Shaping Process Semantics

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Joint work with Harald Röck
Monterey Workshop, Paris, October 2006

The Idea

- we apply *traffic shaping* technology known in the networking community to *software processes*
- software processes invoke *system calls* to access resources, perform I/O, etc.
- we see system calls as *network packets*

Process Shaping

- process shaping changes the *order* and *times* in which system calls (and potentially other *side effects* of processes) are handled before given to any performance-oriented kernel subsystems
- process shaping promotes more disciplined *system composition*

Application Processes

Timing Calls | I/O Calls | IPC Calls | Virtual Memory

Kernel

Process Shaping

Interrupt Handling | I/O Scheduling | IPC Handling | Memory Management

Hardware

Semantics

Performance

Proposal

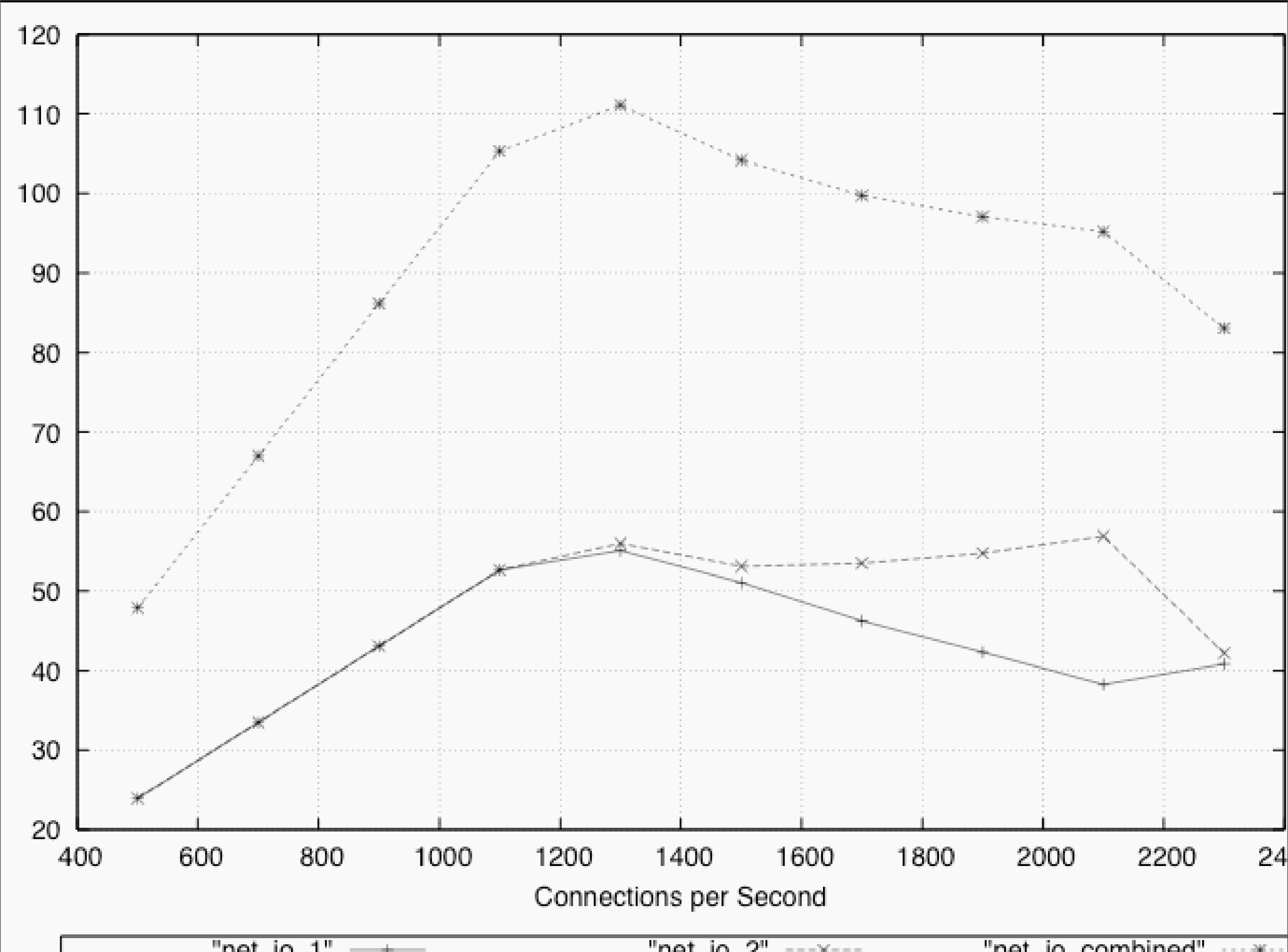
- we propose the notion of *process shaping* to complement, not replace, the notion of *serving* processes *as fast as possible*
- we advocate a shift in research attention from performance- to *semantics-oriented* handling of software processes

Claim

- we claim that *faster* processors, more efficient scheduling, and lower kernel *latency*, in analogy to *shorter* packet transmission times, will make process shaping increasingly effective
  - see ATM versus Gigabit Ethernet
- note that used-to-be-exotic real-time patches increasingly make their way into general-purpose operating systems

Experiment I

- we run two separate web server processes on an *unmodified* Linux 2.6 server machine with Gigabit Ethernet
- two client machines generate workload by requesting the same and thus *cached* 380KB file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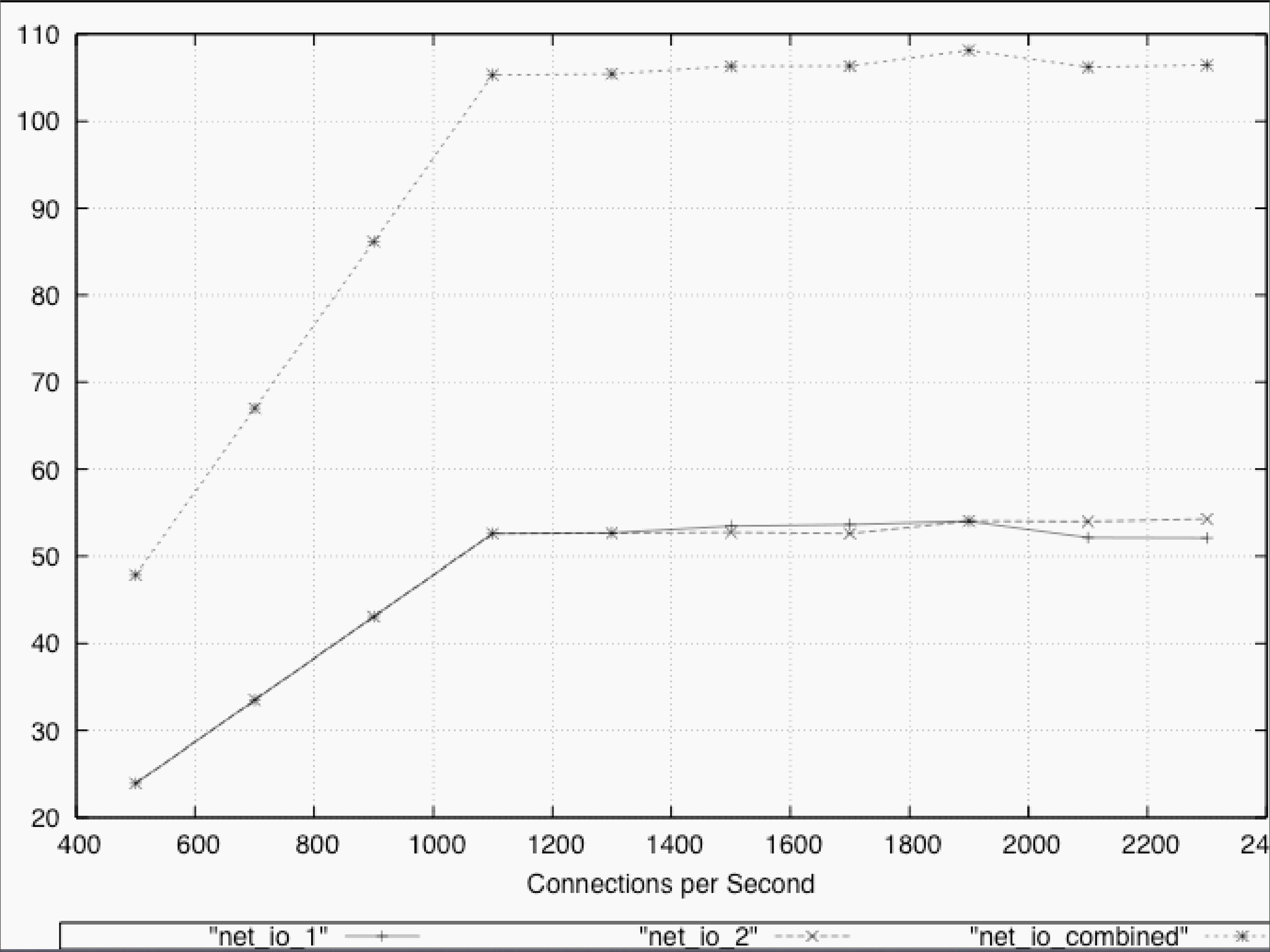
1000
1200
1400
1600
1800
2000
2200
24
Connections per Second
"net_io_1"
"net_io_2"
"net_io_combined"

Experiment II

- we run two separate web server processes on a *process-shaping* Linux 2.6 server machine with Gigabit Ethernet
- two client machines generate workload by requesting the same and thus *cached* 380KB file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1200
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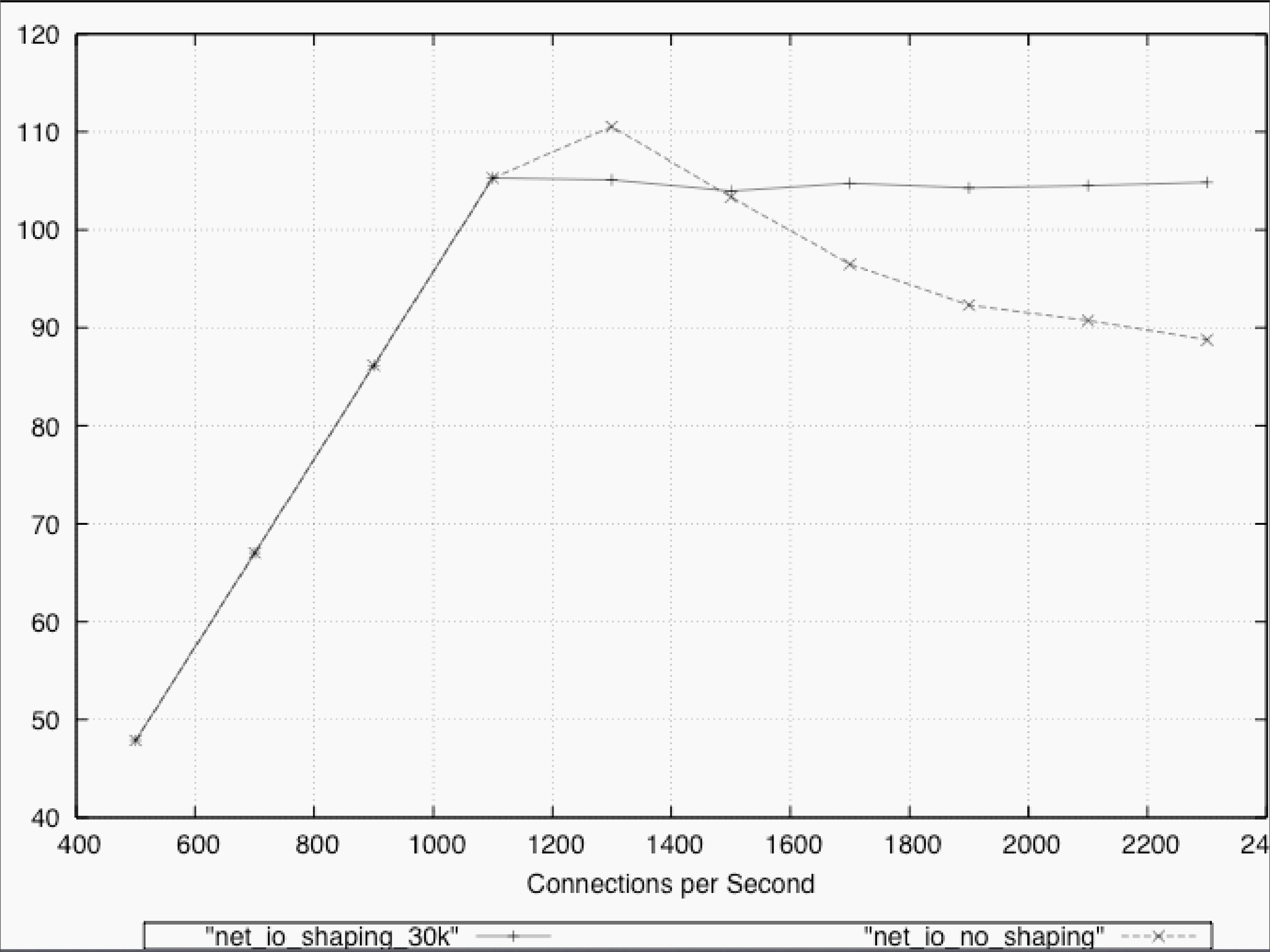
2000
2200
24
Connections per Second
"net_io_1"
"net_io_2"
"net_io_combined"

Experiment I+II

- higher total peak performance without process shaping
- but total peak performance more robust with process shaping


120
110
100
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80
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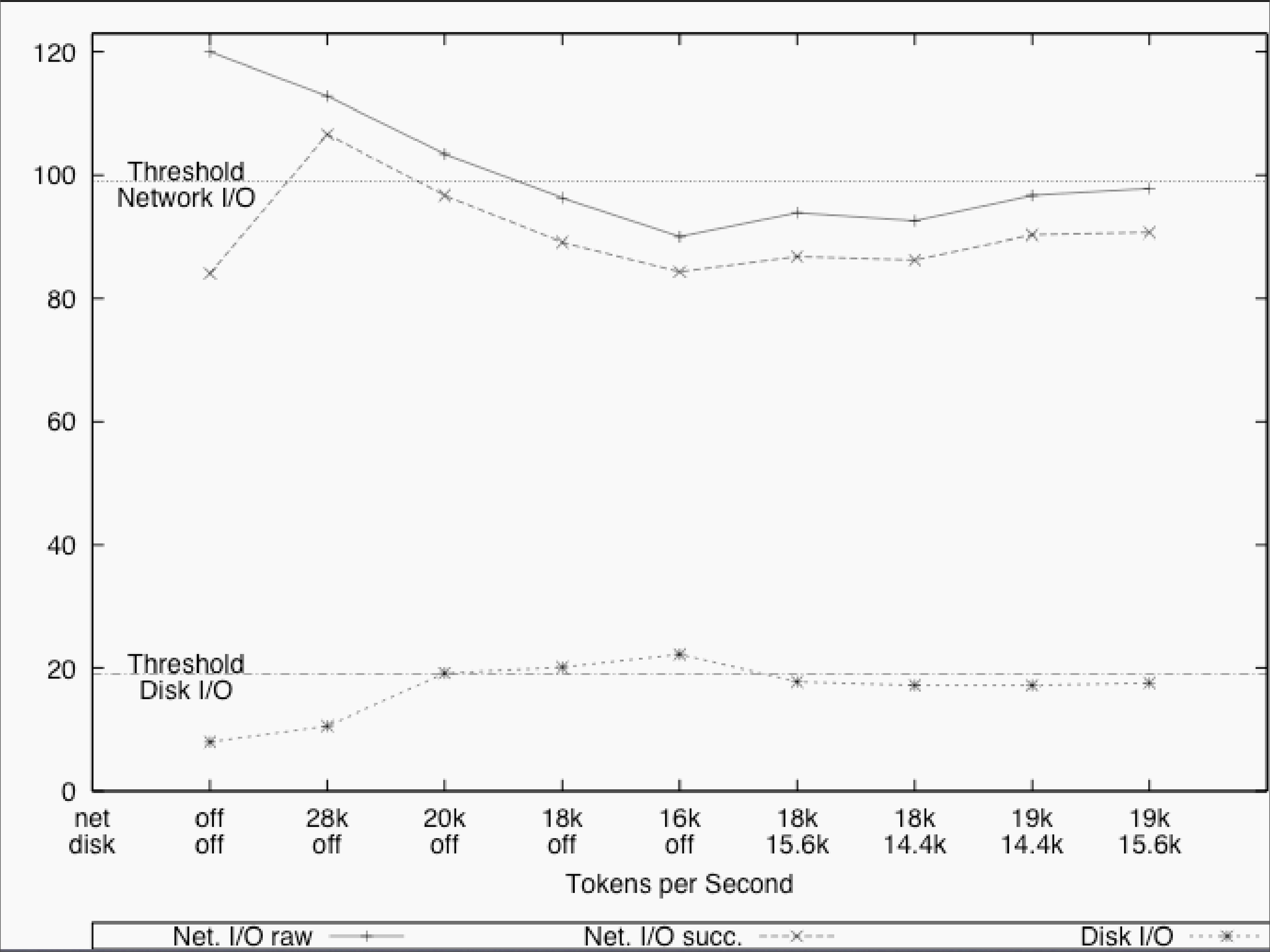
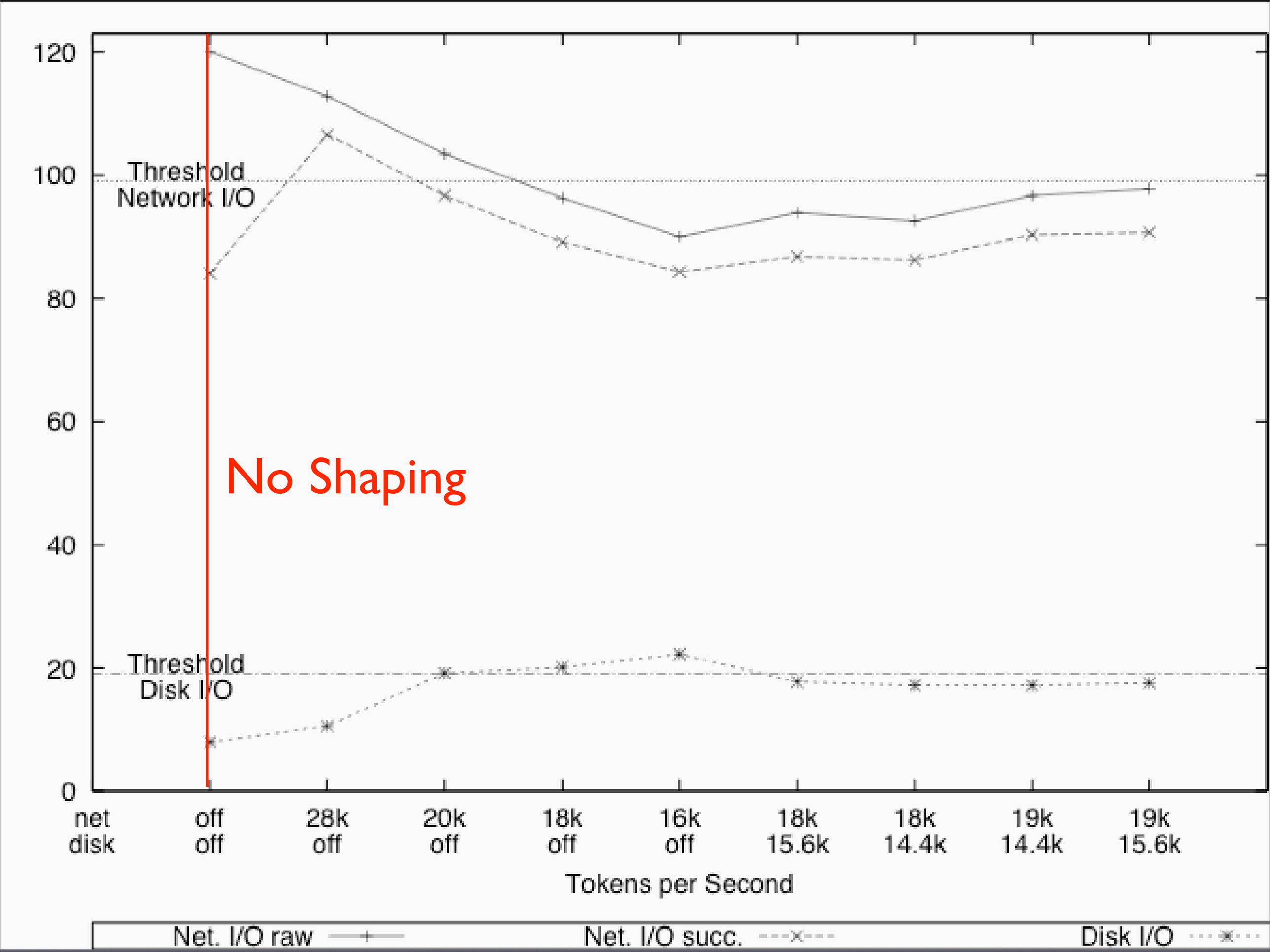
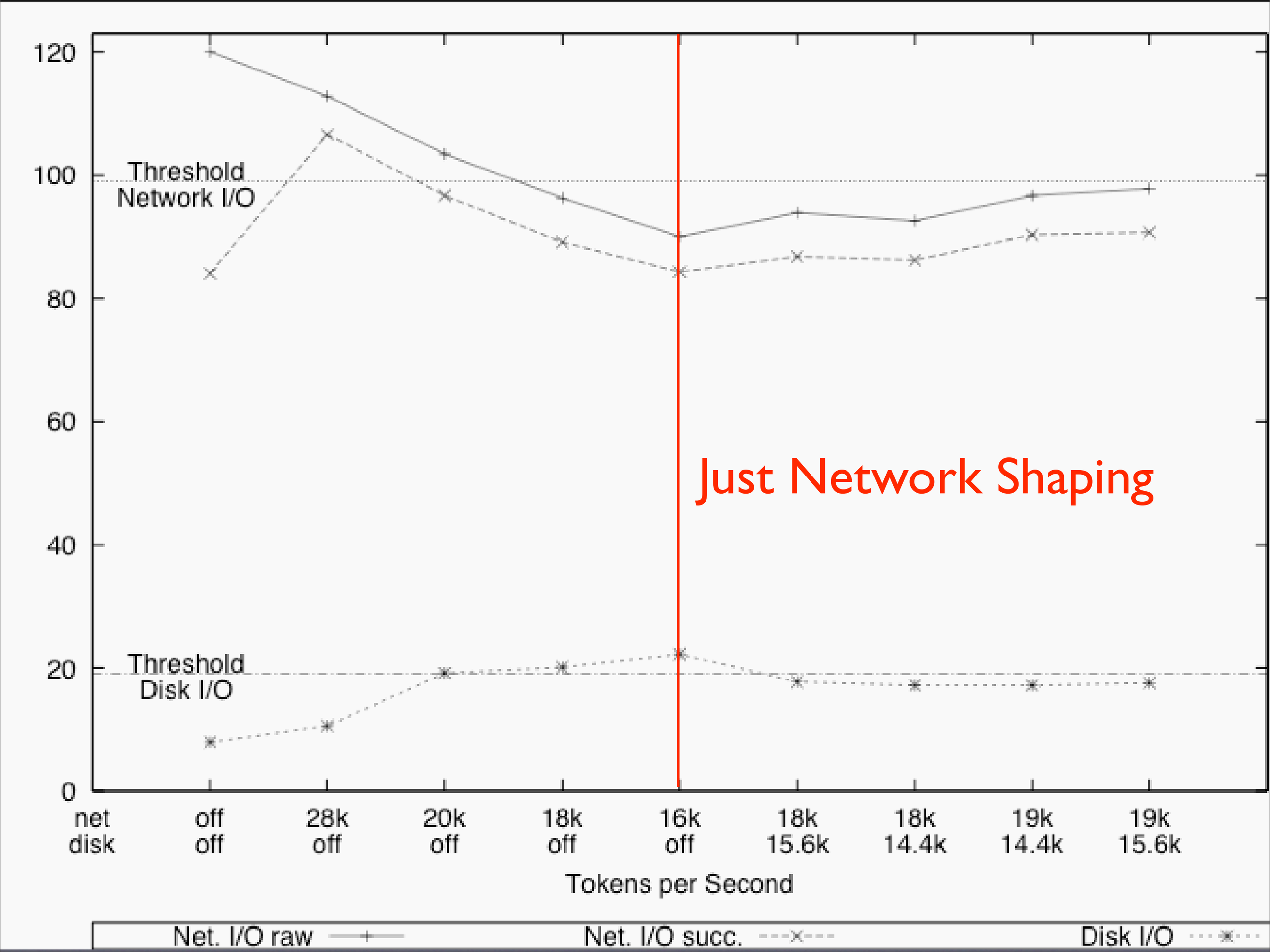
40
400
600
800
1000
1200
1400
1600
1800
2000
2200
24
Connections per Second
"net_io_shaping_30k"
"net_io_no_shaping"

Experiment III

- we run a *video-streaming* server on a *process-shaping* Linux 2.6 server machine with Gigabit Ethernet
- to generate background *network traffic*, we also run one of the web servers of experiment II on the same machine
- to generate background *disk traffic*, we also run several web servers processing requests for a non-cached 1GB file


120
100
80
60
40
20
0
Threshold
Network I/O
Threshold
Disk I/O
net
disk
off
off
28k
off
20k
off
18k
off
16k
off
18k
15.6k
18k
14.4k
19k
14.4k
19k
15.6k
Tokens per Second
Net. I/O raw
Net. I/O succ.
Disk I/O


120
100
80
60
40
20
0
Threshold
Network I/O
Threshold
Disk I/O
No Shaping
net
disk
off
off
28k
off
20k
off
18k
off
16k
off
18k
15.6k
18k
14.4k
19k
14.4k
19k
15.6k
Tokens per Second
Net. I/O raw
Net. I/O succ.
Disk I/O


120
100
80
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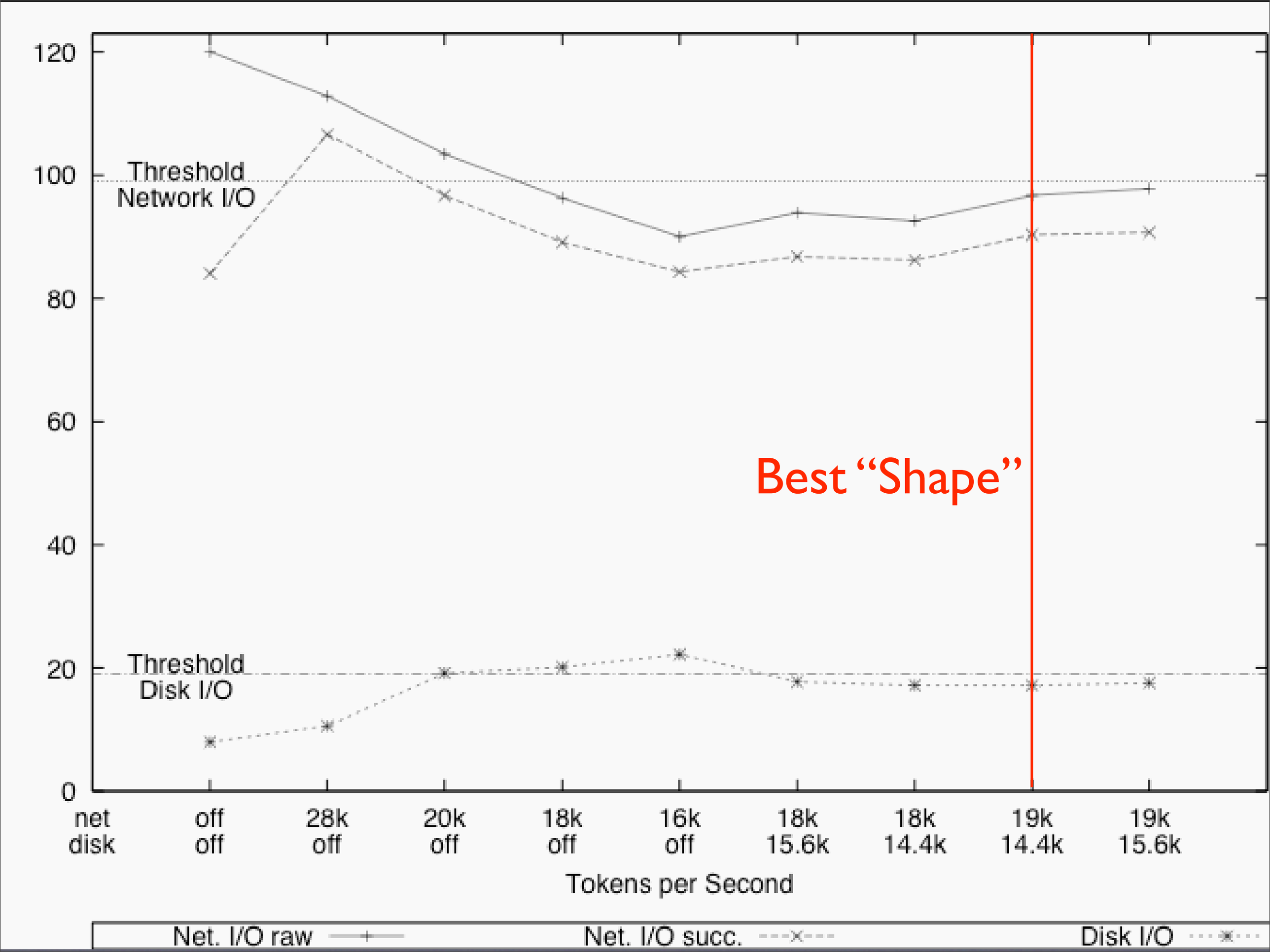
40
20
0
Threshold
Network I/O
Threshold
Disk I/O
Just Network Shaping
net
disk
off
off
28k
off
20k
off
18k
off
16k
off
18k
15.6k
18k
14.4k
19k
14.4k
19k
15.6k
Tokens per Second
Net. I/O raw
Net. I/O succ.
Disk I/O


120
100
80
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Threshold
Network I/O
Threshold
Disk I/O
Best "Shape"
net
disk
off
off
28k
off
20k
off
18k
off
16k
off
18k
15.6k
18k
14.4k
19k
14.4k
19k
15.6k
Tokens per Second
Net. I/O raw
Net. I/O succ.
Disk I/O

Future

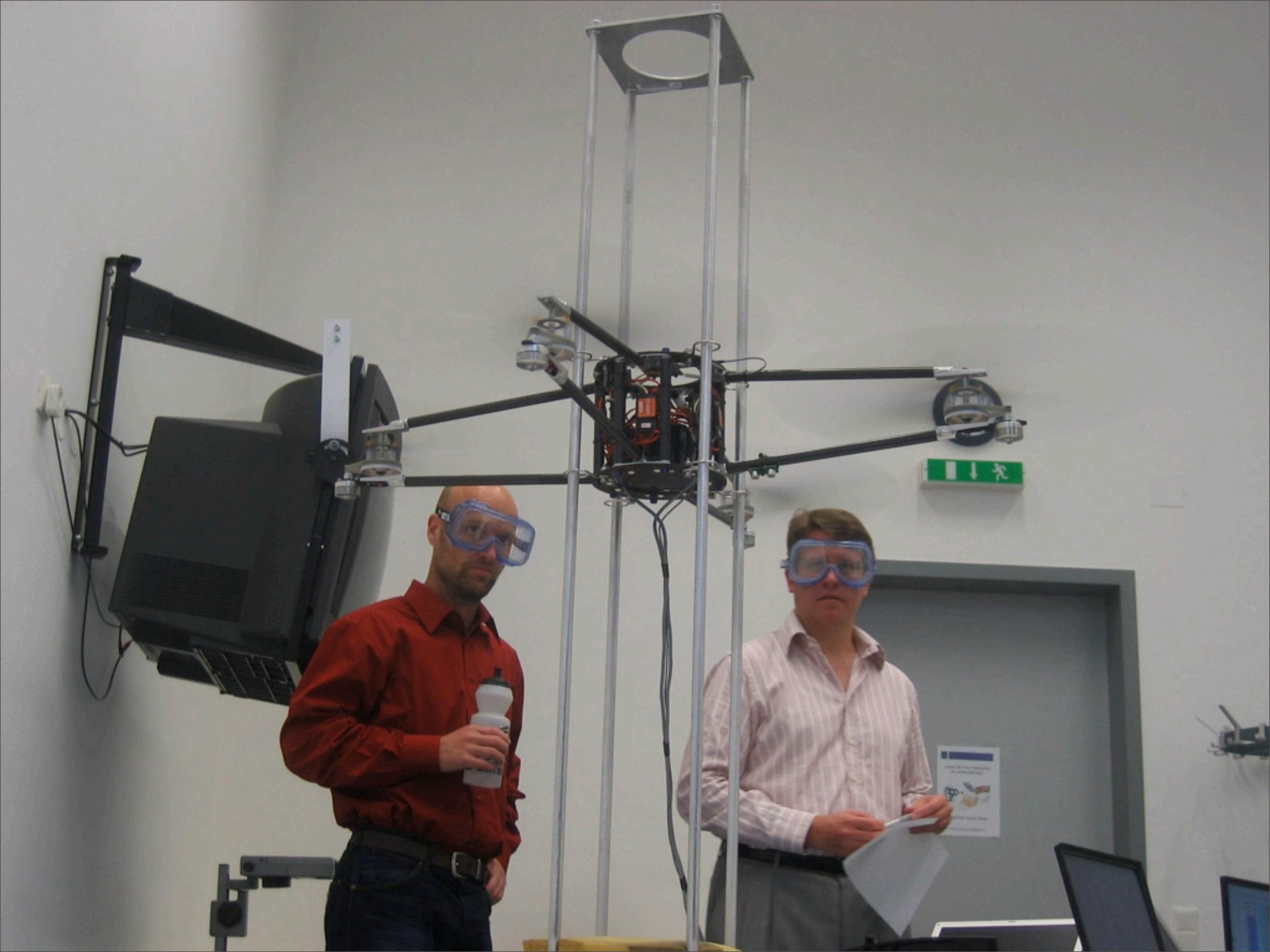
- Multimedia (*Soft* Real Time): Can kernel-level process shaping automatically find the best "shape"?
- Control (*Hard* Real Time): Can kernel-level process shaping provide sufficient real-time guarantees?

Experiment IV

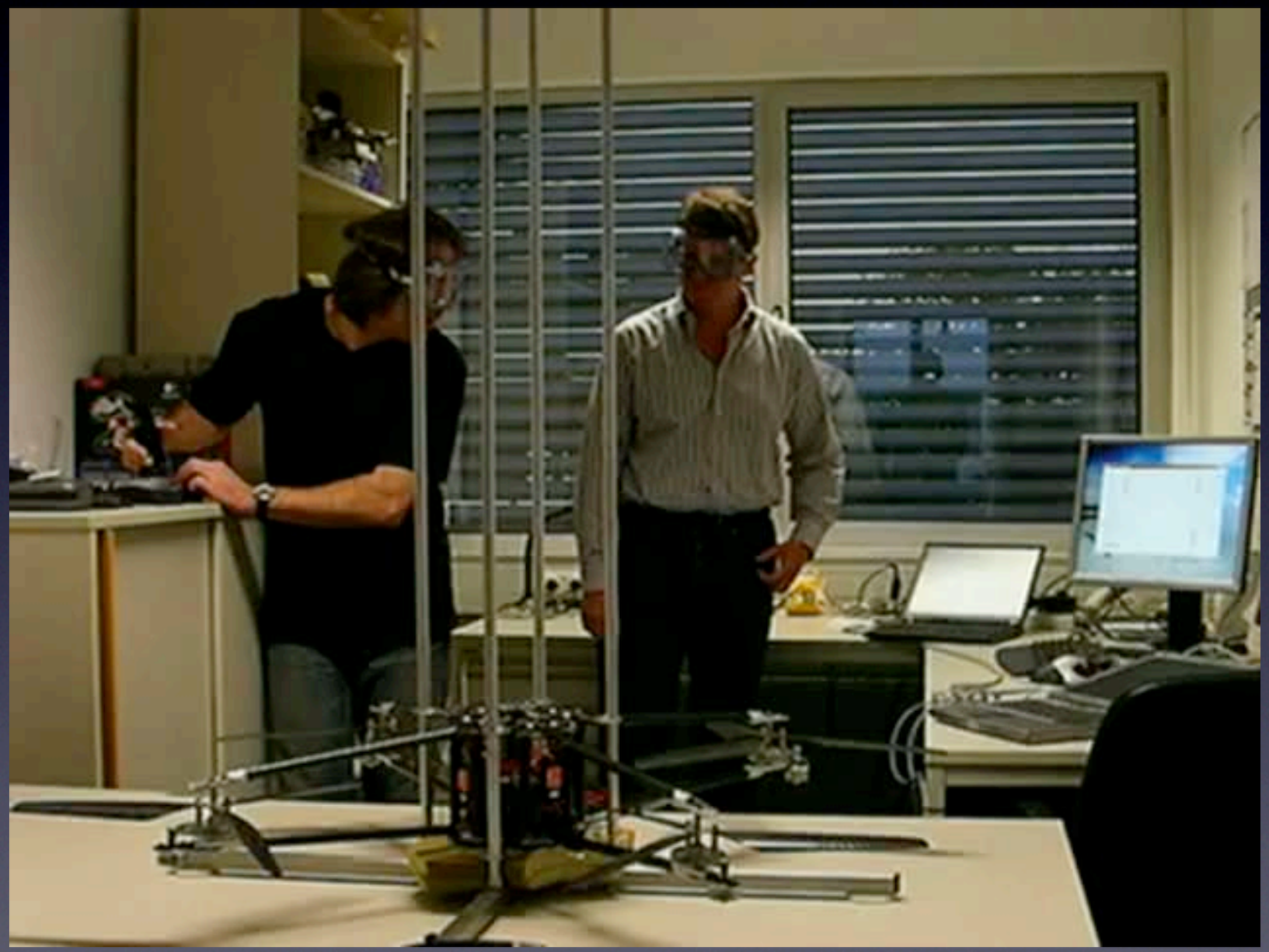
- we run helicopter flight control software written in *Java* on IBM's commercial J9 JVM with the real-time garbage collector *Metronome* on top of a Linux 2.6 machine with real-time patches applied to the kernel
- joint work with J. Auerbach, D. Bacon, H. Röck, and R. Trummer

The JAviator Project

javiator.cs.uni-salzburg.at



First All Java Flight



Thank you