency
 - 2 us between packets
 - 125 us. between packets



B3. Latency

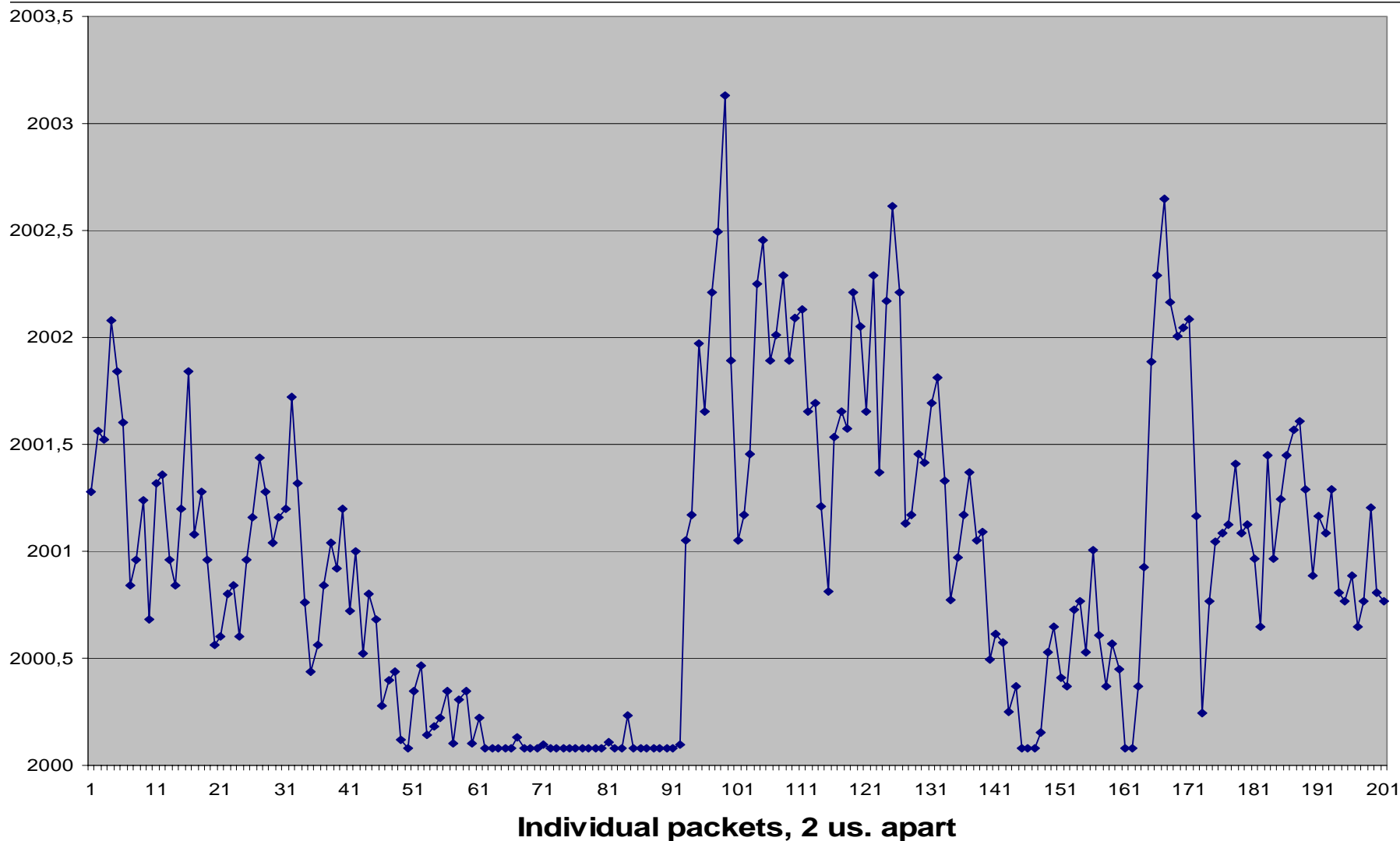
Streaming high prio. small packets 8 hops (400 km., 2ms.)
with hot receiver **Preemptive ($\frac{1}{2}$ K)** Jumbo packets background



B3. Latency

Streaming high prio. small packets 8 hops with hot receiver

Preemptive (1/2 K) Jumbo packets background (Details)

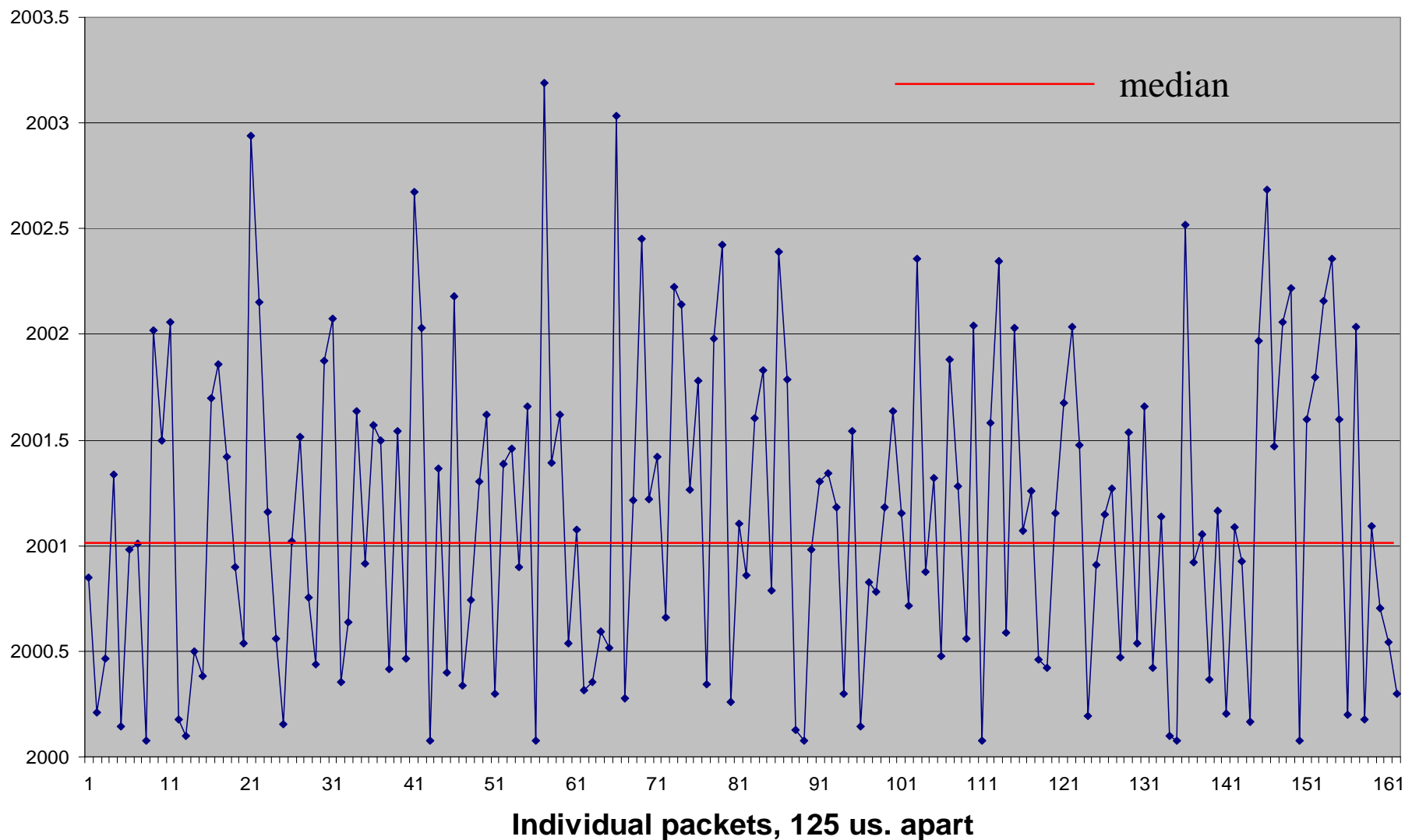




B3. Latency

Streaming high prio. small packets 8 hops with hot receiver

Preemptive ($\frac{1}{2}$ K) Jumbo packets background 125 us. stream



B3. Conclusion:

Streaming small high prio. packets with Hot receiver and Preemptive Jumbo packets



- ◆ This is not a fully overloaded system
- ◆ Observed added latency between 0 and 3.4 us.
- ◆ Theoretically between 0 and 4.1 us.
- ◆ Max observed added latency is 3.6 us.
- ◆ 0.1% added latency greater than 3.3 us.
- ◆ 1% added latency greater than 2.9 us.
- ◆ Median 1.0 us. Mean 1.1 us.
- ◆ 0.5% went through with no added latency
- ◆ 10% less than 0.2 us.
- ◆ Max jitter as large as the total latency variation

Overall conclusion

- ◆ Scenario A – Random background

 - Overloaded system

 - Different background low priority packet *sizes* clearly give difference foreground packet *latency*

- ◆ Scenario B – Hot receiver background

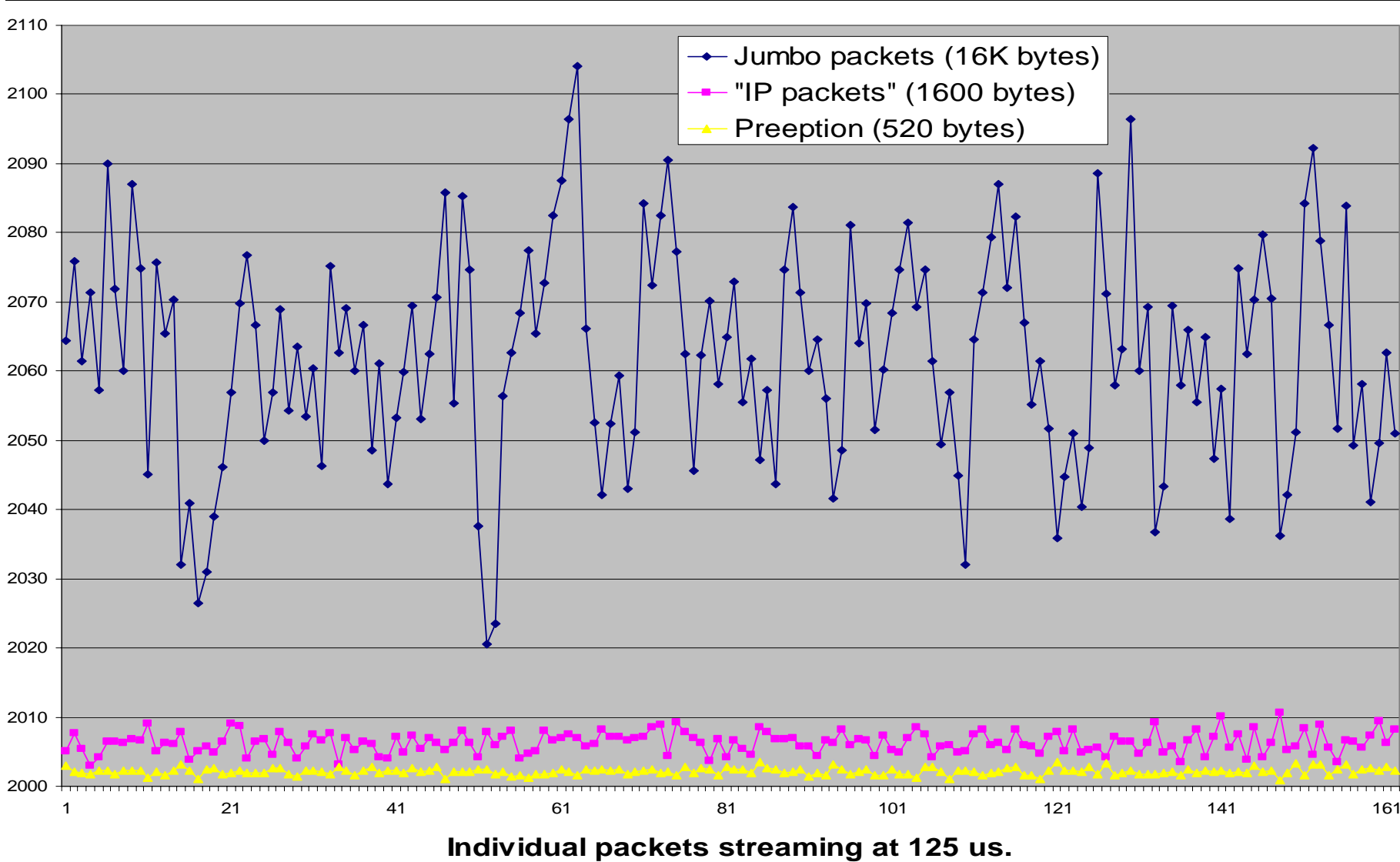
 - More variably loaded system

 - Still differently *sized* background packets clearly influence foreground packet *latency*

- ◆ Jitter almost as large as total latency variation

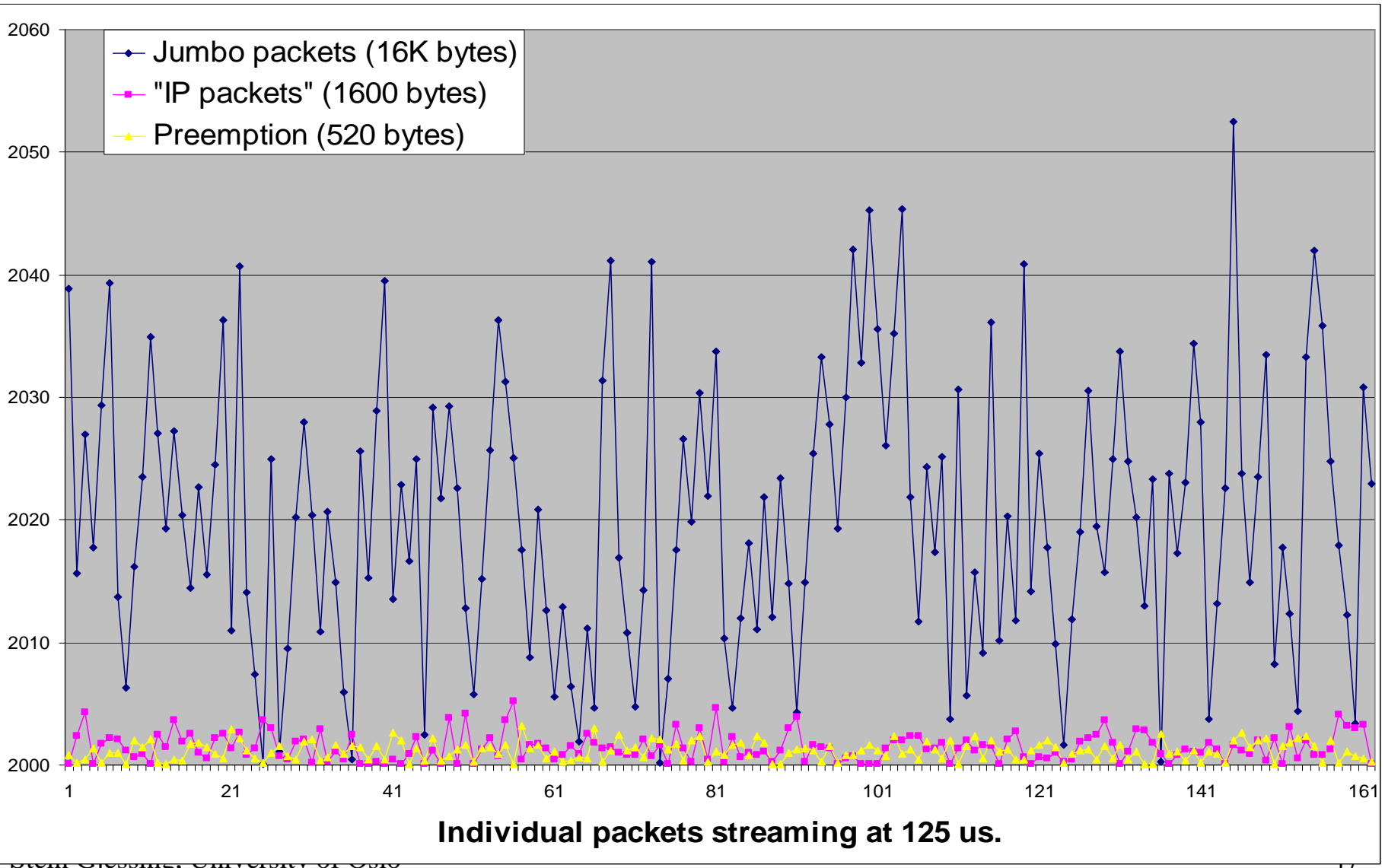


Conclusion Scenario A: Streaming small high prio. packets with random overloaded background (3 packet sizes)





Conclusion Scenario B: Streaming small high prio. packets with hot receiver, high load, background (3 packet sizes)



Individual packets streaming at 125 us.



Overall Conclusion – 10Gbit/sec system

- ◆ In a "high load" system 1% of the packets observe half of the theoretical max latency
- ◆ In an overloaded system 1% of the packets observe close to the theoretical max latency
- ◆ Hence with Jumbo packets (16K) and no preemption it is possible to get 100 us. added latency with 8 nodes (128 us. theoretical max). This is close to the 125 us. synchronous stream interval (TDM frame interval)
- ◆ Jitter almost as large as total latency variation