Sia Sharma
DS210
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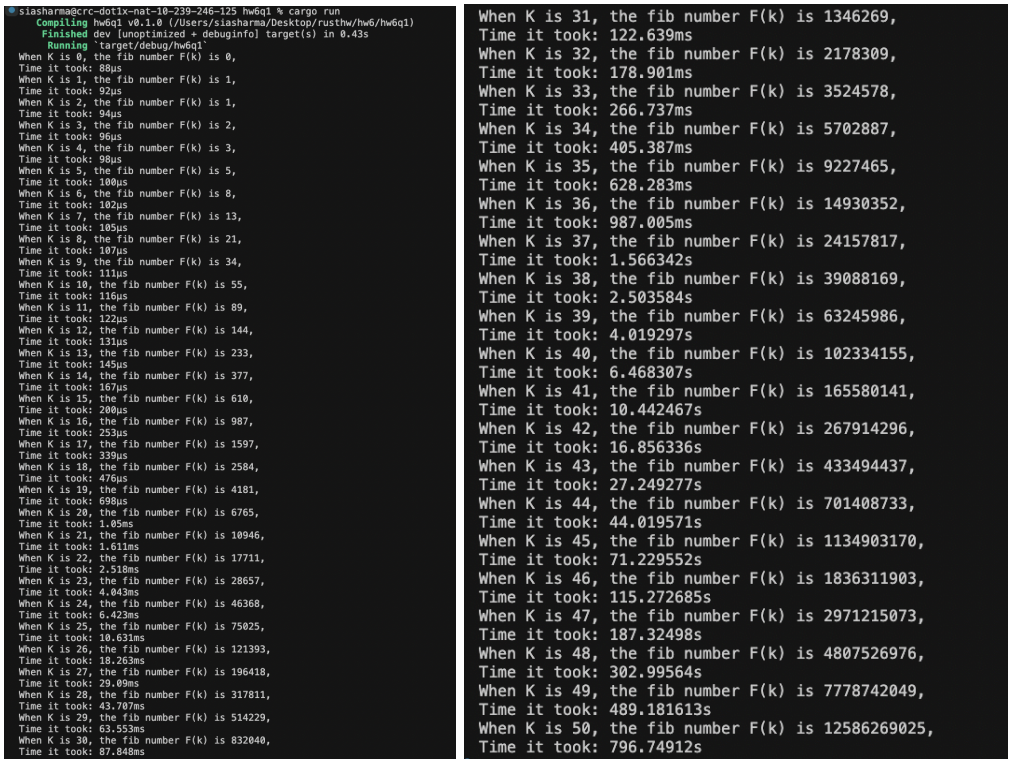
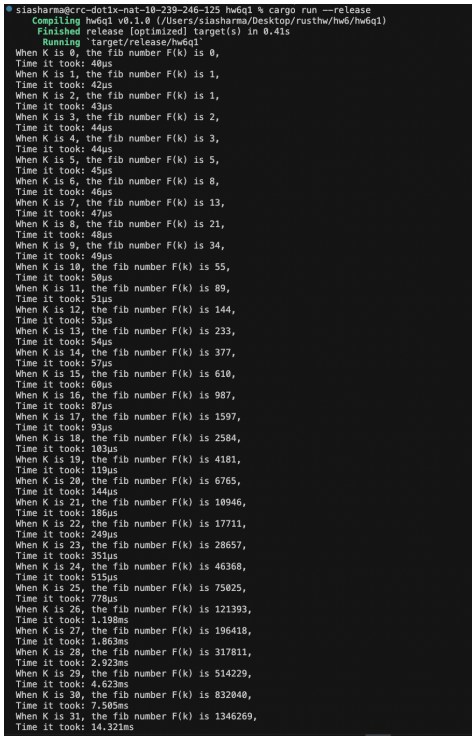
Q1:

cargo run Results:



```
siasharma@crc-dot1x-nat-10-239-246-125 hw6q1 % cargo run
   Compiling hw6q1 v0.1.0 (/Users/siasharma/Desktop/rusthw/hw6/hw6q1)
    Finished dev [unoptimized + debuginfo] target(s) in 0.43s
     Running `target/debug/hw6q1`
When K is 0, the fib number F(k) is 0,
Time it took: 88µs
When K is 1, the fib number F(k) is 1,
Time it took: 92µs
When K is 2, the fib number F(k) is 1,
Time it took: 94µs
When K is 3, the fib number F(k) is 2,
Time it took: 96µs
When K is 4, the fib number F(k) is 3,
Time it took: 98µs
When K is 5, the fib number F(k) is 5,
Time it took: 100µs
When K is 6, the fib number F(k) is 8,
Time it took: 102µs
When K is 7, the fib number F(k) is 13,
Time it took: 105µs
When K is 8, the fib number F(k) is 21,
Time it took: 107µs
When K is 9, the fib number F(k) is 34,
Time it took: 111µs
When K is 10, the fib number F(k) is 55,
Time it took: 116µs
When K is 11, the fib number F(k) is 89,
Time it took: 122µs
When K is 12, the fib number F(k) is 144,
Time it took: 131µs
When K is 13, the fib number F(k) is 233,
Time it took: 145µs
When K is 14, the fib number F(k) is 377,
Time it took: 167µs
When K is 15, the fib number F(k) is 610,
Time it took: 200µs
When K is 16, the fib number F(k) is 987,
Time it took: 253µs
When K is 17, the fib number F(k) is 1597,
Time it took: 339µs
When K is 18, the fib number F(k) is 2584,
Time it took: 476µs
When K is 19, the fib number F(k) is 4181,
Time it took: 698µs
When K is 20, the fib number F(k) is 6765,
Time it took: 1.05ms
When K is 21, the fib number F(k) is 10946,
Time it took: 1.611ms
When K is 22, the fib number F(k) is 17711,
Time it took: 2.518ms
When K is 23, the fib number F(k) is 28657,
Time it took: 4.043ms
When K is 24, the fib number F(k) is 46368,
Time it took: 6.423ms
When K is 25, the fib number F(k) is 75025,
Time it took: 10.631ms
When K is 26, the fib number F(k) is 121393,
Time it took: 18.263ms
When K is 27, the fib number F(k) is 196418,
Time it took: 29.09ms
When K is 28, the fib number F(k) is 317811,
Time it took: 43.707ms
When K is 29, the fib number F(k) is 514229,
Time it took: 63.553ms
When K is 30, the fib number F(k) is 832040,
Time it took: 87.848ms
When K is 31, the fib number F(k) is 1346269,
Time it took: 122.639ms
When K is 32, the fib number F(k) is 2178309,
Time it took: 178.901ms
When K is 33, the fib number F(k) is 3524578,
Time it took: 266.737ms
When K is 34, the fib number F(k) is 5702887,
Time it took: 405.387ms
When K is 35, the fib number F(k) is 9227465,
Time it took: 628.283ms
When K is 36, the fib number F(k) is 14930352,
Time it took: 987.005ms
When K is 37, the fib number F(k) is 24157817,
Time it took: 1.566342s
When K is 38, the fib number F(k) is 39088169,
Time it took: 2.503584s
When K is 39, the fib number F(k) is 63245986,
Time it took: 4.019297s
When K is 40, the fib number F(k) is 102334155,
Time it took: 6.468307s
When K is 41, the fib number F(k) is 165580141,
Time it took: 10.442467s
When K is 42, the fib number F(k) is 267914296,
Time it took: 16.856336s
When K is 43, the fib number F(k) is 433494437,
Time it took: 27.249277s
When K is 44, the fib number F(k) is 701408733,
Time it took: 44.019571s
When K is 45, the fib number F(k) is 1134903170,
Time it took: 71.229552s
When K is 46, the fib number F(k) is 1836311903,
Time it took: 115.272685s
When K is 47, the fib number F(k) is 2971215073,
Time it took: 187.32498s
When K is 48, the fib number F(k) is 4807526976,
Time it took: 302.99564s
When K is 49, the fib number F(k) is 7778742049,
Time it took: 489.181613s
When K is 50, the fib number F(k) is 12586269025,
Time it took: 796.74912s
```

cargo run –release Results:

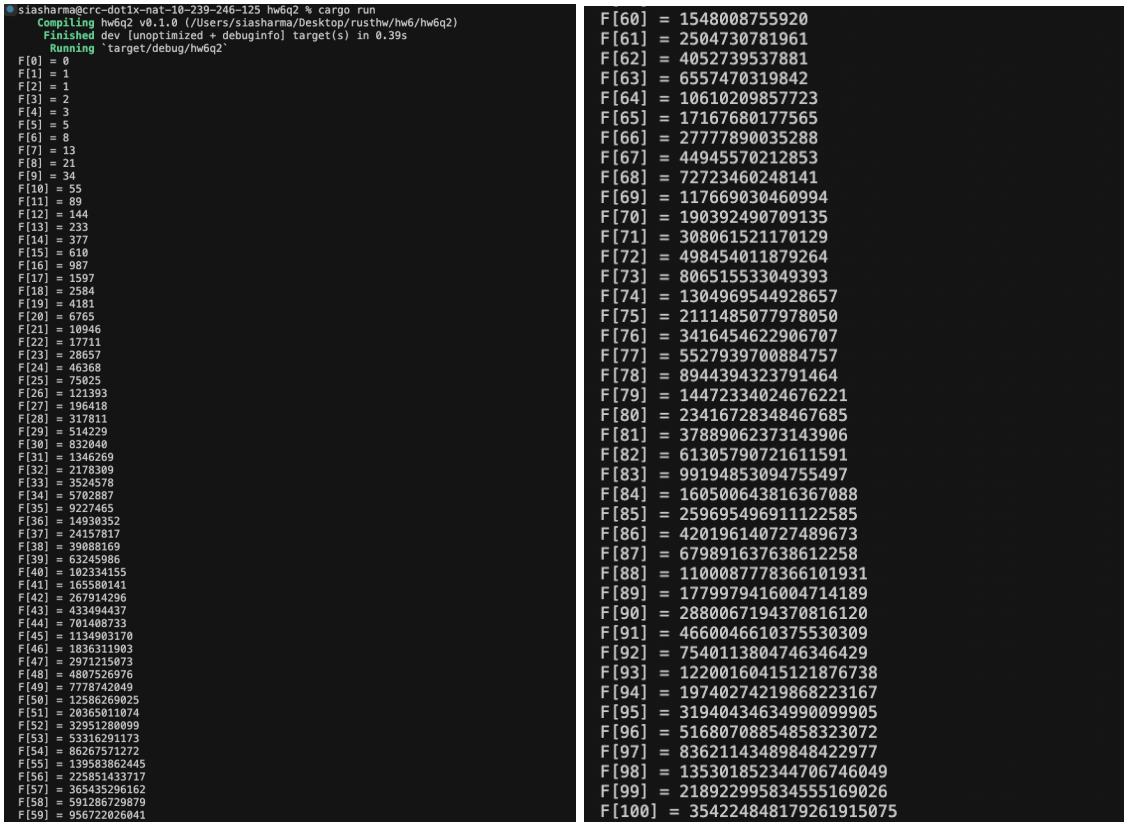


```
siasharma@crc-dot1x-nat-10-239-246-125 hw6q1 % cargo run --release
   Compiling hw6q1 v0.1.0 (/Users/siasharma/Desktop/rusthw/hw6/hw6q1)
    Finished release [optimized] target(s) in 0.41s
     Running `target/release/hw6q1`
When K is 0, the fib number F(k) is 0,
Time it took: 40µs
When K is 1, the fib number F(k) is 1,
Time it took: 42µs
When K is 2, the fib number F(k) is 1,
Time it took: 43µs
When K is 3, the fib number F(k) is 2,
Time it took: 44µs
When K is 4, the fib number F(k) is 3,
Time it took: 44µs
When K is 5, the fib number F(k) is 5,
Time it took: 45µs
When K is 6, the fib number F(k) is 8,
Time it took: 46µs
When K is 7, the fib number F(k) is 13,
Time it took: 47µs
When K is 8, the fib number F(k) is 21,
Time it took: 48µs
When K is 9, the fib number F(k) is 34,
Time it took: 49µs
When K is 10, the fib number F(k) is 55,
Time it took: 50µs
When K is 11, the fib number F(k) is 89,
Time it took: 51µs
When K is 12, the fib number F(k) is 144,
Time it took: 53µs
When K is 13, the fib number F(k) is 233,
Time it took: 54µs
When K is 14, the fib number F(k) is 377,
Time it took: 57µs
When K is 15, the fib number F(k) is 610,
Time it took: 60µs
When K is 16, the fib number F(k) is 987,
Time it took: 87µs
When K is 17, the fib number F(k) is 1597,
Time it took: 93µs
When K is 18, the fib number F(k) is 2584,
Time it took: 103µs
When K is 19, the fib number F(k) is 4181,
Time it took: 119µs
When K is 20, the fib number F(k) is 6765,
Time it took: 144µs
When K is 21, the fib number F(k) is 10946,
Time it took: 186µs
When K is 22, the fib number F(k) is 17711,
Time it took: 249µs
When K is 23, the fib number F(k) is 28657,
Time it took: 351µs
When K is 24, the fib number F(k) is 46368,
Time it took: 515µs
When K is 25, the fib number F(k) is 75025,
Time it took: 778µs
When K is 26, the fib number F(k) is 121393,
Time it took: 1.198ms
When K is 27, the fib number F(k) is 196418,
Time it took: 1.863ms
When K is 28, the fib number F(k) is 317811,
Time it took: 2.923ms
When K is 29, the fib number F(k) is 514229,
Time it took: 4.623ms
When K is 30, the fib number F(k) is 832040,
Time it took: 7.505ms
When K is 31, the fib number F(k) is 1346269,
Time it took: 14.321ms
When K is 32, the fib number F(k) is 2178309,
Time it took: 23.734ms
When K is 33, the fib number F(k) is 3524578,
Time it took: 39.565ms
When K is 34, the fib number F(k) is 5702887,
Time it took: 64.643ms
When K is 35, the fib number F(k) is 9227465,
Time it took: 97.298ms
When K is 36, the fib number F(k) is 14930352,
Time it took: 147.388ms
When K is 37, the fib number F(k) is 24157817,
Time it took: 227.708ms
When K is 38, the fib number F(k) is 39088169,
Time it took: 356.85ms
When K is 39, the fib number F(k) is 63245986,
Time it took: 565.175ms
When K is 40, the fib number F(k) is 102334155,
Time it took: 902.082ms
When K is 41, the fib number F(k) is 165580141,
Time it took: 1.447195s
When K is 42, the fib number F(k) is 267914296,
Time it took: 2.328894s
When K is 43, the fib number F(k) is 433494437,
Time it took: 3.752125s
When K is 44, the fib number F(k) is 701408733,
Time it took: 6.061603s
When K is 45, the fib number F(k) is 1134903170,
Time it took: 9.812705s
When K is 46, the fib number F(k) is 1836311903,
Time it took: 15.935035s
When K is 47, the fib number F(k) is 2971215073,
Time it took: 25.689377s
When K is 48, the fib number F(k) is 4807526976,
Time it took: 41.526499s
When K is 49, the fib number F(k) is 7778742049,
Time it took: 67.064811s
When K is 50, the fib number F(k) is 12586269025,
Time it took: 108.498337s
```

Q1 Report: Both cargo run and cargo run –release displayed an increase in time it took to calculate Fk as the value of K got larger. However, overall, cargo run –release took much less time for higher values of K than cargo run, and it was around 8x faster for a K value of 50.

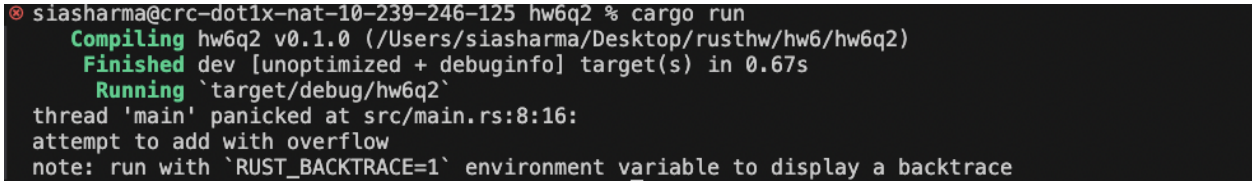
Q2:

Results with type u128:

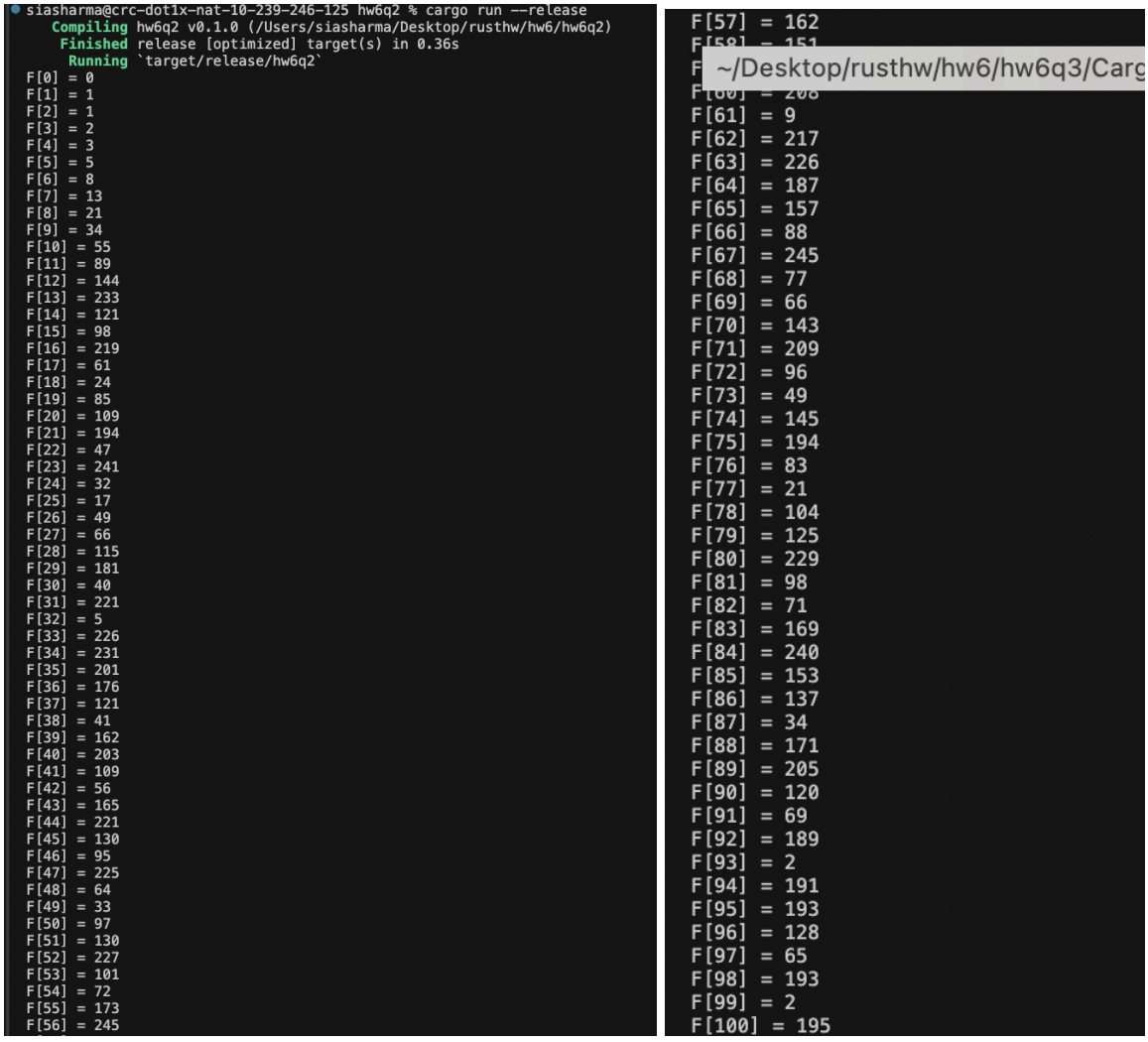


Results with type u8:

cargo run:



cargo run –release:



Q2 Report: With the entry type as u128 bit integers, the program runs smoothly as it is optimized for the computation with the large bit number. However, when you reduce it to u8 bit integers, with cargo run there was an overflow occurrence as u8 can only run numbers from 0 to 255. This is because the computation created output numbers larger than the capacity existing. When using cargo run –release, the release build allows it to run faster, but when the output gets larger than the maximum fibonacci numbers u8 can hold, the results are incorrect as the low number of bits is not enough for the output, and therefore it outputs random numbers under 255.

Q3:

Output result:

```
siasharma@crc-dot1x-nat-10-239-246-125 hw6q3 % cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.08s
     Running `target/debug/hw6q3`
5
when k = 5, sum = 55
siasharma@crc-dot1x-nat-10-239-246-125 hw6q3 % cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.00s
     Running `target/debug/hw6q3`
100
when k = 100, sum = 338350
siasharma@crc-dot1x-nat-10-239-246-125 hw6q3 % cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.00s
     Running `target/debug/hw6q3`
1000
when k = 1000, sum = 333833500
siasharma@crc-dot1x-nat-10-239-246-125 hw6q3 % cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.03s
     Running `target/debug/hw6q3`
1500
when k = 1500, sum = 1126125250
siasharma@crc-dot1x-nat-10-239-246-125 hw6q3 % cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.03s
     Running `target/debug/hw6q3`
2000
when k = 2000, sum = 2668667000
```

Q3 Report: The range of integers I used is significantly large as they comply with the u32 bit requirement of the function. Overflow does not occur unless I go over the 32 bit integer value, which is an output of 4,294,967,296 (higher than what u32 bit can store in memory). My sufficiently high integer value was 2000, which yielded a sum of 2,668,667,000, which was still lower than what u32 can store.

(The highest u32 number 4,294,967,296 was sourced from this Wikipedia page: https://en.wikipedia.org/wiki/4,294,967,295#:~:text=In%20computing%2C%204%2C294%2C967%2C295%20is%20the,system%20can%20store%20in%20memory.)