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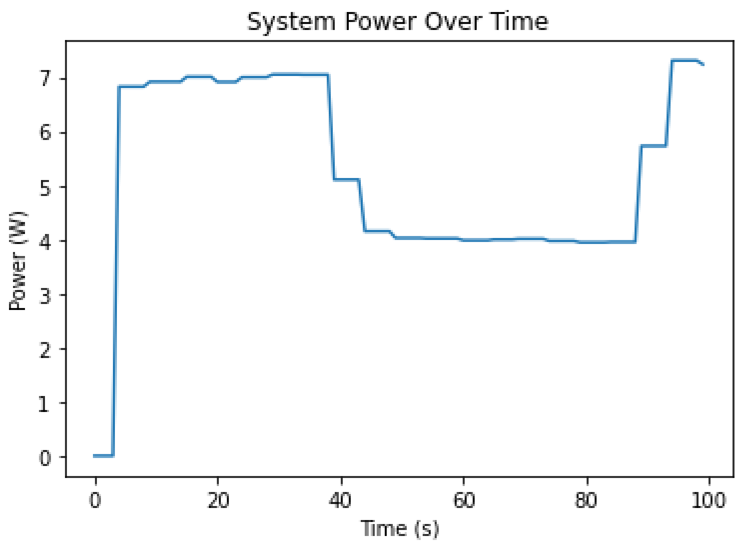
Dr. Marculescu
11 Mar 2021

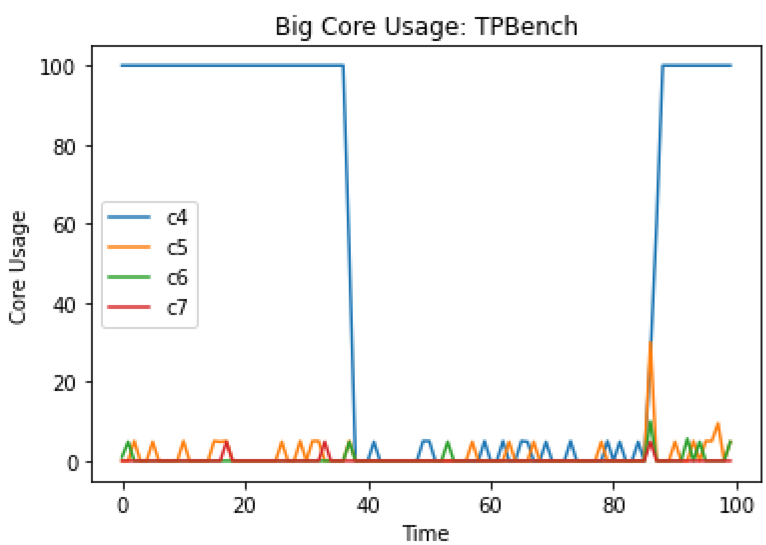
Homework 2

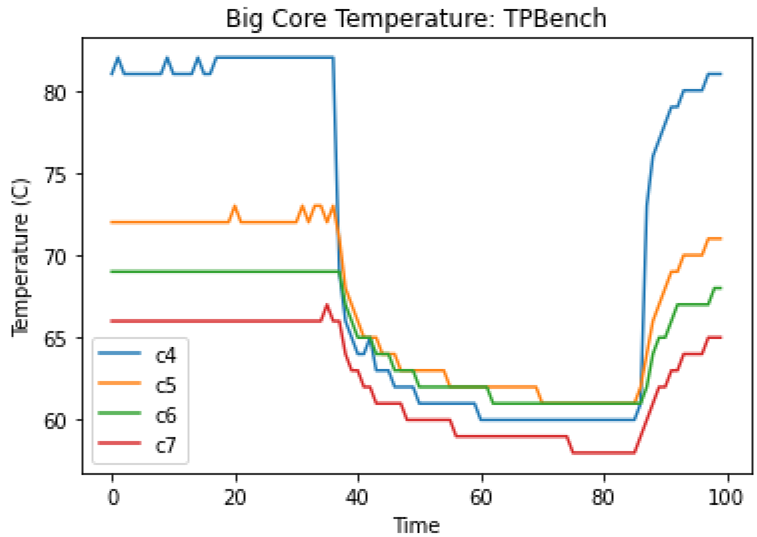
Contribution statement: Vijay and I both worked on #1, #2, and #4 together, switching off writing code in person. Vijay did #3 by himself, but walked Adit through his code.

Problem 1: System physical and cyber characteristics

Q1: System power, core usage, and temperature graphs for big cluster





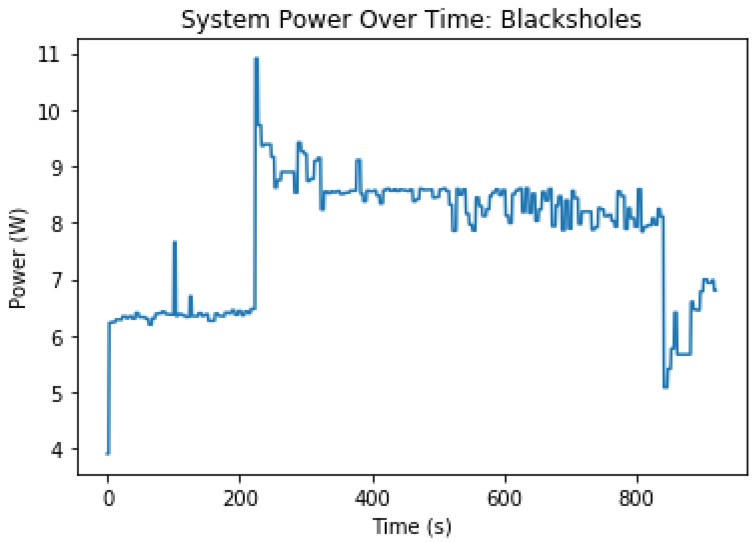


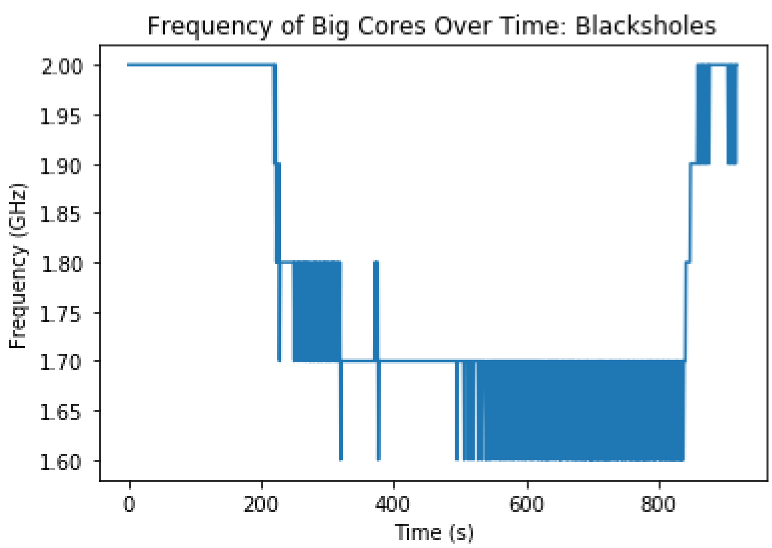
Q2: How many phases of benchmark execution can you identify based on temperature dynamics? Do you see any difference in the temperature range across the four big cores?

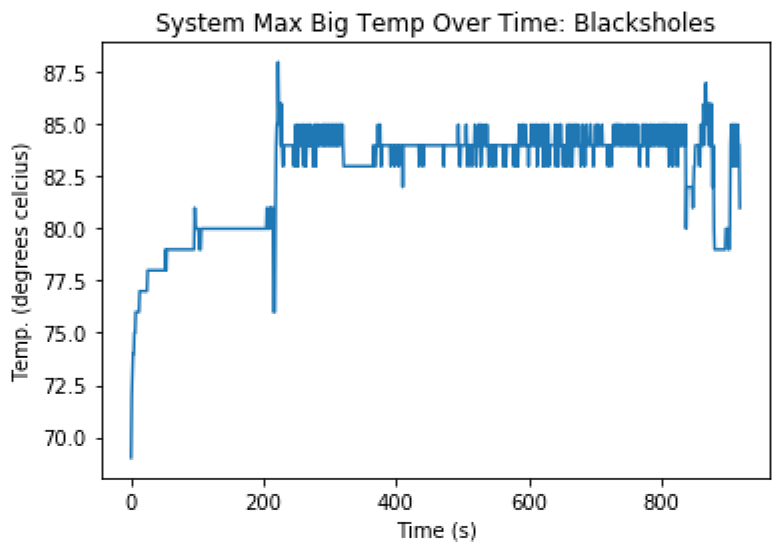
We can see three phases of the benchmark execution based on the temperature data collected on the big cores. As we observe core 4, the only core constrained to execute the benchmark, it starts out at the highest temp of the 4 big cores, dips steeply down in cooling during downtime, and then steeply rises in temperature after over 40s of downtime. Phase 1 can be identified as this initial state in which the core is at its highest usage, phase 2 is when the core is in downtime, and phase 3 is when the core is back up at its highest usage. Another note that c5, c6, and c7 follow respectively in decreasing temperature rating compared to the constrained core, which makes sense since they are next to each other in that order.

Q3: Blacksholes and Bodytrack graphs for power consumption, frequency, and max temperature for the big cores

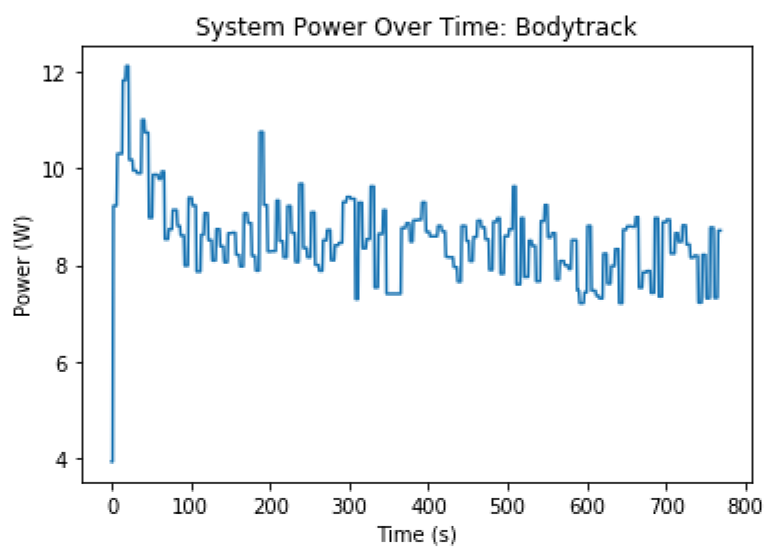
Blacksholes:

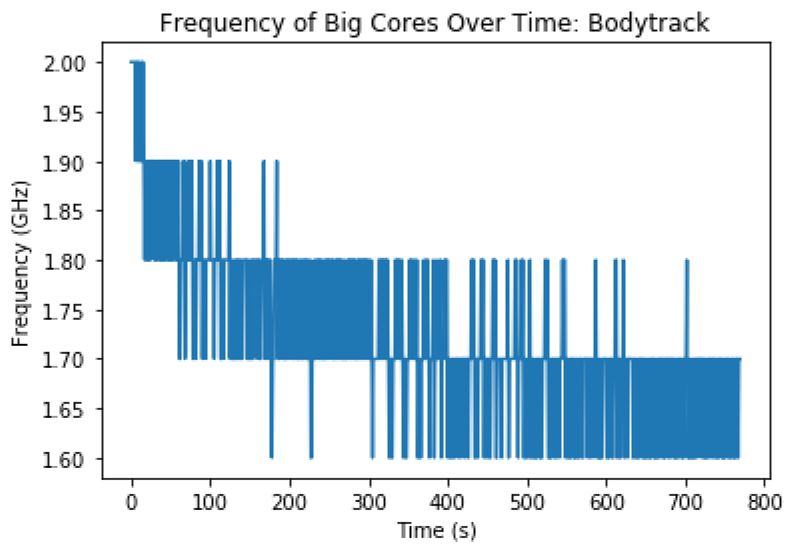


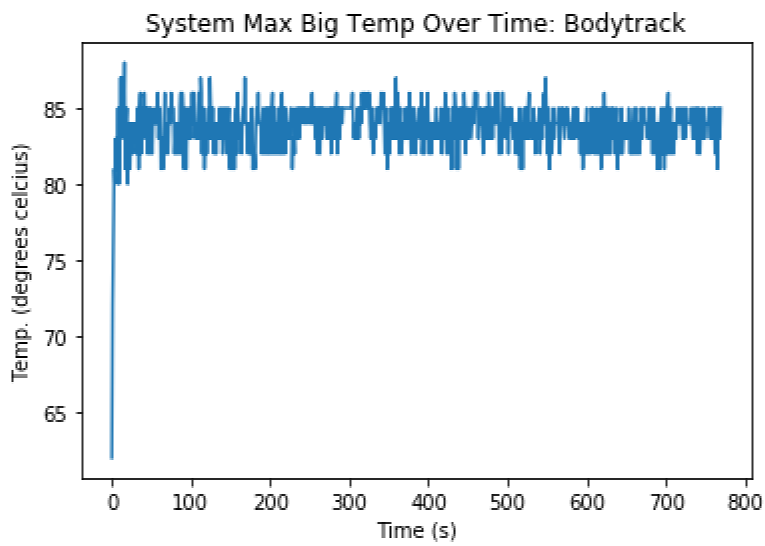



System Max Big Temp Over Time: Blacksholes
Temp. (degrees celcius)
87.5
85.0
82.5
80.0
77.5
75.0
72.5
70.0
0
200
400
600
800
Time (s)

Bodytype:


System Power Over Time: Bodytrack
Power (W)
12
10
8
6
4
0
100
200
300
400
500
600
700
800
Time (s)





Q4:

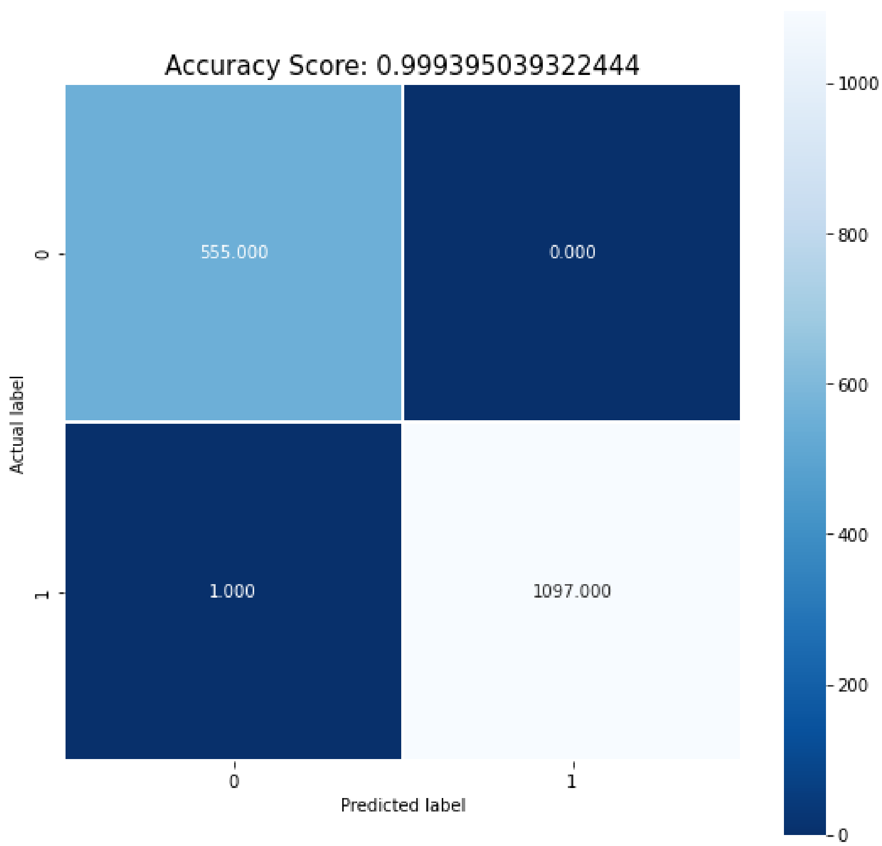
Benchmark	Run Time (s)	Avg. Power (W)	Avg. Max Temp. (˚C)	Max Temp. (˚C)	Energy (J)
Blacksholes	177.273	8.348	82.674	88.0	1427.52
Bodytrack	154.544	8.348	83.86234	88.0	1396.98

Problem 2: System power prediction

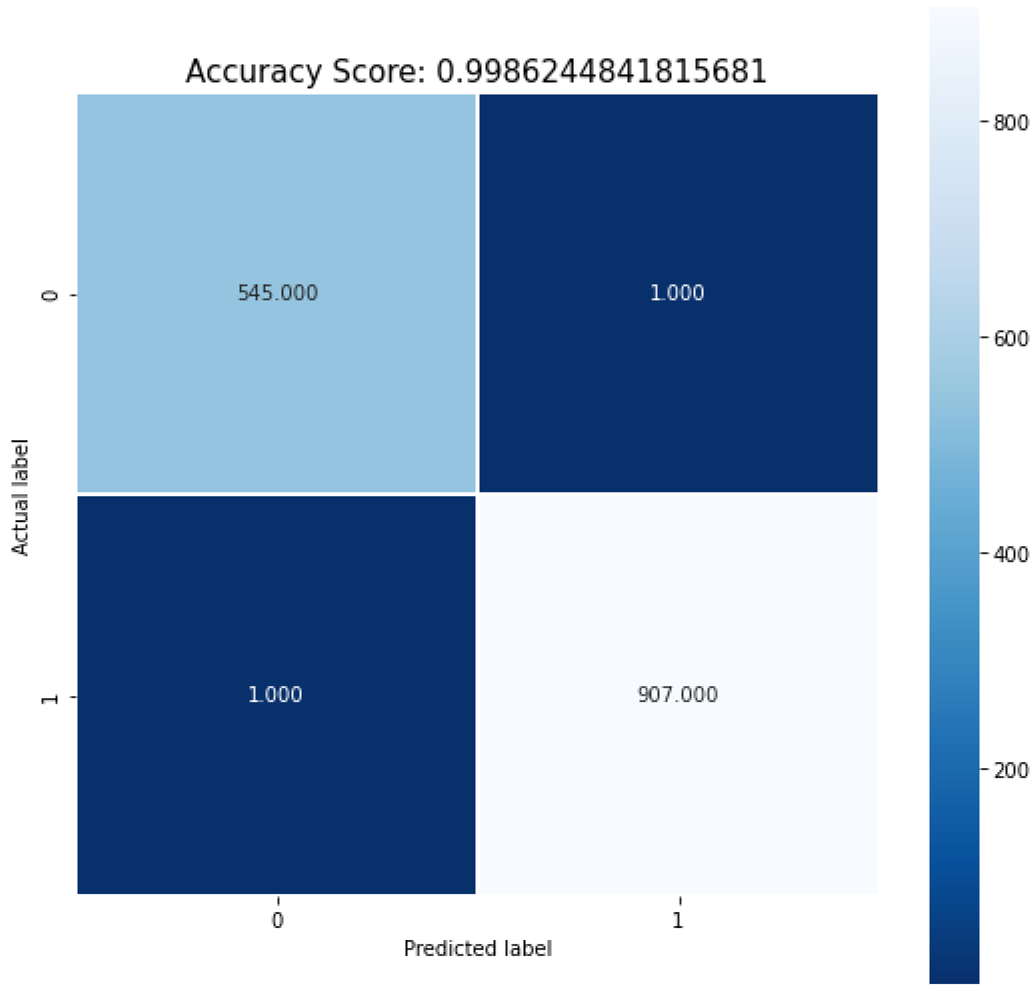
Q1:

Benchmark	Training Accuracy (%)	Test Accuracy (%)	Training MSE	Test MSE
Blacksholes	100	0.999395	0.00181286	0.003146262
Bodytrack	100	0.998624	0.00181286	0.096259057

Q2: Blacksholes + Bodytrack test confusion matrix for classification results (decision tree)
Blacksholes:



Bodytrack:



Accuracy Score: 0.9986244841815681
545.000
1.000
1.000
907.000
0
1
Actual label
0
1
Predicted label
800
600
400
200

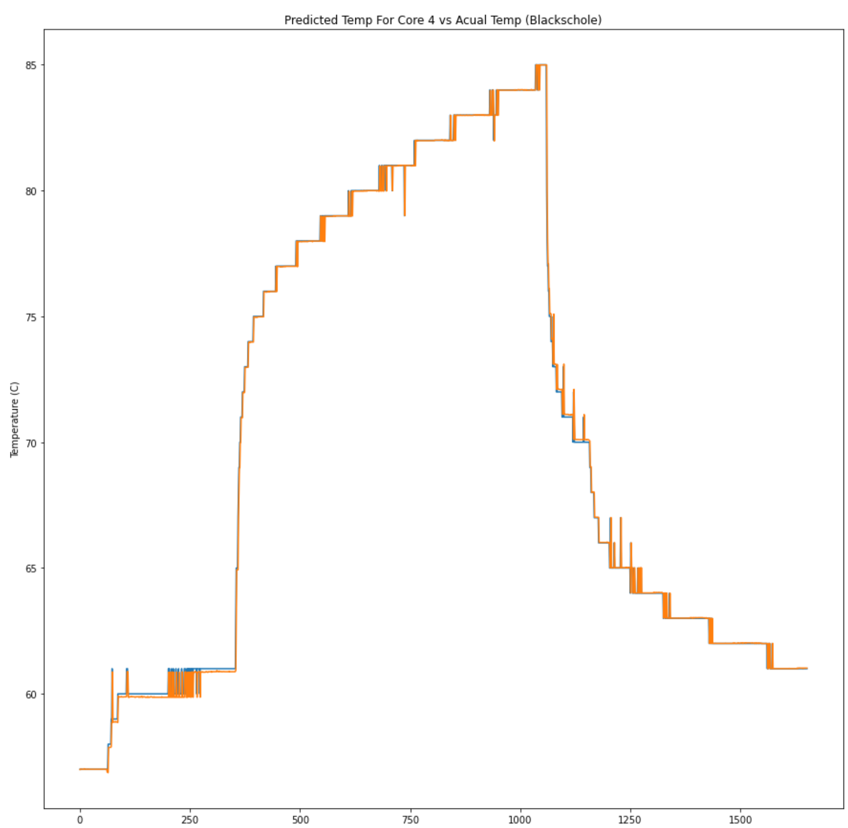
Problem 3: System temperature prediction

Q1:

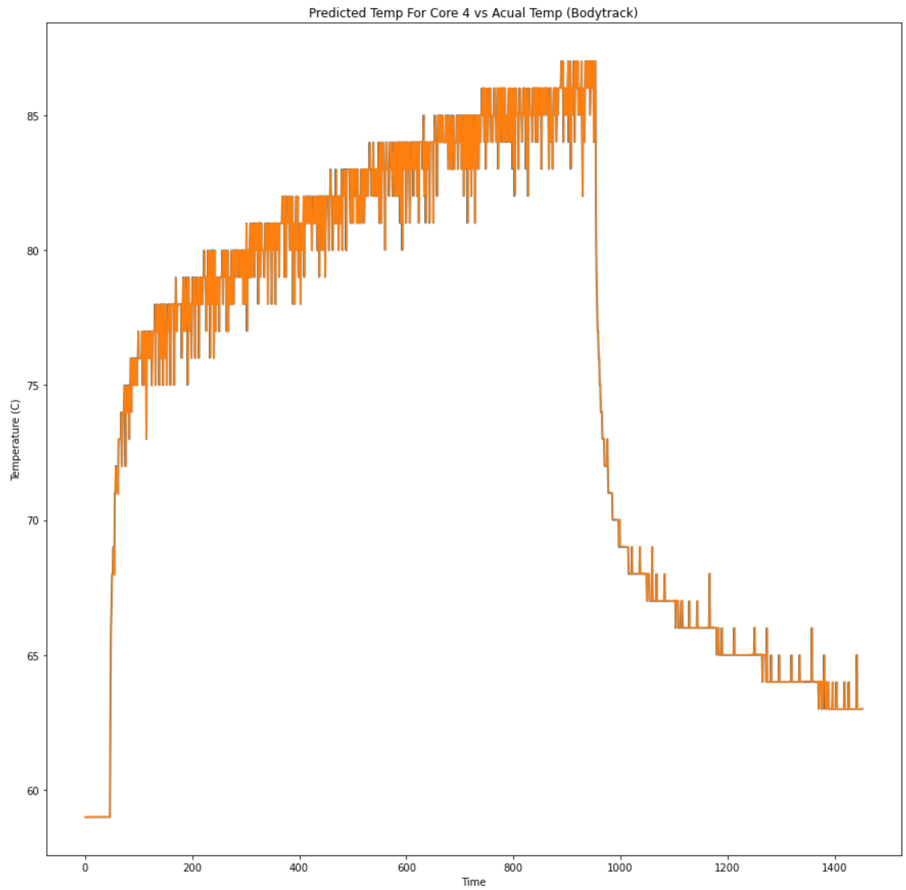
Benchmark	Test MSE (core 4)	Test MSE (core 5)	Test MSE (core 6)	Test MSE (core 7)
Blacksholes	0.1538	0.3220	0.1896	0.1158
Bodytrack	1.4208	1.4015	1.4082	0.7360

Q2: Temperature predictions against actual values plots for both blacksholes and bodytrack

Bodysholes:



Bodytrack:


Predicted Temp For Core 4 vs Acual Temp (Bodytrack)
Temperature (C)
Time
60
65
70
75
80
85
0
200
400
600
800
1000
1200
1400

Q3: What other techniques can be used to improve the regressor?

1. Regularization - use a penalty to punish large weights
2. Feature engineering - using a mathematical combination of the 4 temperature columns to generate a new feature that provides more information to the model
3. Hyperparameter tuning of the model to find optimal learning rate, batch size, and number of epochs.

Problem 4: System thermal and CPU usage optimization
Q1:

Data points with governor in effect

Benchmark	Runtime (s)	Avg. Power (W)	Avg. Max Temp. (˚C)	Max Temp (˚C)	Energy (J)
Blacksholes	243.0797	5.4737	67.6749	71.0	1326.8208
Bodytrack	194.1774	5.9285	68.3506	71.0	1146.5722

Data points from previous question (no governor)

Benchmark	Run Time (s)	Avg. Power (W)	Avg. Max Temp. (˚C)	Max Temp. (˚C)	Energy (J)
Blacksholes	177.273	8.348	82.674	88.0	1427.52
Bodytrack	154.544	8.348	83.86234	88.0	1396.98

In comparing our results here from P1Q4, our governor had a longer runtime on the benchmarks as compared to our implementation with no governor. Avg. power decreased by around 2.5W on Blacksholes and around 2W on Bodytrack when running with the governor. Avg. max temp was also decreased by around 13˚C and the max temp was decreased by 15 degrees on both benchmarks with the governor. Not to mention a significant decrease in Energy, almost 8% and 18% for Blacksholes and Bodytrack, respectively, when compared to running the benchmark without the governor.
Our governor complied with the thermal limit extremely well, hovering at and below 70˚C, our upper threshold. Our max temp on both benchmarks was 73.0, which is a reasonable margin of error from our max threshold of 70.0, giving us a 4.29% margin.

Q2: What is the cyber-physical trade-off of implementing the proposed governor? Discuss such trade-offs by comparing the runtime, power consumption and thermal limits of each program you obtained in this problem against what you got in Problem 1 (Question 4).

Once the governor is in effect, programs will take a significantly greater amount of time to run due to the constraints placed on the temperature and usage. However, because of these constraints, the average power and max temperature are significantly lower when the governor is in effect. Also, the total energy consumed is slightly lower when the governor is in place. The overall trade-off for using a governor is to give up runtime in return for less power usage.