Predicting (Disk Scheduling) Performance with Virtual Machines

Robert Geist, Zach Jones, James Westall

Clemson University

Motivation

- CPSC 822: Operating System Design: Case Study
  - second level, graduate OS course at Clemson
  - since 1985: walk through source of a UNIX derivative (this semester: Linux 2.6.30)
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- standard evaluation (5 yrs. out): *the* most valuable course of educational career (e.g. Satish Dharmaraj)

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Yeow! How do I measure that?

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- provide a new, high-performance, disk scheduling algorithm as a case study
- describe the *iprobe*, a key kernel modification tool, which should have wide application

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  - upon break:
    - pre-handler;
    - target (single step mode);
    - post-handler;
    - resume;

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    - jprobe return (restore stack and state);
    - first instruction in single-step mode;
    - remainder of function (empty post-handler);

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    - custom second-stage pre-handler
    - custom (non-empty) post-handler

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  - post-handler:
    - load IP with replacement function address;
    - overwrite no-op with backup copy;
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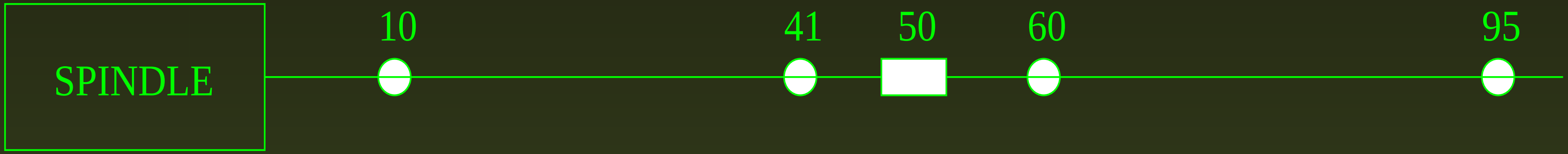
  - disks are performance bottlenecks
- algorithms not constrained to be *work-conserving*

An Example



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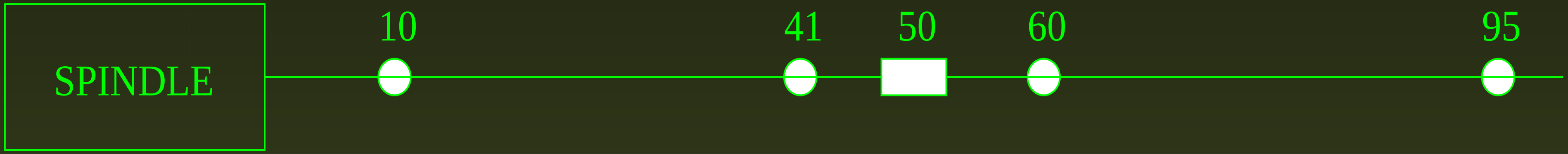

- order of arrival is 95, 10, 60, 41 (r/w head at 50)

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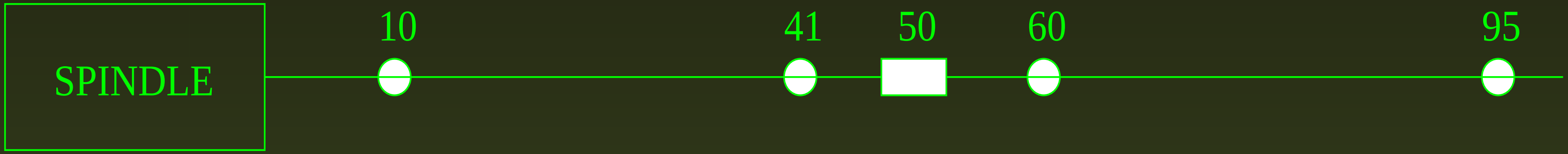

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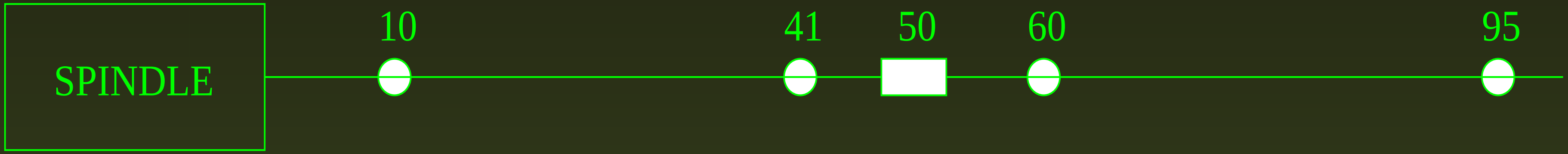

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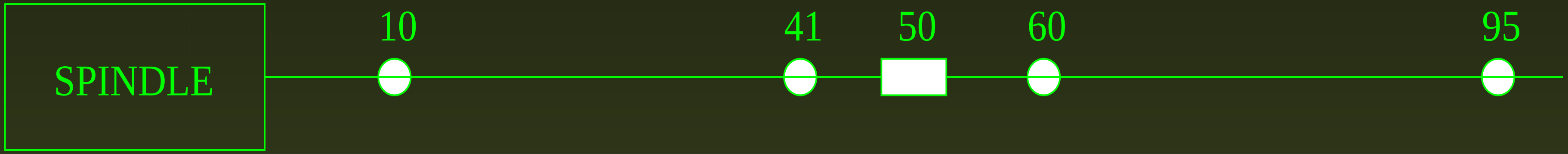
schedule	service	wait	response
95	45	0	45
10	85	45	130
60	50	130	180
41	19	180	199
mean	49.75	88.75	138.50

An Example (Continued)



Greedy or *shortest access time first (SATF)* schedule:

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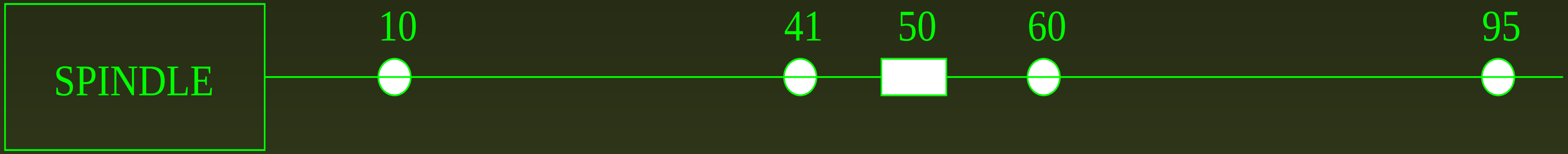
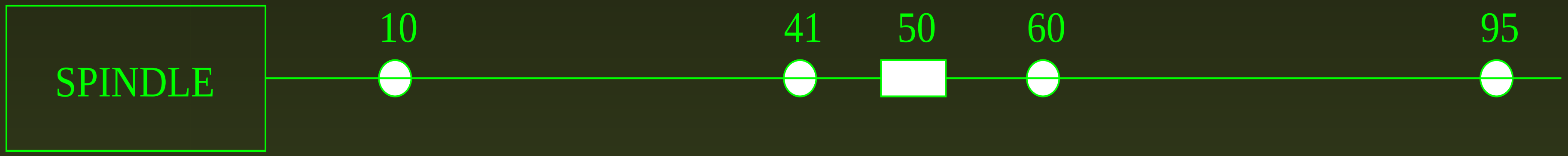


Greedy or *shortest access time first (SATF)* schedule:

schedule	service	wait	response
41	9	0	9
60	19	9	28
95	35	28	63
10	85	63	148
mean	37.00	25.00	62.00

An Example (Continued)



SPINDLE

10 41 50 60 95

SATF often claimed to be optimal, but ...

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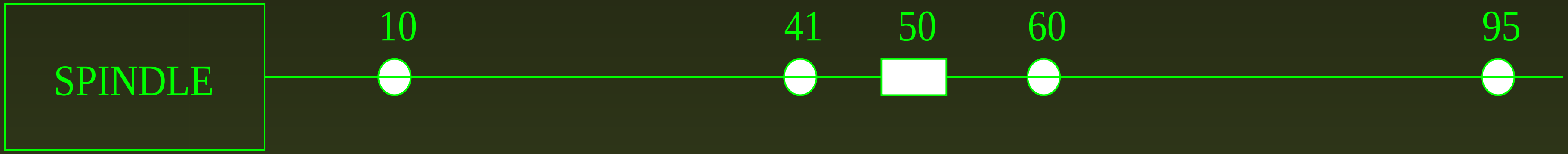

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schedule	service	wait	response
60	10	0	10
41	19	10	29
10	31	29	60
95	85	60	145
mean	36.25	24.75	61.00

Schedulers Supplied with Linux 2.6

- No-op
- Anticipatory
- Deadline
- Completely Fair Queueing

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- out-wait deceptive idleness (5 ms)

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- cache model assumptions: fully associative, FIFO replacement, wrap-around within segments
- scheduling:
  - maintain shadow cache within scheduler
  - on each dispatch, check entire queue for predicted cache hit
  - if predicted hit, schedule immediately

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- *iprobe*: delay virtual request completion $kX_r - X_v$
- oops! k is unknown

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System reports current k
Rule 1: accuracy
Rule 2: simulation run-time

Test Platforms

Real:

- Linux 2.6.30
- dual Intel Xeon 2.80GHz CPUs
- Western Digital IDE system drive
- dual 73.4 GB Seagate Cheetah 15.4K SCSI drives
- dual Adaptec 39320A Ultra320 SCSI controllers
- tests restricted to single SCSI drive

Test Platforms

Virtual:

- KVM-based, virtual Linux 2.6.30
- hosted on IBM 8853AC1 dual 2.83GHz Xeon blade
- virtual 73.4 GB SCSI disk
- virtual disk on NetApp FAS960c, access NFS

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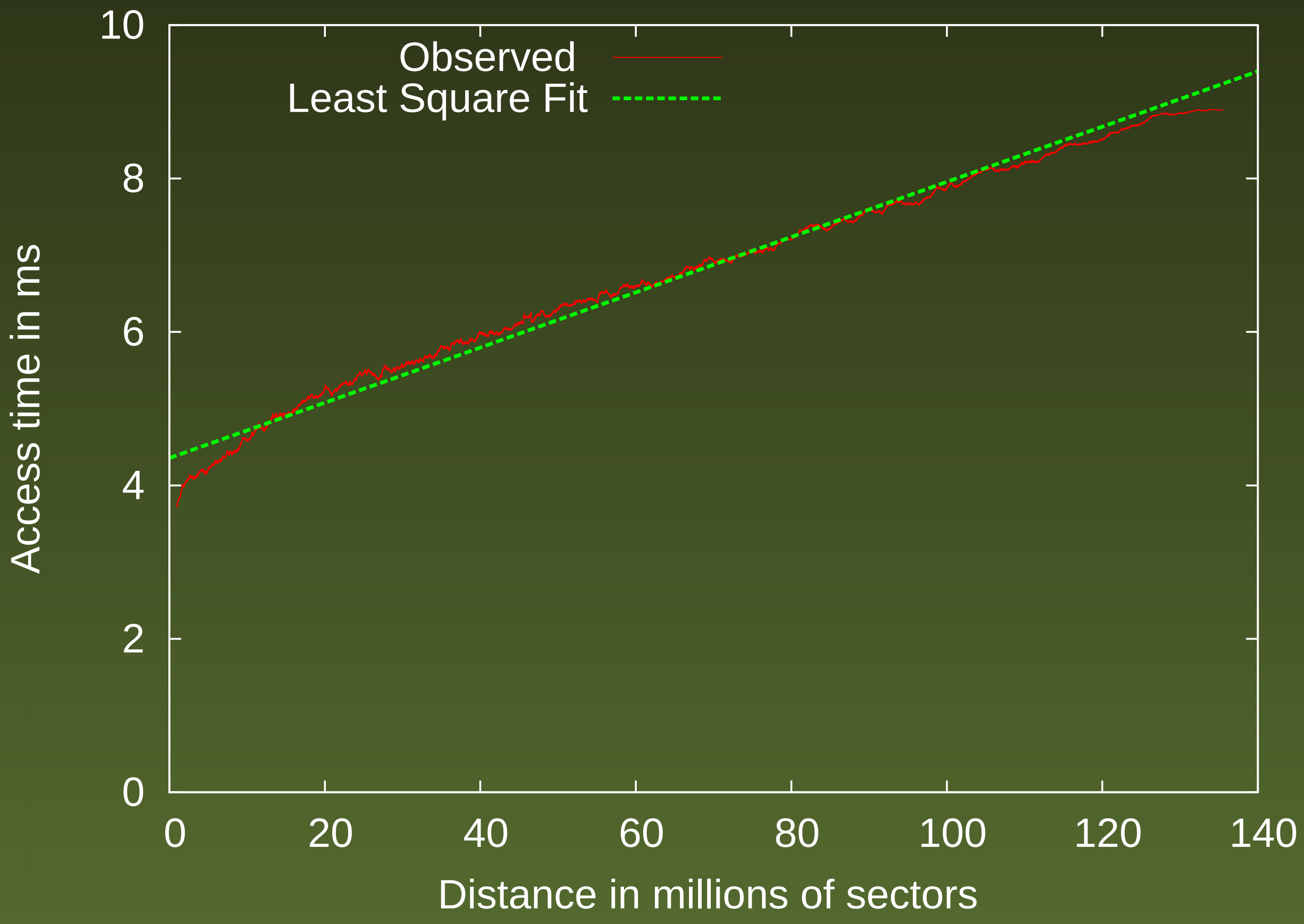

Test Platforms

Cache Model (Seagate manual and *sdparm*):

- 64 segments
- 221 sectors per segment
- 64-sector pre-fetch

Workload

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        repeat($n$ times){
            select file from $L$ files using Zipf($L$);
            while(file not read){
                read one page;
                generate $t$ from Pareto($\alpha_2$,$k_2$);
                sleep $t$ ms;
                }
            }
        }
```

Distributions

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Parameters from Barford-Crovella study

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	real			virtual (k=8)		
sched.	*cats*	*dline*	*cfq*	*cats*	*dline*	*cfq*
μ_S	1.96	2.71	1.39	2.58	3.24	2.36
σ_S^2	8.51	9.76	5.85	9.03	8.23	7.78
μ_R	37.35	59.87	124.70	53.79	78.27	117.13
tput	8.19	6.08	2.19	6.15	5.06	3.38

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σ_S^2	11.13	8.80	17.62	6.22	6.05	10.30
μ_R	114.91	121.87	179.17	189.45	198.33	258.75
tput	12.00	12.04	9.08	11.44	11.68	8.82

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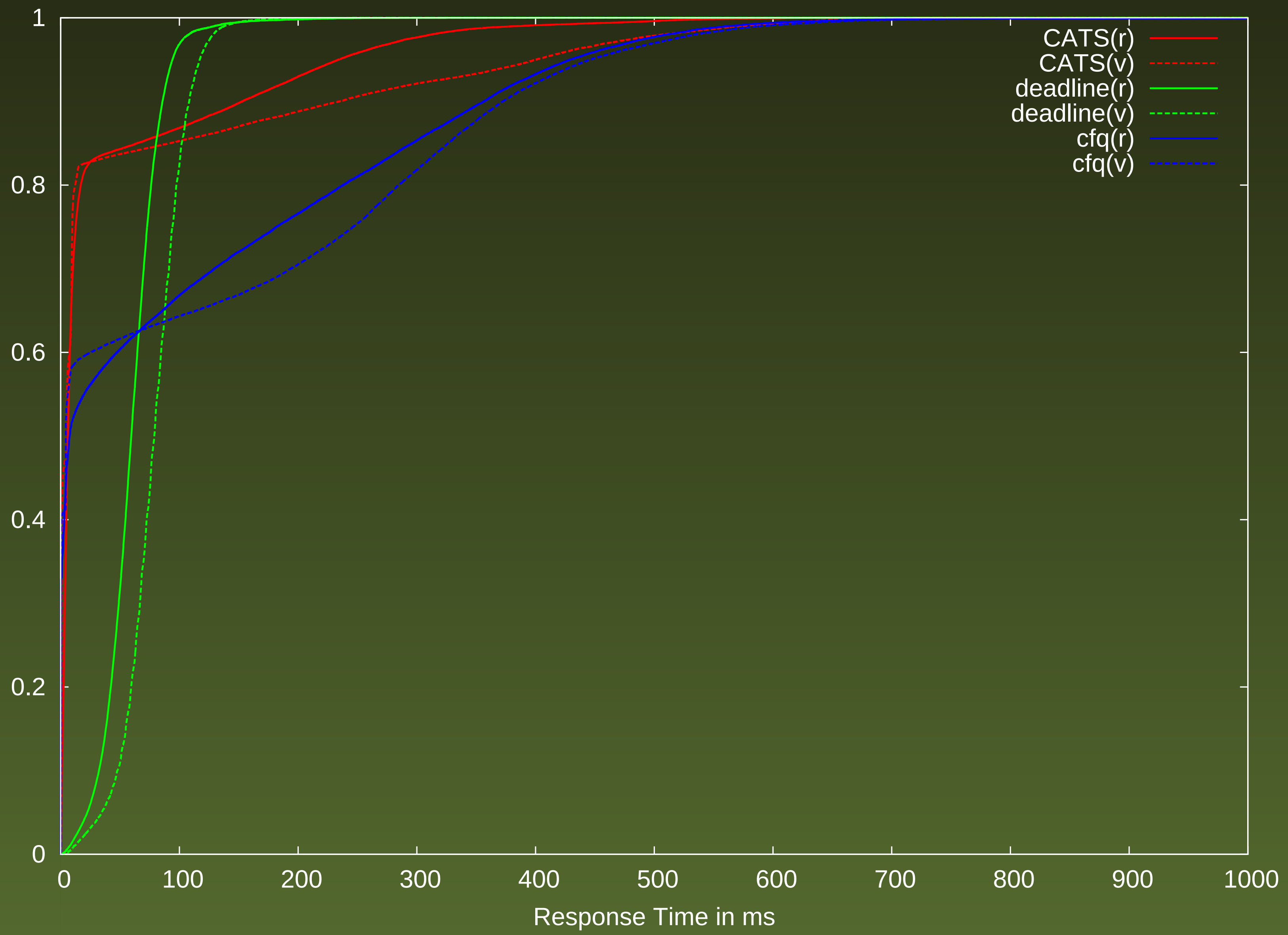

1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
600
700
800
900
1000
Response Time in ms
CATS(r)
CATS(v)
deadline(r)
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cfq(r)
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- Fair criticism: just using virtual Linux as elaborate simulator
- True, but good results with almost zero programming effort!

Where has he been ... ?