



A Multi-Dimensional Adaptive Variable Rate Task Model and Its Potential Role in Reducing Resource Utilization of Embedded Systems

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Engine Control Units (ECUs)

Responsibilities:

- Fuel injection
- Spark ignition

Top-Dead-Center:

- Real-time job release
- Due at next ignition

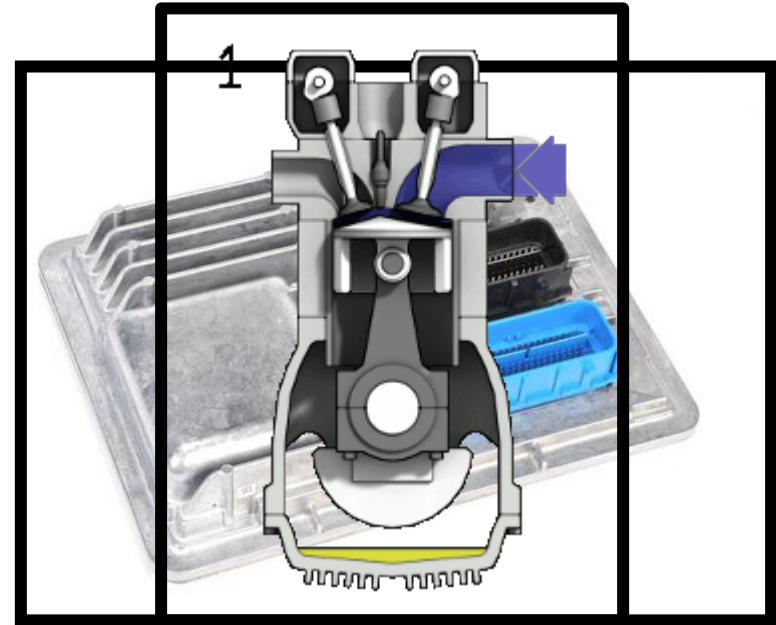
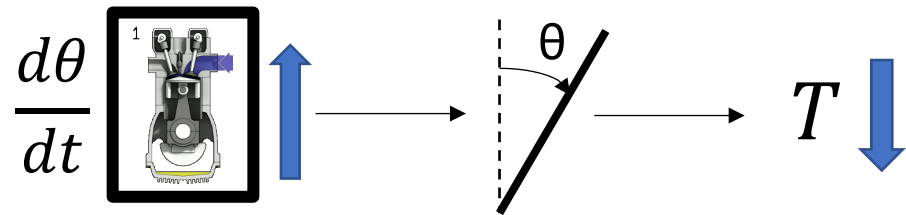
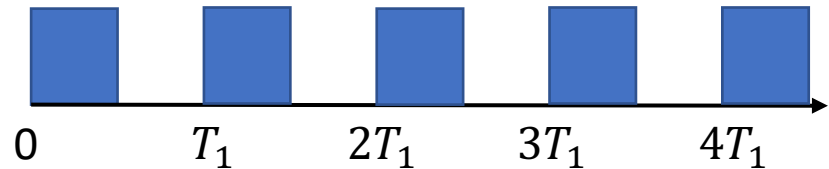


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[https://commons.wikimedia.org/wiki/
File:4StrokeEngine_Ortho_3D_Small.gif](https://commons.wikimedia.org/wiki/File:4StrokeEngine_Ortho_3D_Small.gif)

ECU Real-Time Tasks

Calculations:

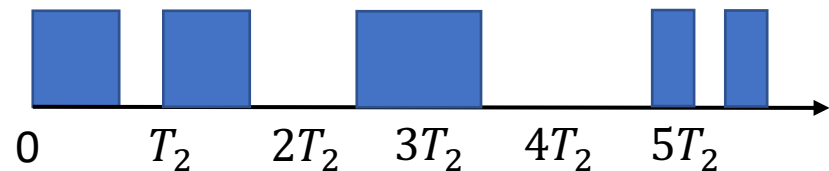
- Fuel-air mixture
- Spark advance



Problem:

- Engines accelerate, decelerate

Number of jobs released ↑

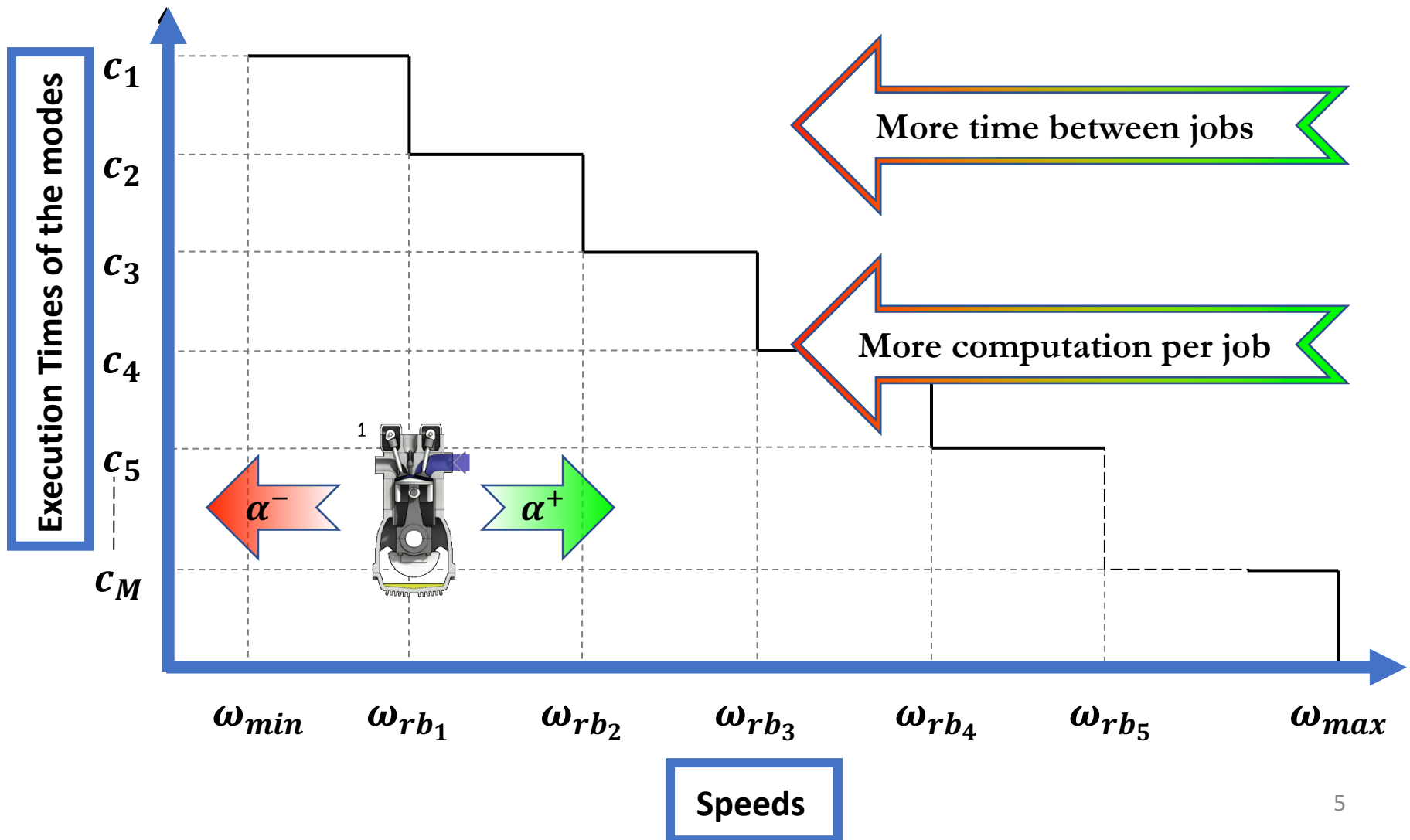


Trivial Solution

Resource requirement of other tasks $<$ Processor time -
Task maximum demand

Under Utilized!!!

Engine Control: Adaptive Variable-Rate (AVR) Tasks



Existing Work on AVR Tasks

Model – Adaptive-Variable Rate / Rhythmic
Biondi et al. [3], Kim et al. [7]

Constant Acceleration between Jobs

Schedulability
Guo and Baruah

Exact
Worst-case
Demand
Biondi et al.

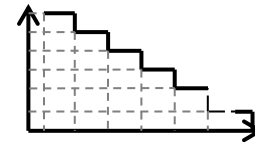
Variable Acceleration between Jobs

Exact Worst-case
Demand **via DRT**
Mohaqeqi et al.

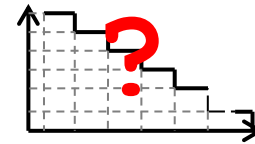
Exact Worst-case
Demand **via**
Knapsack
Bijinemula et al.

What's Missing?

```
AVR-TASK-1D (int rpm) {  
    f1 ();  
    if (rpm < 3000) {  
        f2 ();  
    else if (rpm > 6000) {  
        f3 ();  
    }  
    f4 ();  
}
```



More Realistically

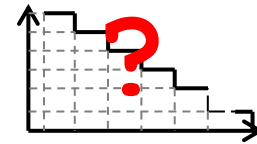


```
AVR-TASK-2D(int rpm, float temp) {  
    f1 ();  
    if (rpm < 3000) {  
        f2 ();  
    }  
    else if (rpm > 6000) and (temp > 3000) {  
        f3 ();  
    }  
    f4 ();  
}
```

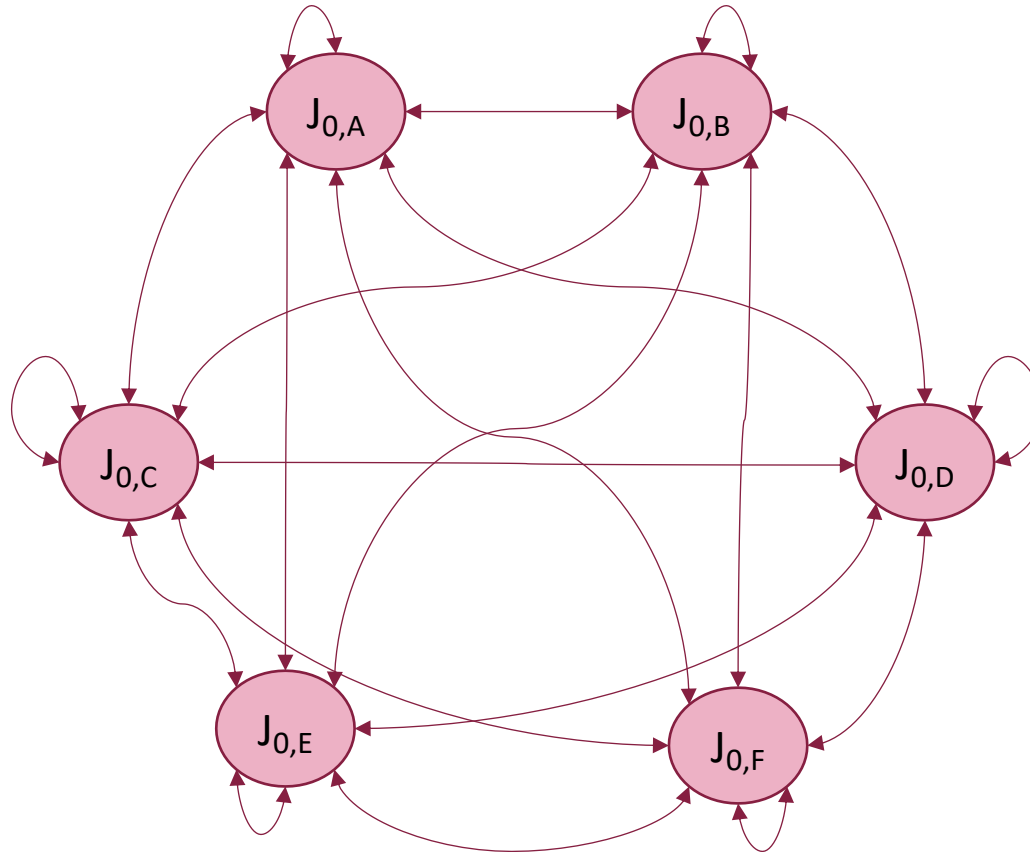
Who cares?

Requirements + Challenges

- Need
 - n-dimensional AVR task model
 - ... and schedulability analysis
- Why hard?
 - Need to deeply understand inner-working of engine
- High risk, high reward



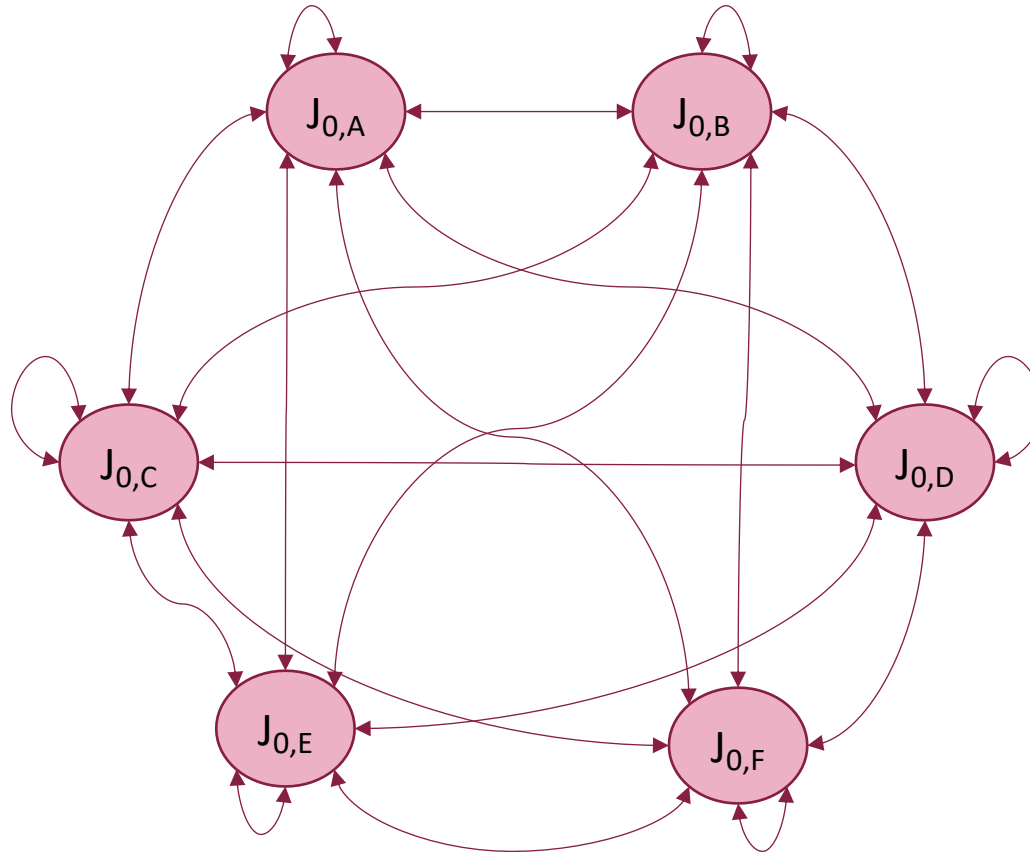
A Starting Point?



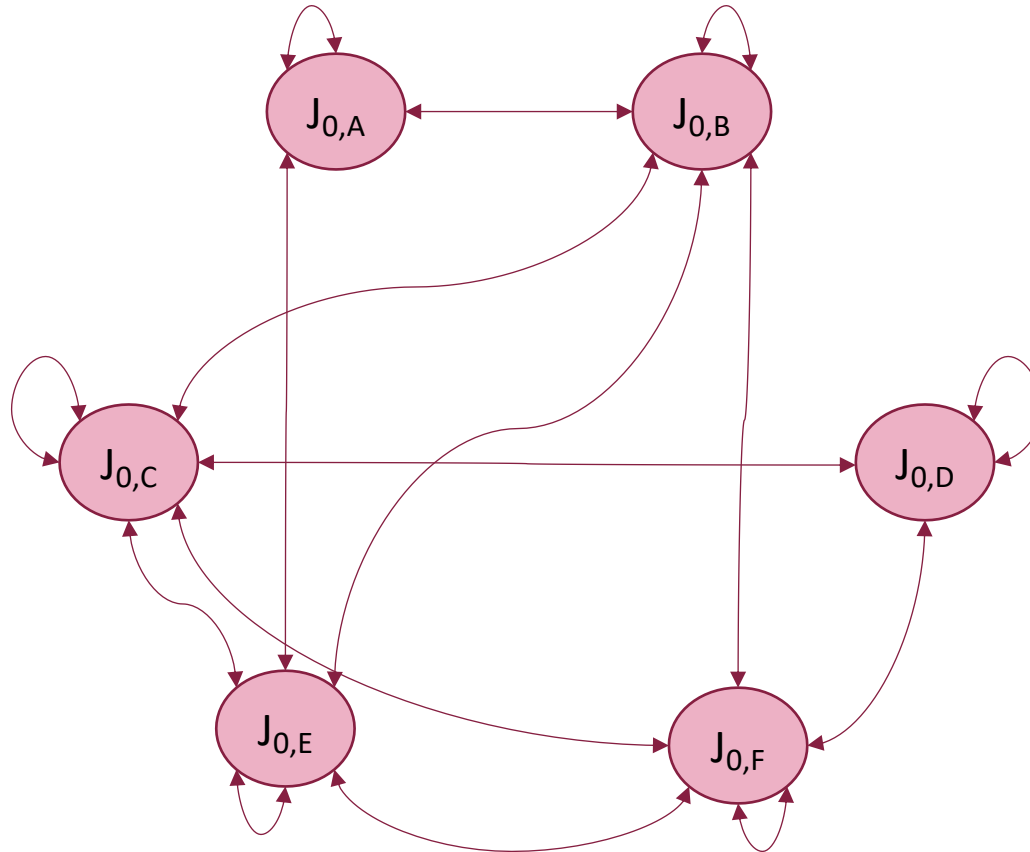
Is That All?

- The physical dimensions may be interdependent
 - E.g., temperature and pressure
- (How) does that help with modeling and schedulability analysis?

A Starting Point?



A Starting Point?





Who's Interested?

Ideas?!?