2014–2015 HMC Computer Science Clinic SpaceX Project

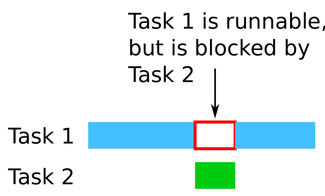
Process Time Analysis in Spaceflight

Problem Statement

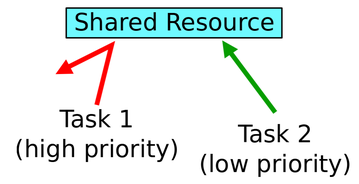
Our goal was to make it **easier** and **faster** for SpaceX engineers to find software problems by creating a tool that **visualizes** rocket data and highlights problem areas. We wanted to create an **improved user experience** and to provide more visualizations of the data than the current tool, KernelShark.

SpaceX, Rockets, and Software

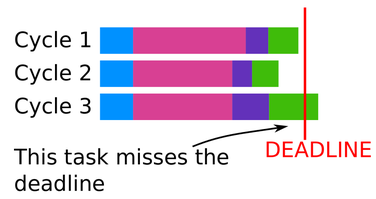
SpaceX rockets contain computers that run flight software. By looking at a schedule of the tasks running on these computers, developers look for problems like these:



Preemptions: Tasks 1 and 2 are running on the same CPU. When Task 2 runs, Task 1 is blocked by it, and must wait for Task 2 to stop until it can run again.

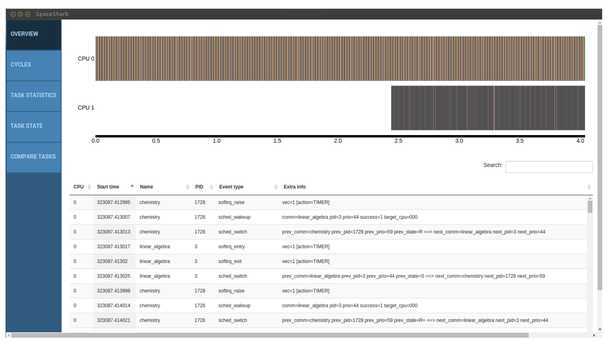


Priority Inversions: Task 2 is using a shared resource that Task 1 needs access to, so Task 1 is blocked from running until it can access that resource, even though it is higher priority than Task 2.



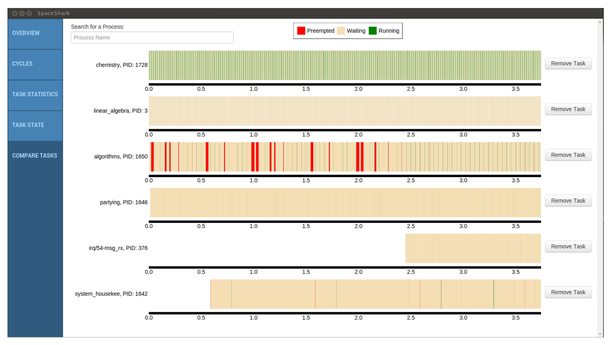
Missed Deadlines: Tasks run cyclically on the computer, with a deadline at the end of each cycle. The pattern of tasks generally looks similar between different cycles.

Visualizing a Rocket's Software



The **Overview** page displays an overview of the rocket's software, including a timeline of running tasks and a more detailed tabular view.

The **Cycles** page breaks the timeline into cycles, so that users can easily compare them for anomalies.



The **Compare** page allows users to see interactions between tasks by displaying multiple task state graphs at once.

Architecture

Our application transforms raw, text-based rocket data into visualizations.

Rocket Data *ftrace*

```
trace-cmd-4442  [002]  1681.955167:
sched_switch:         prev_comm=trace-cmd
prev_pid=4442 prev_prio=120 prev_state=S ==>
next_comm=swapper/2 next_pid=0
next_prio=120
python-2418  [001]  1681.955177:
sched_stat_wait:      comm=trace-cmd pid=4441
```

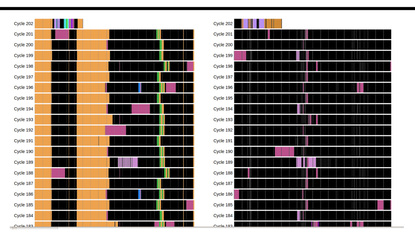
parse — *Java*

Human Readable Format *JSON*

```
"events":[
   {
     "startTime":83067,
     "name":"trace-cmd",
     "cpu":"[001]",
     "pid":3939,
     "eventType":"sched_wakeup"
```

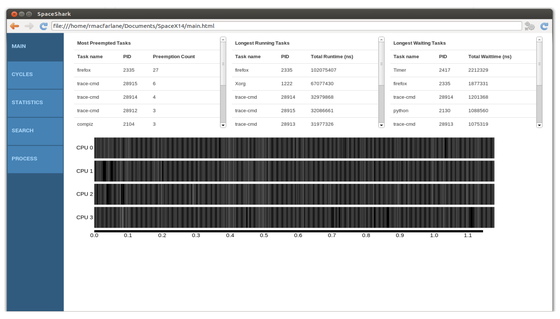
visualize — *d3.js, DataTables.js, IndexedDB*

SpaceShark *Node-Webkit*

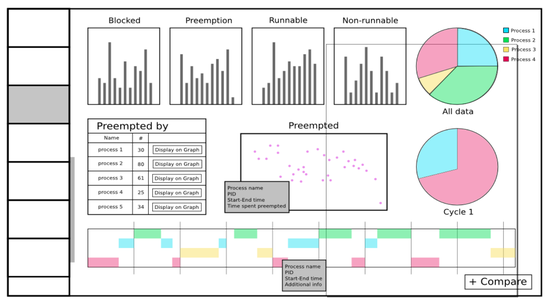


User Testing

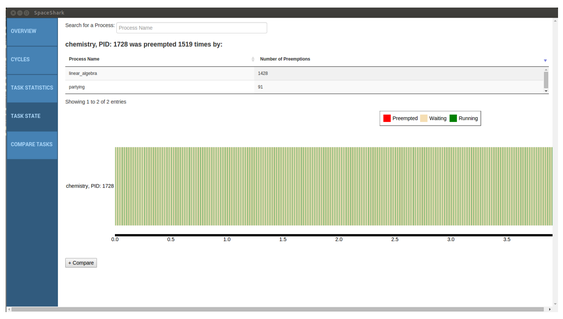
We asked SpaceX engineers for feedback on early prototypes, then used their advice to make a more useful tool.

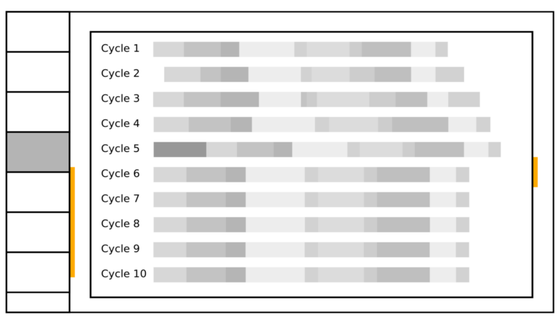


Added tabular view of events list



Focused on preemption statistics





Reversed cycle order

HARVEY MUDD COLLEGE

Acknowledgments

Thanks to our sponsor, SpaceX, for technical and equipment support. Thanks also to the Clinic staff, who made this project possible.

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