The JAviator Project

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Vision

High-performance real-time applications entirely written in Java using standard JDKs

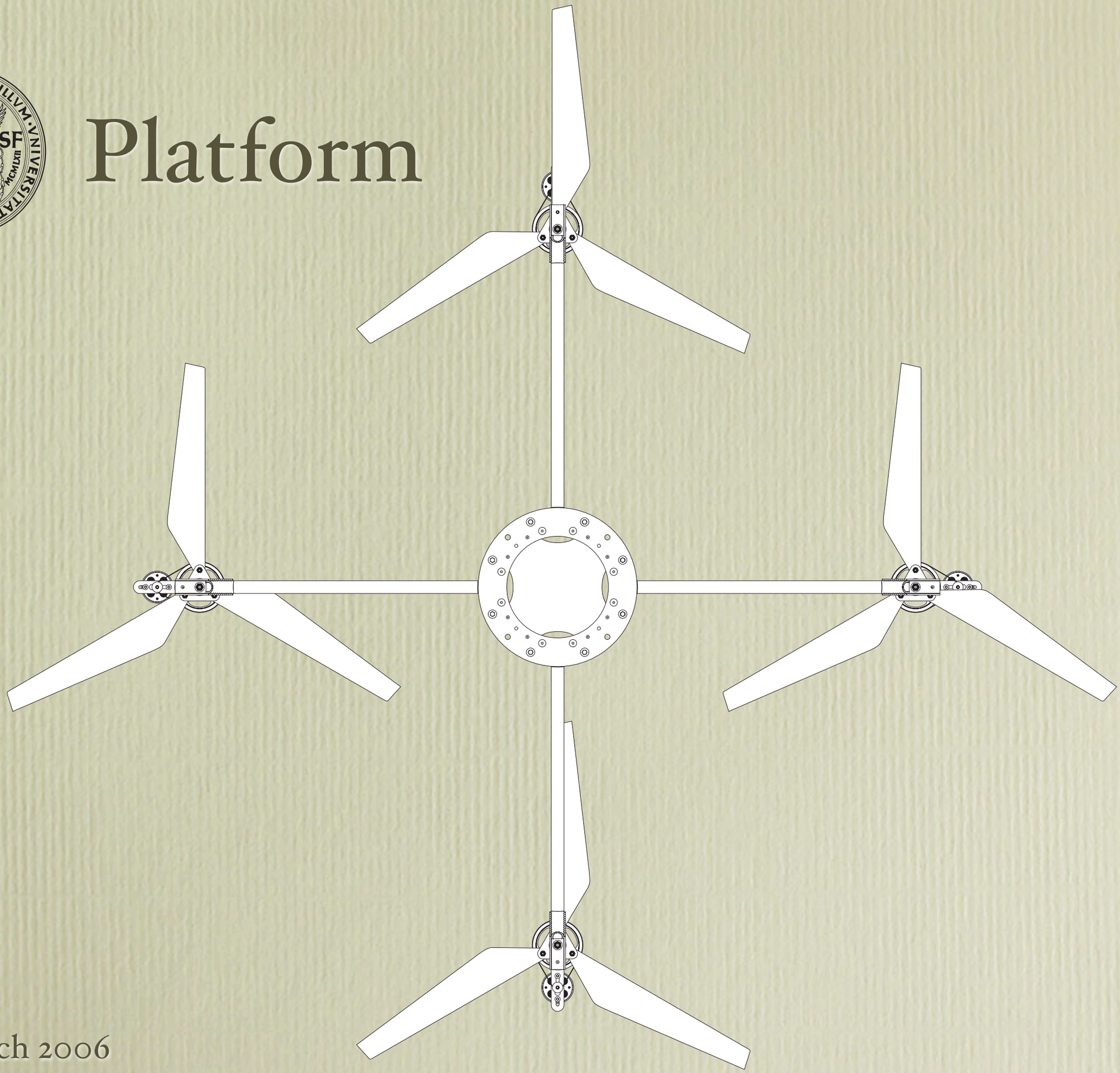
Challenges

1. application: flight control (inspired by the Starmac project at Stanford)
2. memory model: multiple heaps
3. concurrency model: exotasks
4. write-once-run-anywhere in the temporal domain

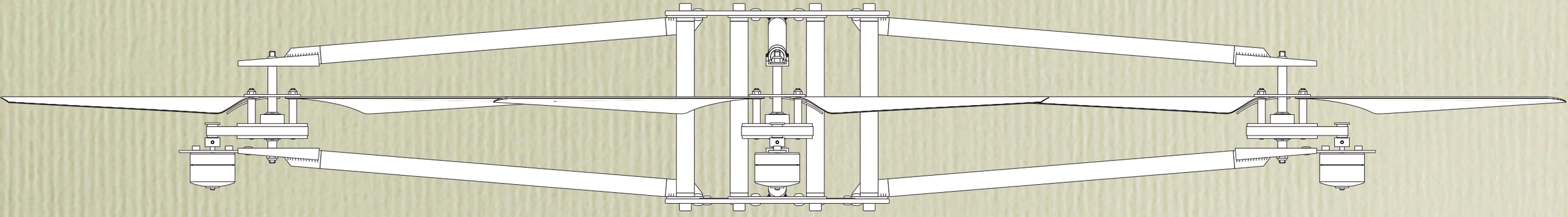
Team

- Salzburg:
  - 2 PhD students (Harald Roeck, Rainer Trummer), 1 masters student (Werner Gitschthaler)
- Timisoara:
  - 1 PhD student (Daniel Iercan)
- IBM T.J. Watson:
  - 1 staff researcher (David Bacon), possibly more

Platform



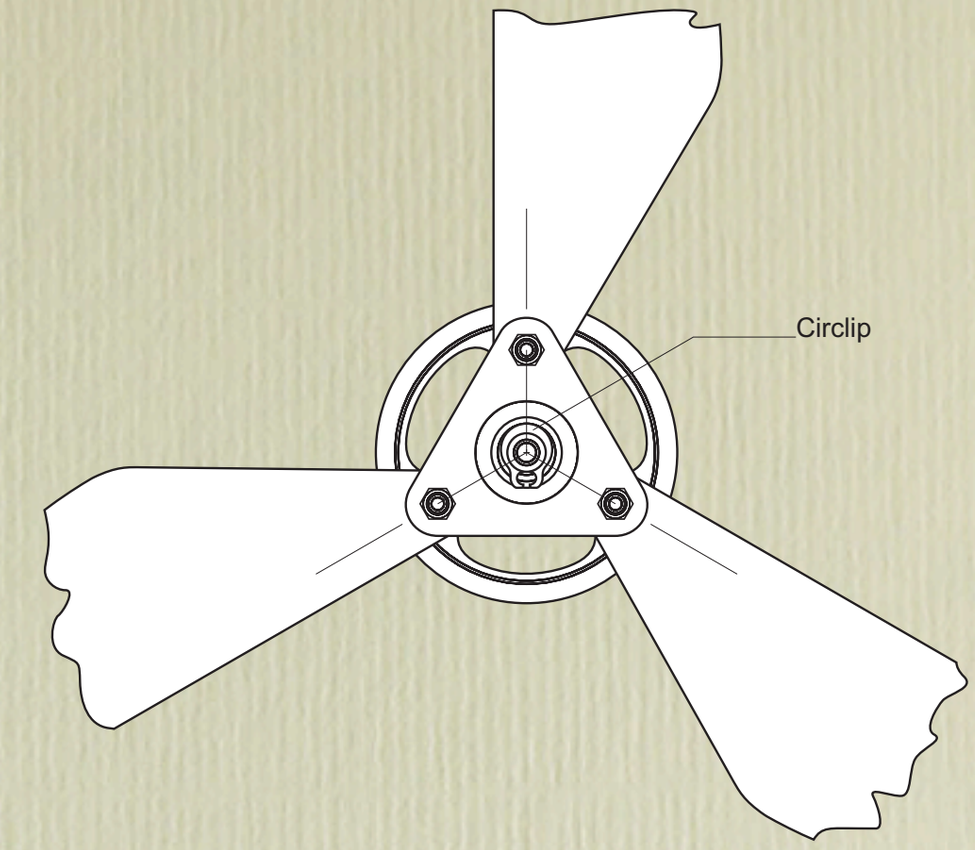
It’s a ‘Bicycle Wheel’

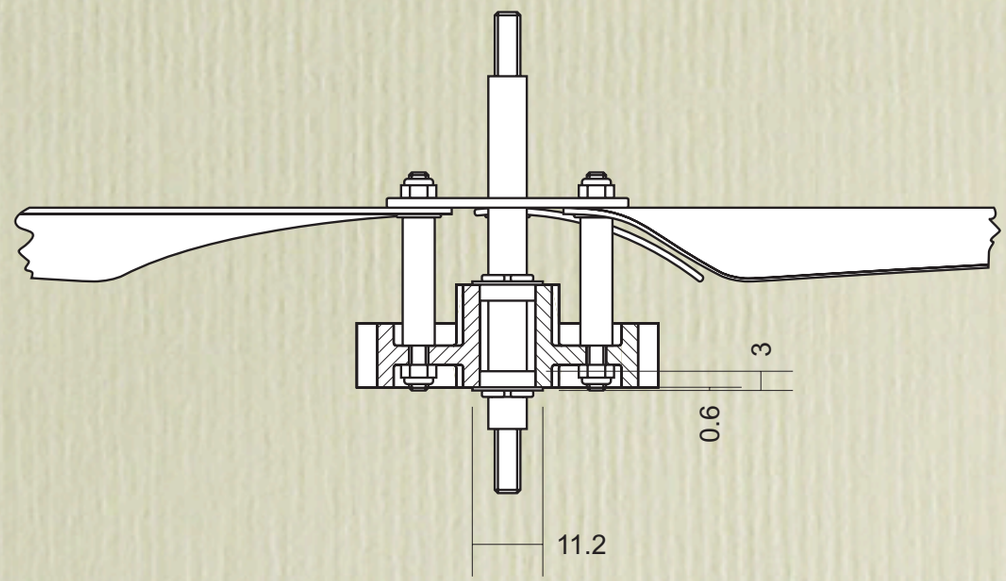


Design

The hardware design including all blueprints will be made available at:

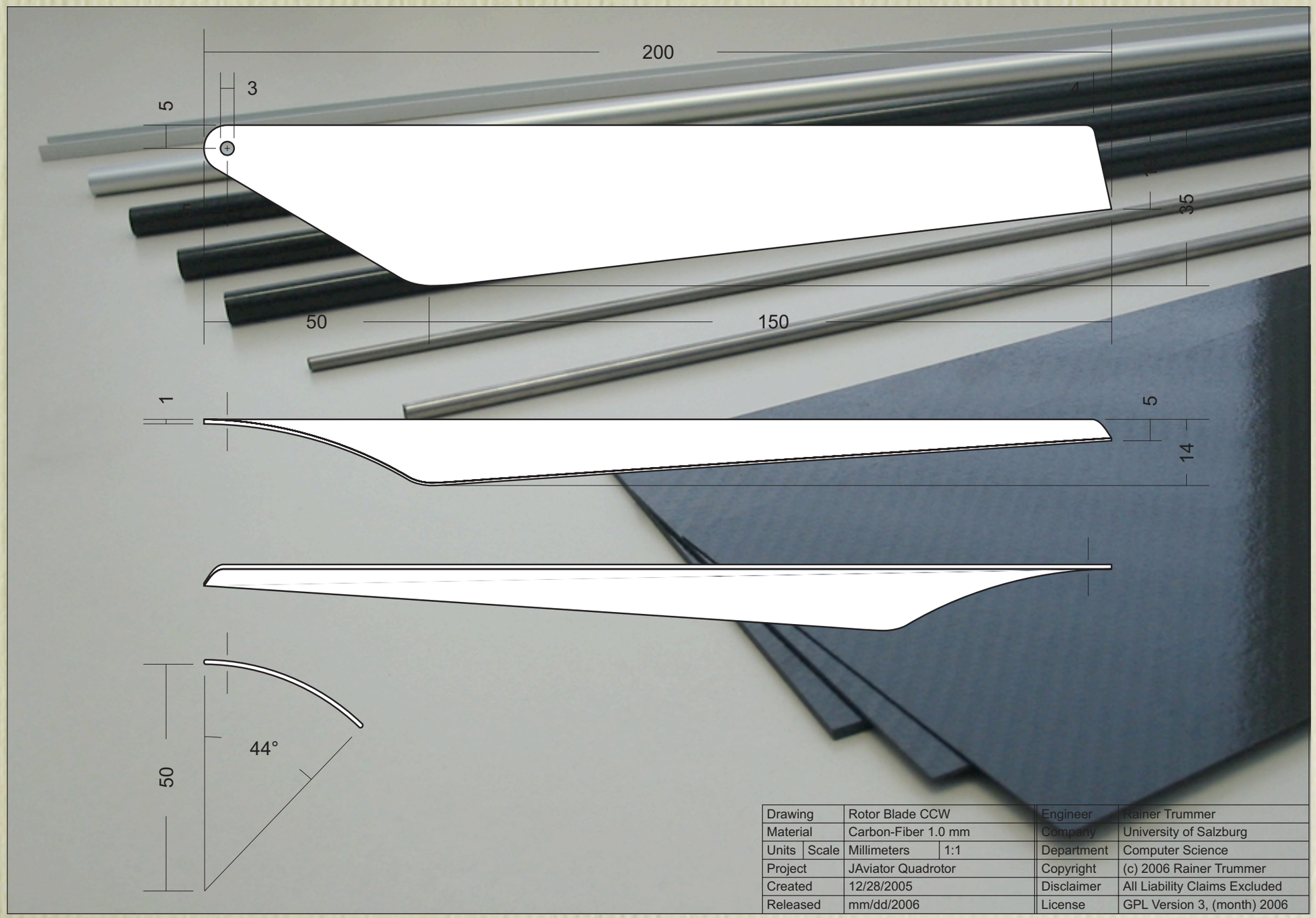
javiator.cs.uni-salzburg.at





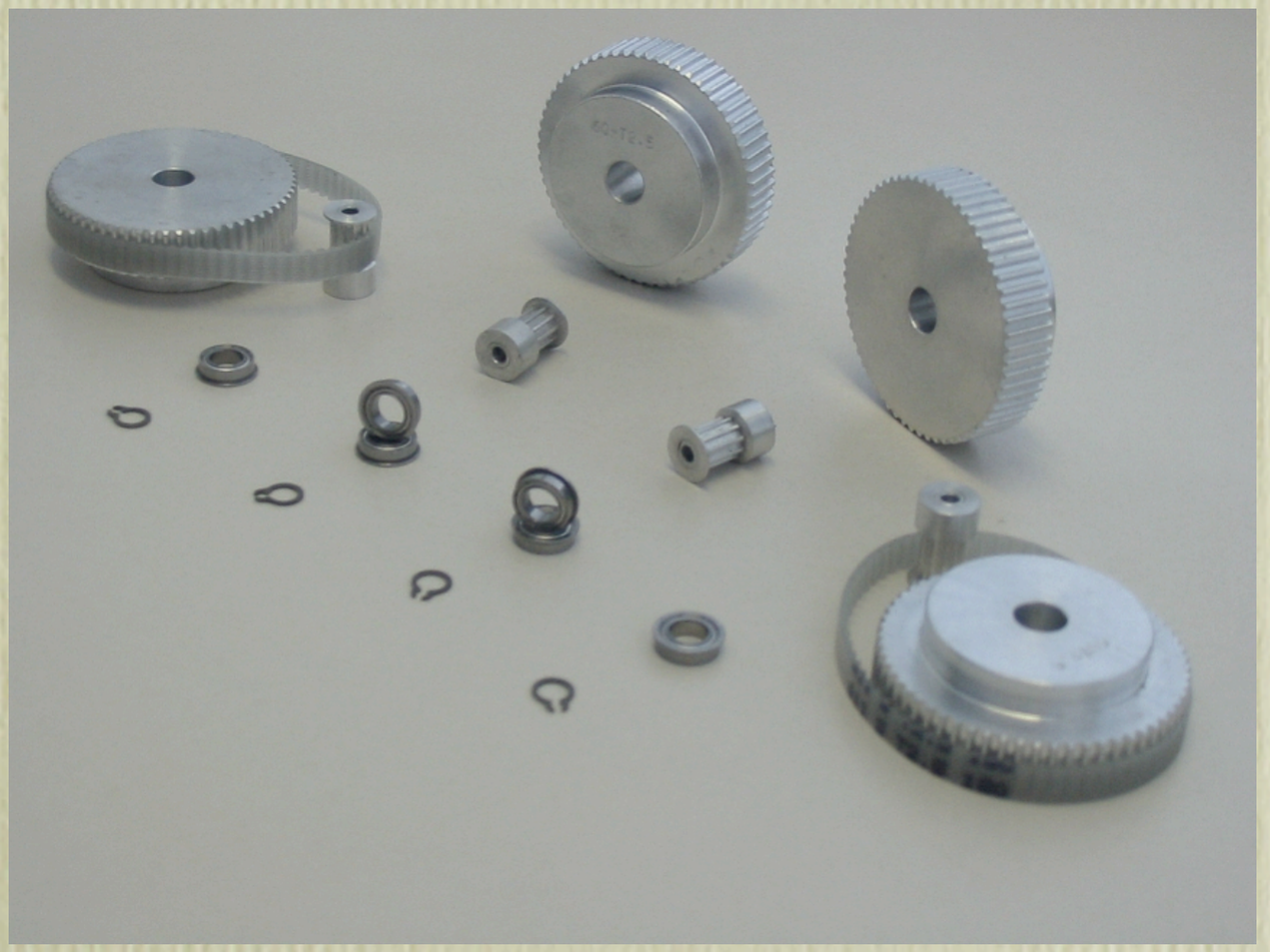
Drawing		Rotor Bearings DDLF-1060		Engineer	Rainer Trummer
Material		Stainless-Steel Alloy		Company	University of Salzburg
Units	Scale	Millimeters	1:1	Department	Computer Science
Project		JAviator Quadrotor		Copyright	(c) 2006 Rainer Trummer
Created		01/07/2006		Disclaimer	All Liability Claims Excluded
Released		mm/dd/2006		License	GPL Version 3, (month) 2006

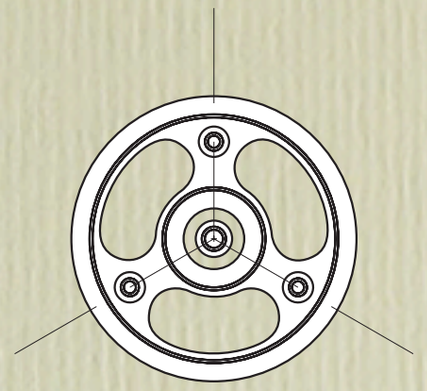
Ouch: Carbon Fiber Blades

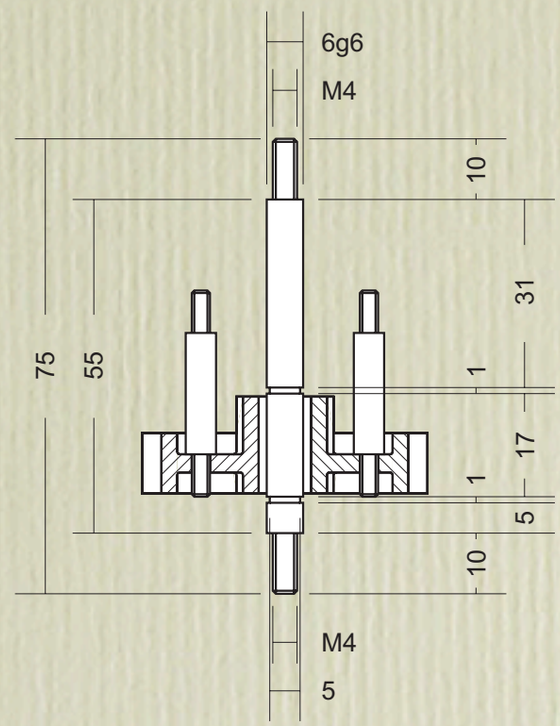


Drawing		Rotor Blade CCW		Engineer	Rainer Trummer
Material		Carbon-Fiber 1.0 mm		Company	University of Salzburg
Units	Scale	Millimeters	1:1	Department	Computer Science
Project		JAviator Quadrotor		Copyright	(c) 2006 Rainer Trummer
Created		12/28/2005		Disclaimer	All Liability Claims Excluded
Released		mm/dd/2006		License	GPL Version 3, (month) 2006

Weight..less







Drawing		Rotor Axle		Engineer	Rainer Trummer
Material		Titan Alloy TiAl6V4		Company	University of Salzburg
Units	Scale	Millimeters	1:1	Department	Computer Science
Project		JAviator Quadrotor		Copyright	(c) 2006 Rainer Trummer
Created		01/07/2006		Disclaimer	All Liability Claims Excluded
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gear transmission ratio: 6:1

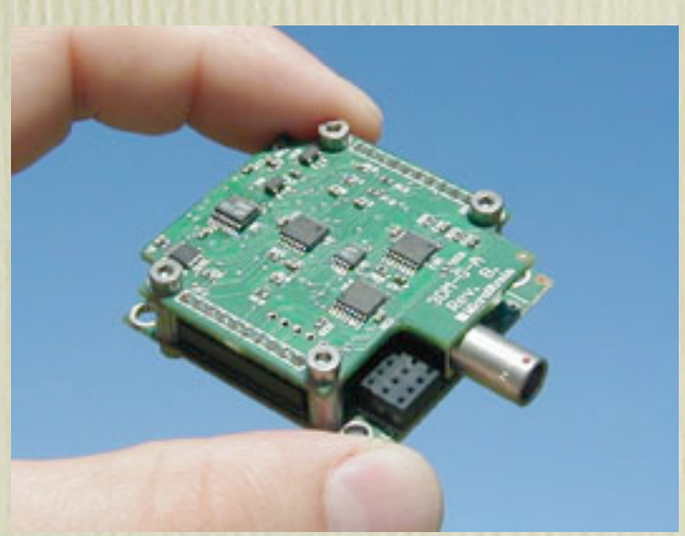
max. rotor speed: 1850 rpm

Brushless Motors

Power: 100W
Weight: 26g
Thrust: 600g

3 Gyros, 3 Accelerometers, and 3 Magnetometers

Microstrain 3DM-GX1
Dynamic orientation: gyros
Static orientation: accs, mags
Fusion: onboard programmable filter
I/O: RS-232, RS-485, analog output



10 Ultrasonic Sensors

Devantech SRF10 Sonar Ranger

Frequency: 40KHz
Range: 3cm-6m
I/O: I2C Bus

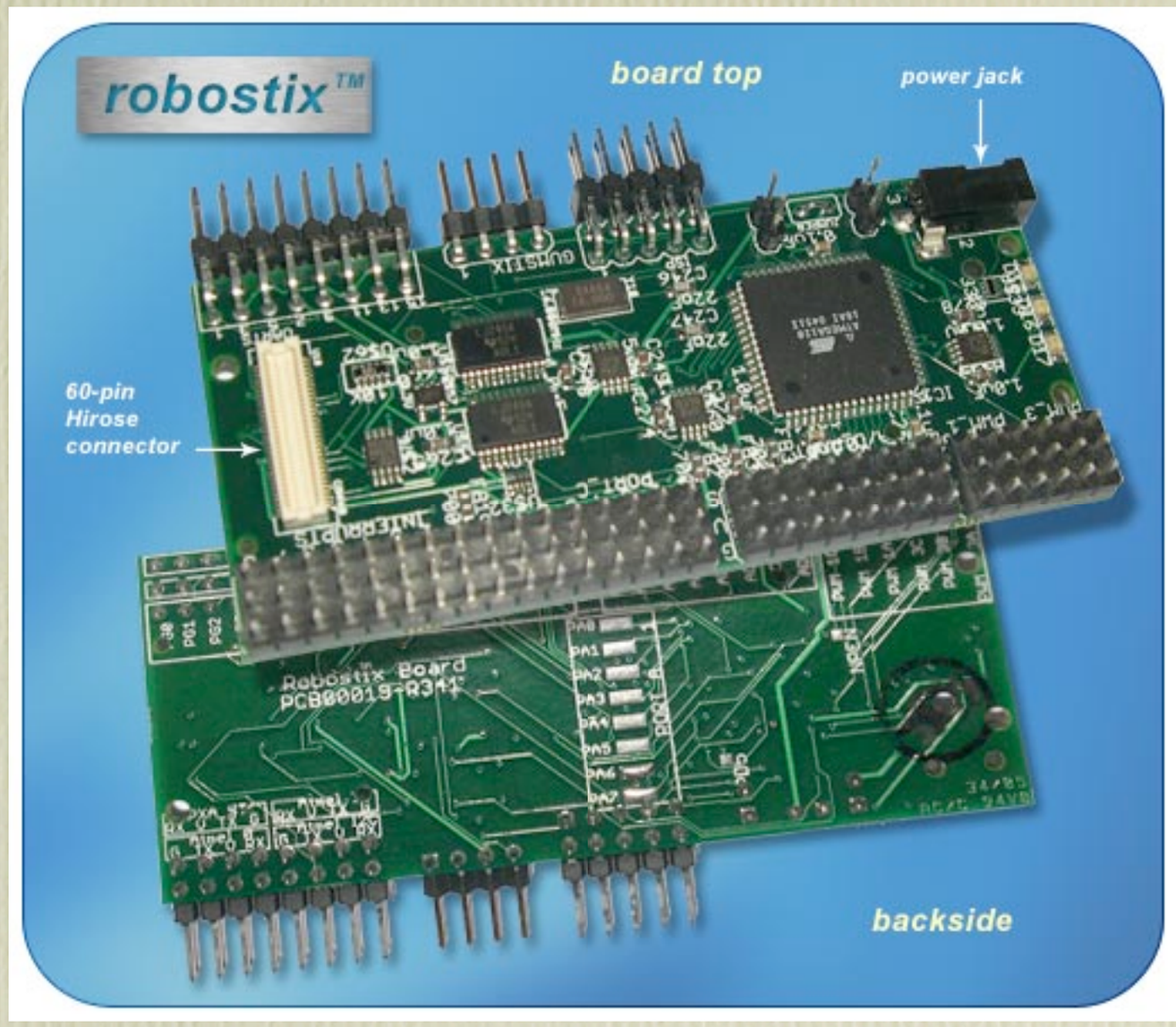
...but what about lasers?

Processor Board

Board: Gumstix
CPU: XScale 400MHz
RAM: 64MB
Flash: 16MB
Network: Bluetooth
OS: Linux 2.6

I/O Board

Board: Robostix
Bus: I2C
I/O: 6 PWM,
8 A/D,
25 GPIO,
2 UART (Atmega)



Rate Requirements

- gyros, accs, mags: up to 350Hz
- ultrasonic sensors: ~12Hz
- motors: ~100Hz

Current Capabilities

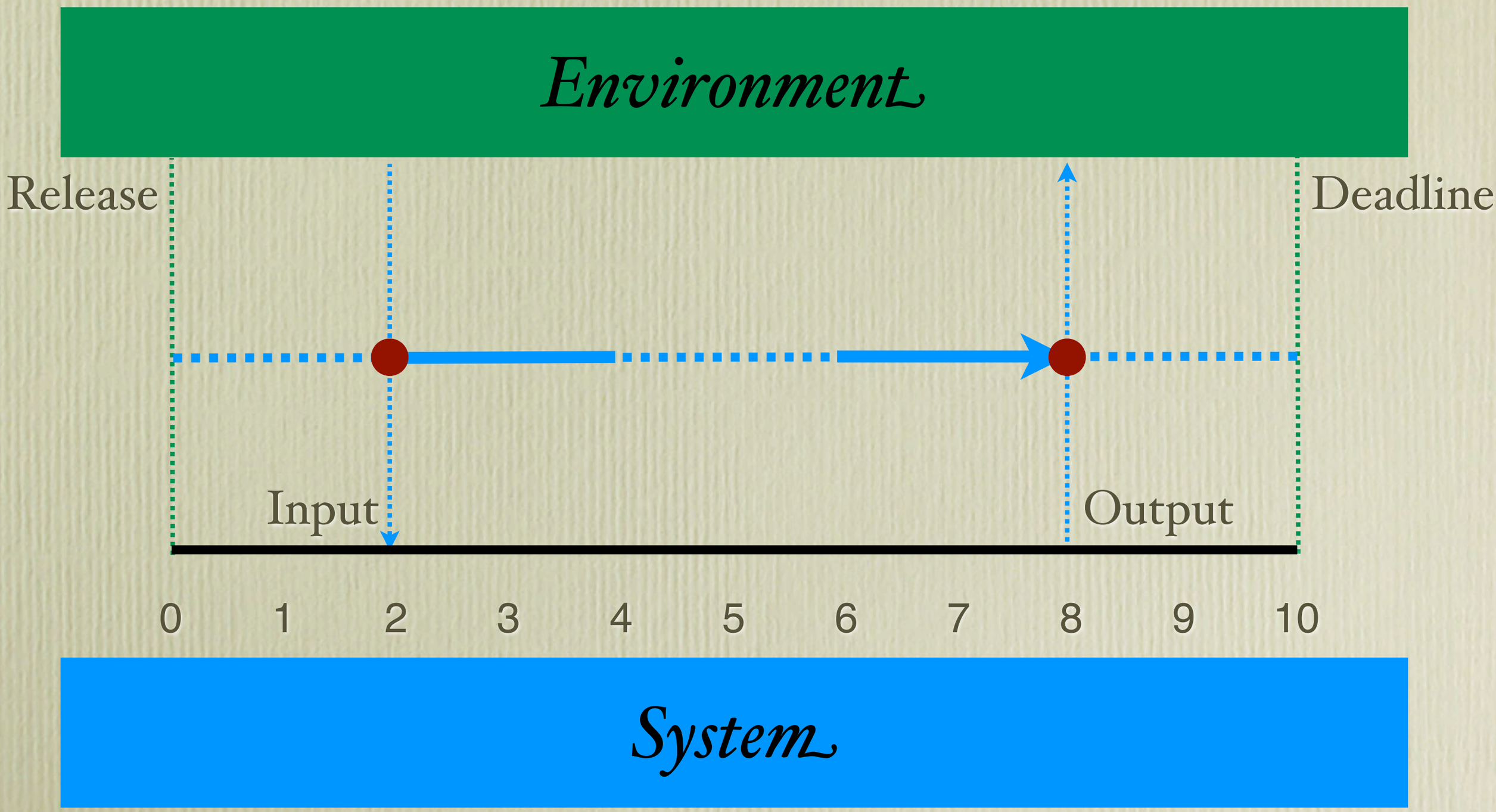
- IBM's real-time GC (Metronome) has a worst-case latency of 700us
- "eventrons" may run at up to 20KHz with a worst-case jitter of 5us (on 2.6 Linux kernel with preemption patches)
- ...but on a 2.4GHz Pentium, though with a 100MB heap...

Next Steps

- port Metronome to ARM (done at IBM)
- integrate GC and exotasks (IBM, Salzburg)
- enable logical execution times (Salzburg)

  ➡ write-once-run-anywhere in the temporal domain

RT Programming Tradition



Logical Execution Time (LET)

Environment

Programming as if there is enough CPU time

Input

Output

Compiler or runtime system checks if CPU time is sufficient.

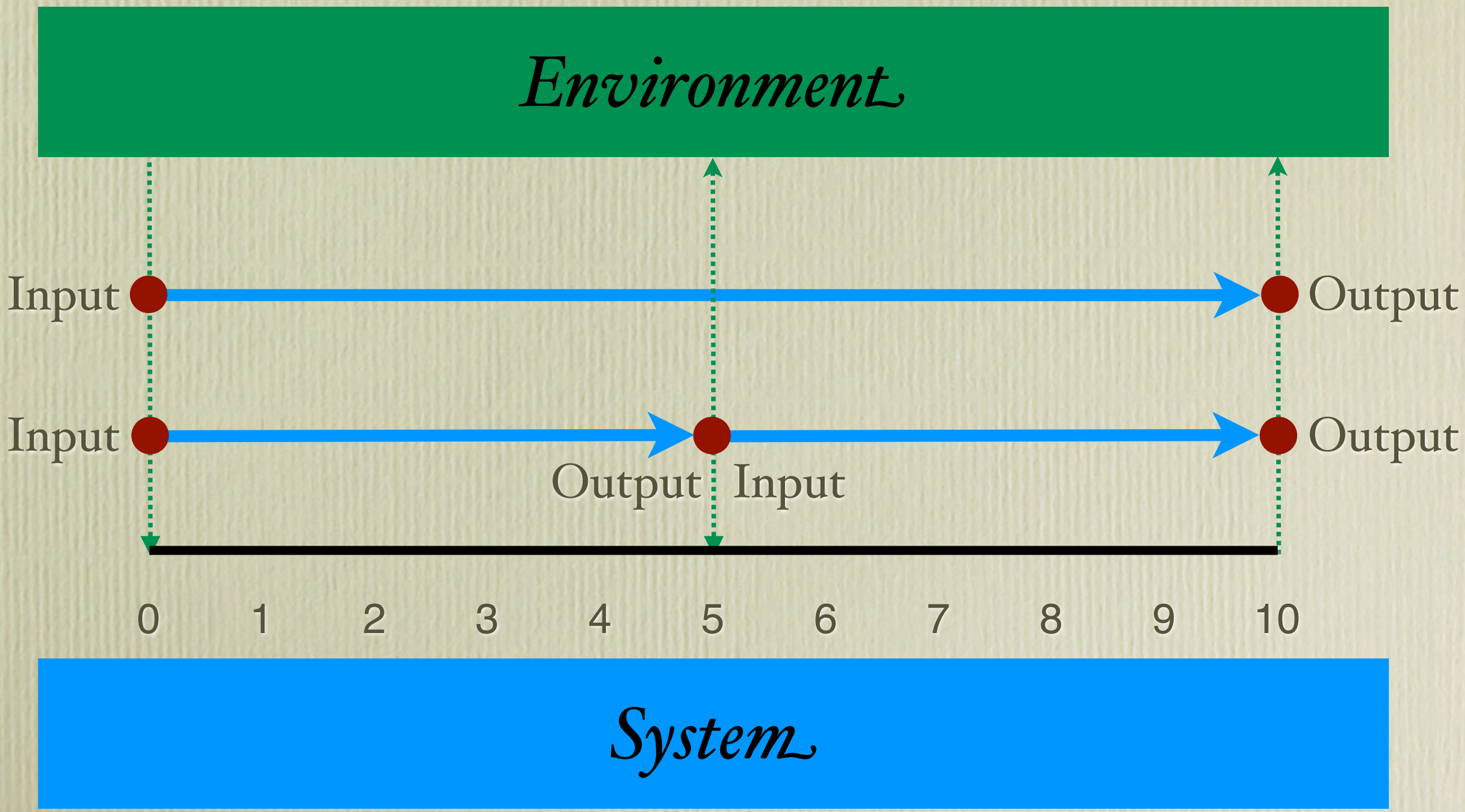
If not, program is not time safe.

compiler error or runtime exception

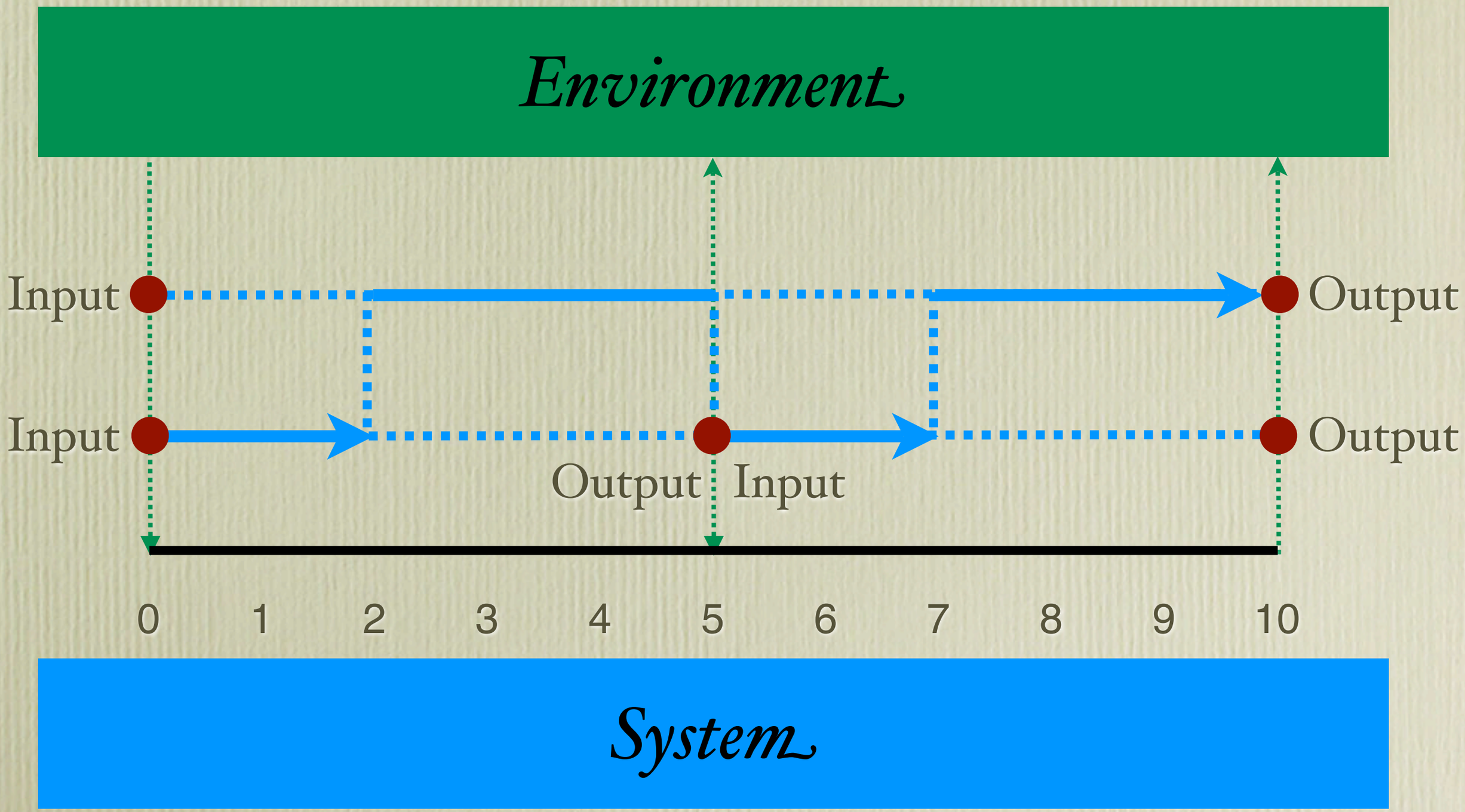
0 1 2 3 4 5 6 7 8 9 10

System

LET Programming



Single CPU, EDF Scheduler



Implementation

- JVMs often map Java threads 1:1 to POSIX threads (IBM's J9 does this)
- POSIX threads invoke system calls to do I/O

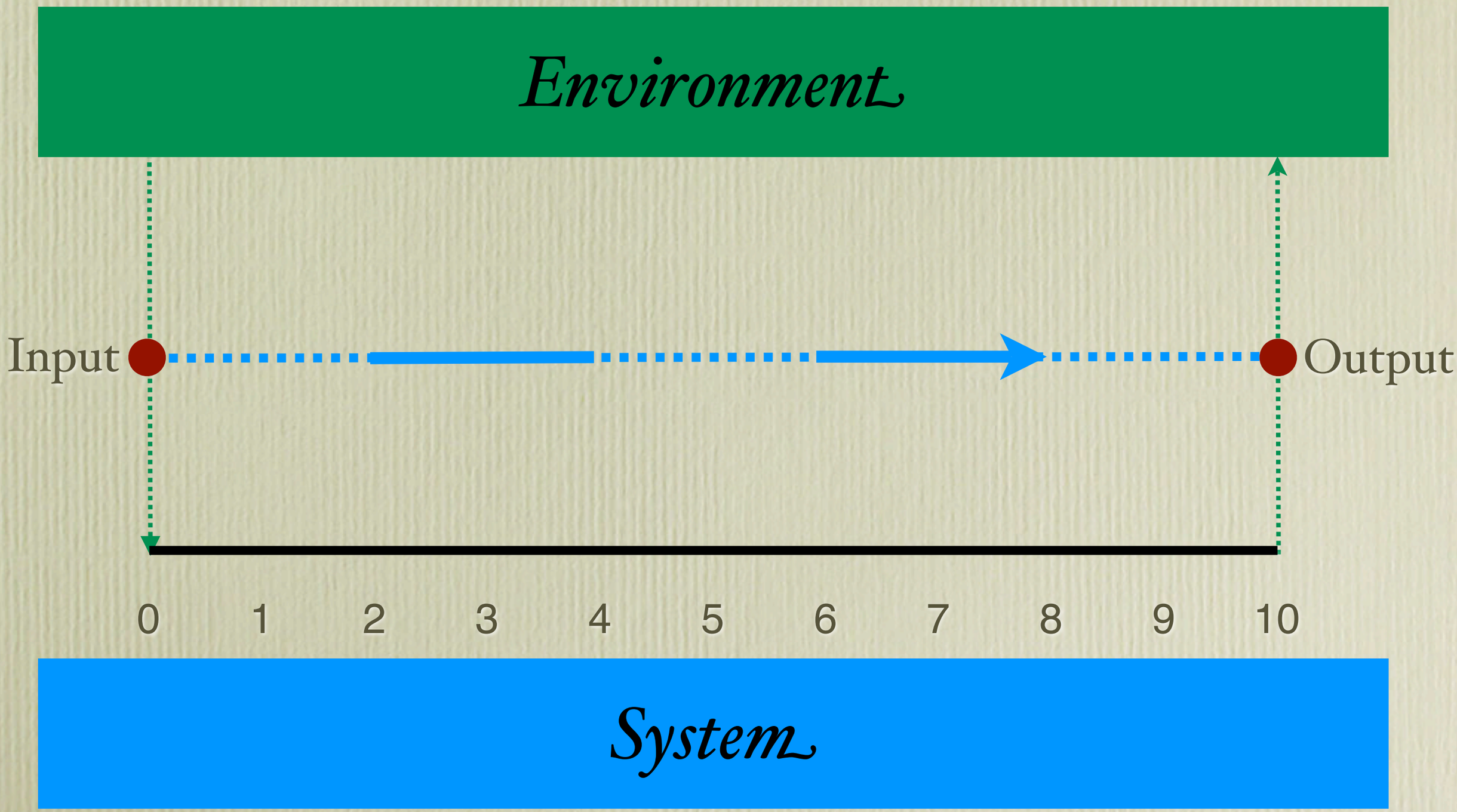
➡ we have implemented a POSIX-compliant threading library that schedules system calls with respect to a given queueing policy

System Call Scheduling

- system calls are seen as ‘network packets’
- threads ‘send’ system calls
- system calls are enqueued and dequeued according to a given policy
- multiple queues: disk, network, cpu, memory, real-time I/O

➡ part of the TAP project: tap.cs.uni-salzburg.at

Logical Execution Time Policy

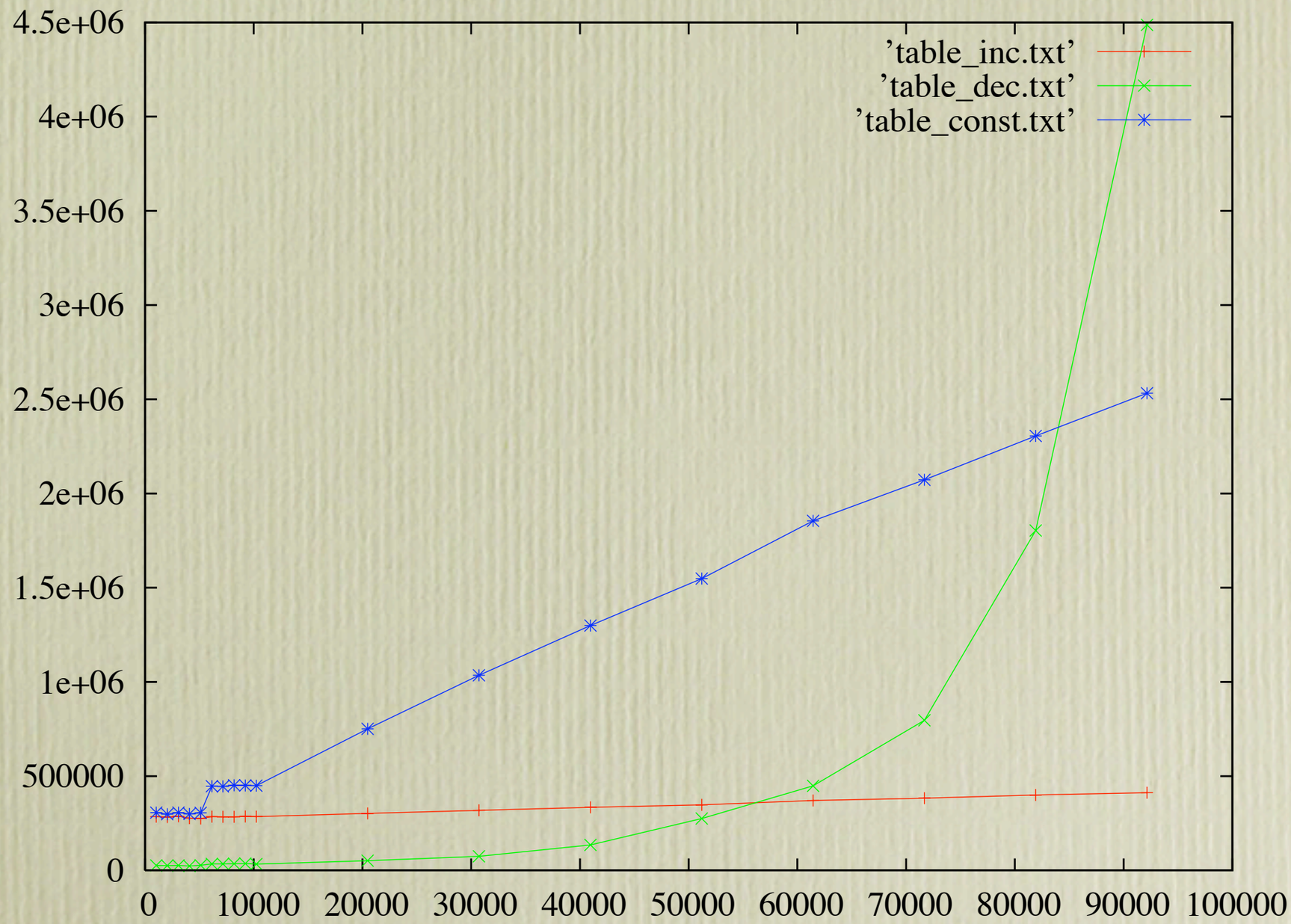


Traffic Shaping System Calls

- queueing discipline: prioritized FIFO
- thread behavior is the classification scheme:
  - e.g., “short-running” threads may have higher “queueing priority” than “long-running” threads

➡ improves latency of interactive threads

Example: Web Server Latency



Thank you