Analysis and Comparison

```
optimized <- read.csv("optimized_l_stars.csv")
paired <- read.csv("paired_l_stars.csv")
randomized <- read.csv("randomized_l_stars.csv")
exact_scores <- read.csv("exact_scores.csv")
```

Approximation ratios

calculate the approximation ratios and actual ratios for k= 3, 4, 5

```
optimized.exact <- merge(optimized, exact_scores, by=c("k", "round")) %>%
  mutate(approx_ratio=2-l/k, actual_ratio=score/exact_score)

paired.exact <- merge(paired, exact_scores, by=c("k", "round")) %>%
  mutate(approx_ratio=2-l/k, actual_ratio=score/exact_score)

randomized.exact <- merge(randomized, exact_scores, by=c("k", "round")) %>%
  mutate(approx_ratio=2-l/(2*k), actual_ratio=score/exact_score)
```

check if actual ratio is smaller than the approximation ratio for all test cases

```
all(optimized.exact$actual_ratio <= optimized.exact$approx_ratio)
```

```
## [1] TRUE
```

```
all(paired.exact$actual_ratio <= paired.exact$approx_ratio)
```

```
## [1] TRUE
```

```
all(randomized.exact$actual_ratio <= randomized.exact$approx_ratio)
```

```
## [1] TRUE
```

Optimized l-stars

Compute an average time and score for each distinct pair of k and l:

```
optimized <- optimized %>%
  group_by(k, l) %>%
  mutate(avg_time = mean(time), avg_score = mean(score)) %>%
  ungroup()
```

A table summarizes the average score for each pair of k and l:

```
optimized %>%
  group_by(k, l) %>%
  summarise(average_score=mean(score)) %>%
  spread(l, average_score) %>%
  kbl(caption = "Average Score") %>%
  kable_paper() %>%
  add_header_above(c(" "=1, "l"=3))
```

Table 1: Average Score

	l		
k	2	3	4
3	84.6	81.0	
4			162.3
5	299.8	291.3	
7	650.7	630.4	618.1
9	1138.0	1142.7	
10			1403.1
11	1793.0	1791.7	
13	2509.6	2514.8	2508.1

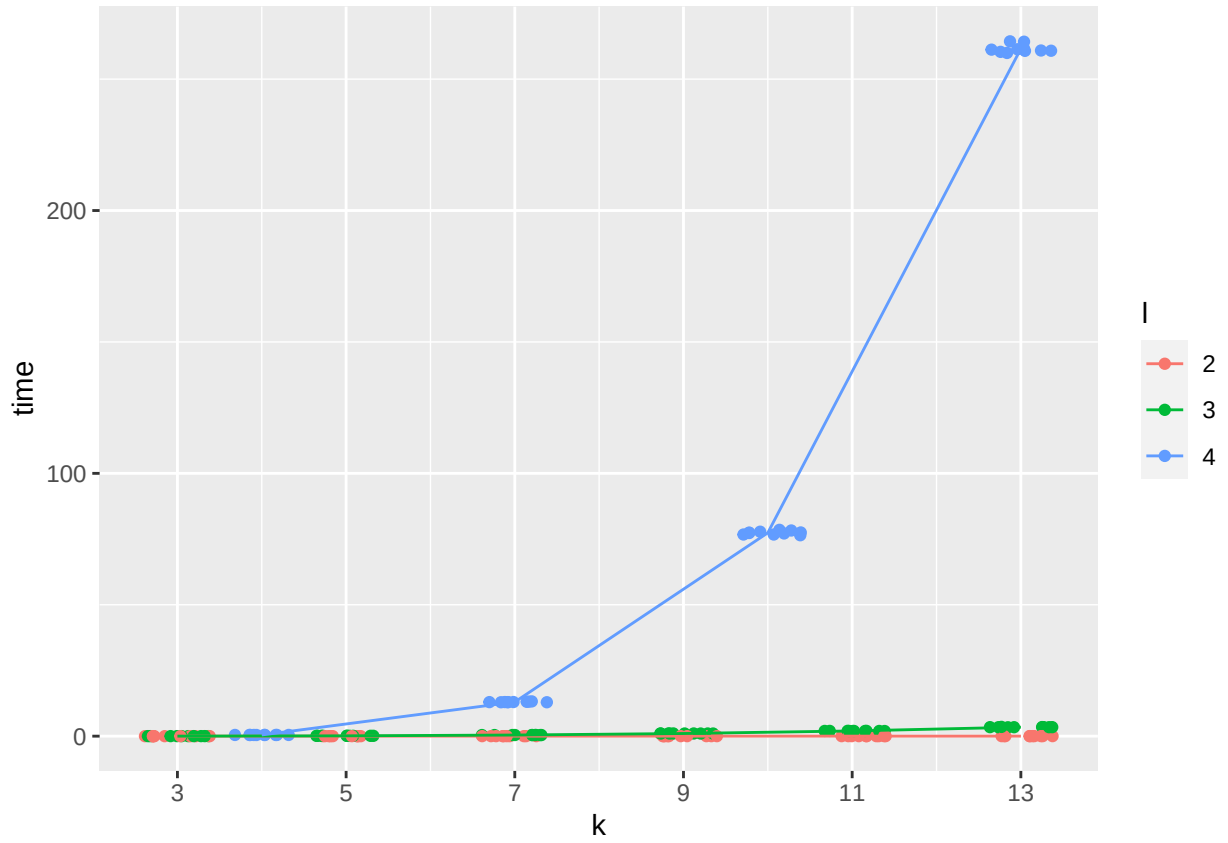
A table summarizes the average running time(s) for each pair of k and l:

```
optimized %>%
  group_by(k, l) %>%
  summarise(average_time=mean(time)) %>%
  spread(l, average_time) %>%
  kable()
```

k	2	3	4
3	0.0014525	0.0160961	
4			0.4570734
5	0.0024602	0.1281418	
7	0.0050193	0.4288990	13.0049551
9	0.0079710	1.0116021	
10			77.3848876
11	0.0117119	1.9815742	
13	0.0158879	3.4252075	261.5766287

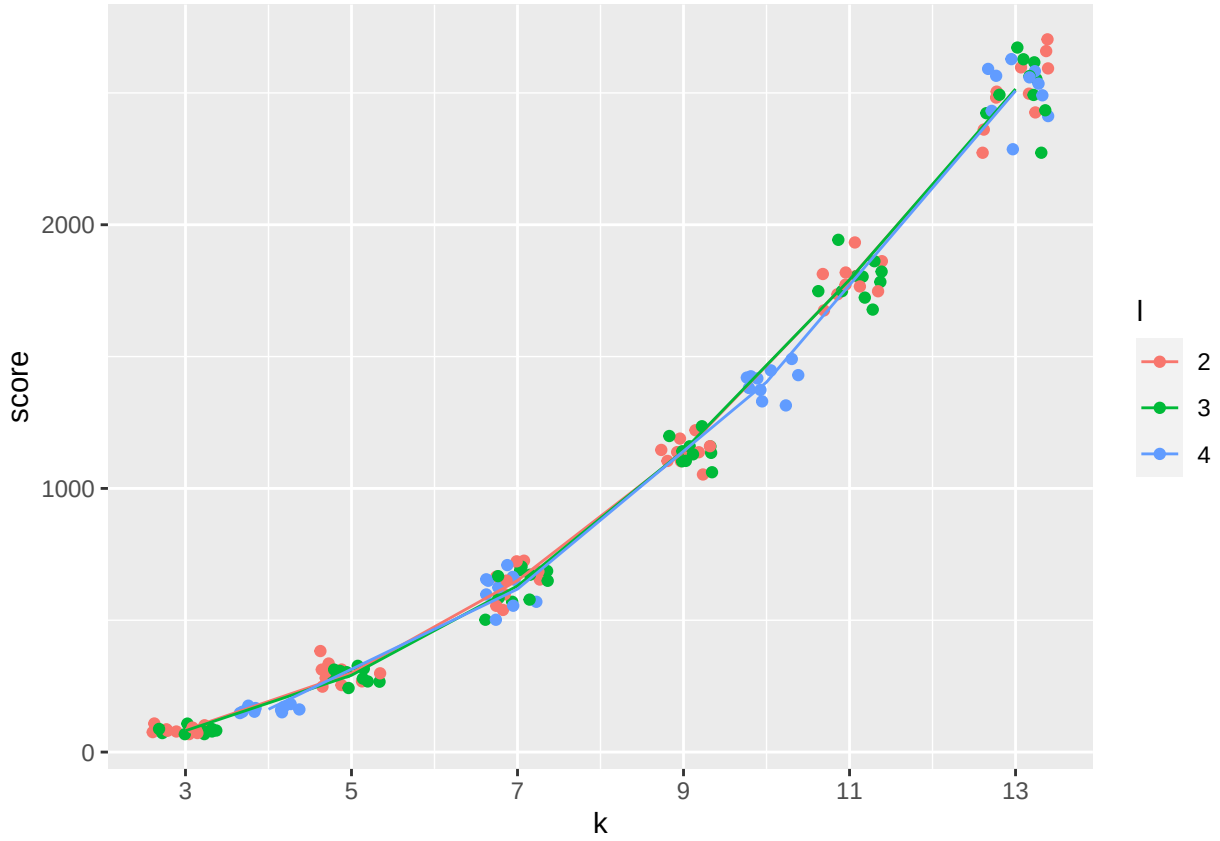
Running time against the number of sequences k

```
optimized %>%
  mutate(l=as.factor(l)) %>%
  ggplot(aes(k, time)) +
  geom_jitter(aes(color=l)) +
  geom_line(aes(k, avg_time, color=l)) +
  scale_x_continuous(breaks=c(3,5,7,9,11,13))
```



SP score against the number of sequences k

```
optimized %>%
  mutate(l=as.factor(l)) %>%
  ggplot(aes(k, score)) +
  geom_jitter(aes(color=l)) +
  geom_line(aes(k, avg_score, color=l)) +
  scale_x_continuous(breaks=c(3,5,7,9,11,13))
```



(2l-1)-stars

Compute an average time and score for each distinct pair of k and l:

```
paired <- paired %>%
  group_by(k, l) %>%
  mutate(avg_time = mean(time), avg_score = mean(score)) %>%
  ungroup()
```

A table summarizes the average score for each pair of k and l:

```
paired %>%
  group_by(k, l) %>%
  summarise(average_score=mean(score)) %>%
  spread(l, average_score) %>%
  kable()
```

k	2	3
3	84.6	
5	299.8	289.9
7	650.7	
9	1139.6	1139.9
11	1803.9	
13	2517.8	2532.6

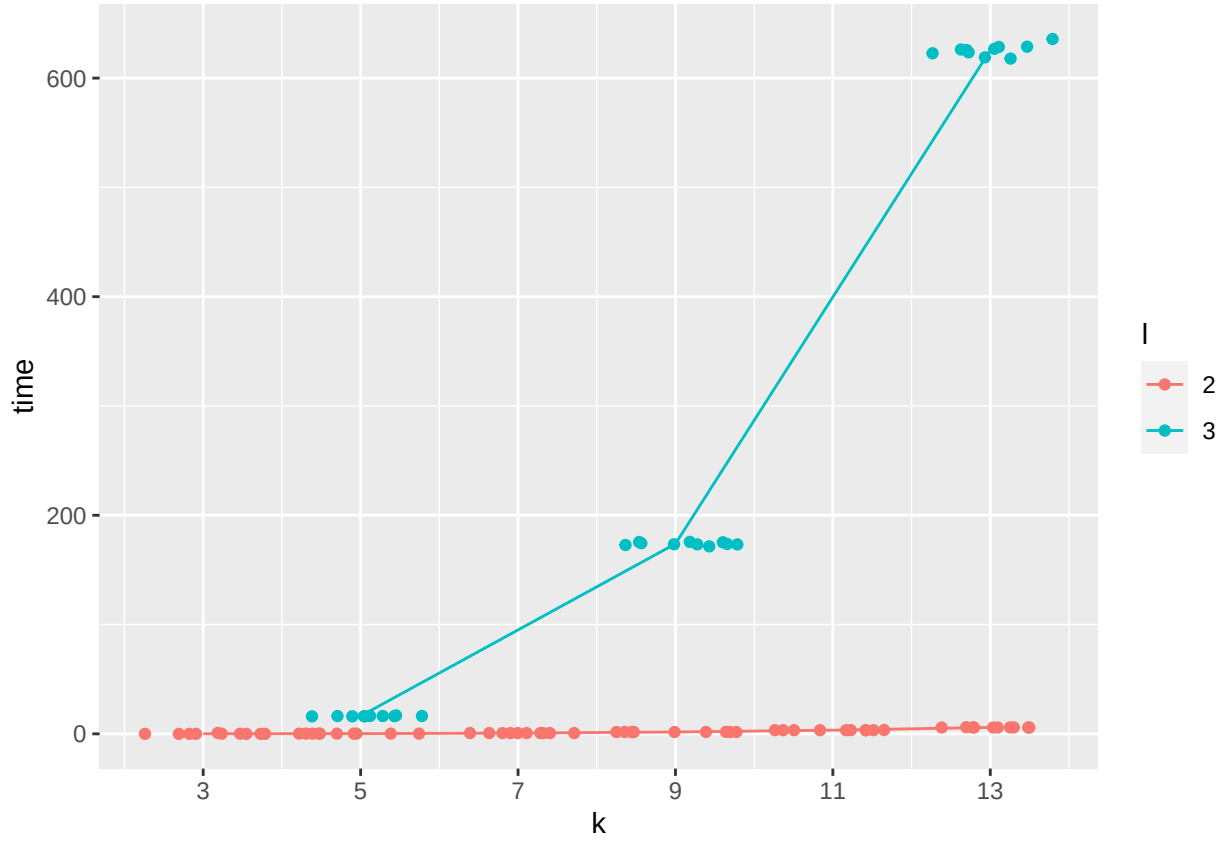
A table summarizes the average running time(s) for each pair of k and l:

```
paired %>%
  group_by(k, l) %>%
  summarise(average_time=mean(time)) %>%
  spread(l, average_time) %>%
  kable()
```

k	2	3
3	0.1266516	
5	0.2049488	16.27379
7	0.7079516	
9	1.7148574	173.91189
11	3.3835768	
13	5.8806980	625.46247

Running time against the number of sequences k

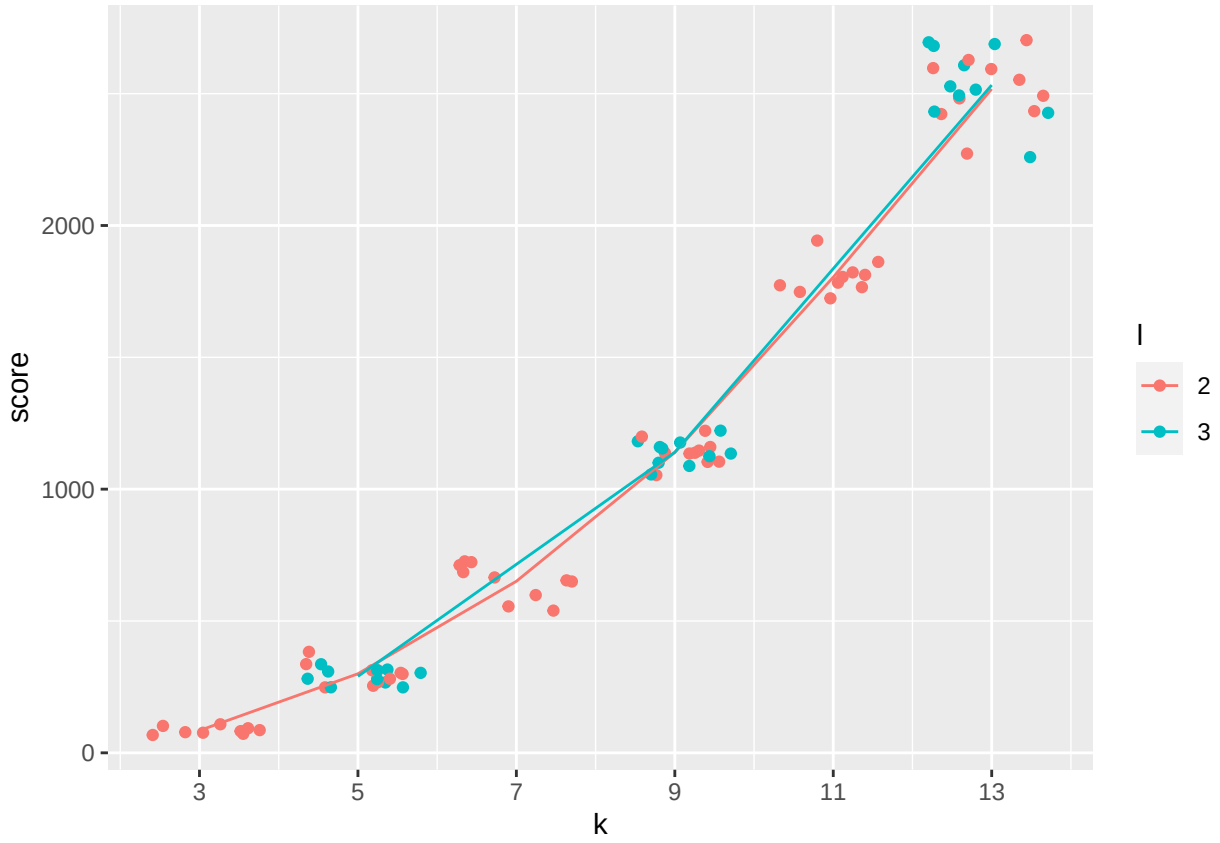
```
paired %>%
  mutate(l=as.factor(l)) %>%
  ggplot(aes(k, time)) +
  geom_jitter(aes(color=l)) +
  geom_line(aes(k, avg_time, color=l)) +
  scale_x_continuous(breaks=c(3,5,7,9,11,13))
```



SP score against the number of sequences k

```
paired %>%
  mutate(l=as.factor(l)) %>%
  ggplot(aes(k, score)) +
```

```
  geom_jitter(aes(color=l)) +
  geom_line(aes(k, avg_score, color=l)) +
  scale_x_continuous(breaks=c(3,5,7,9,11,13))
```



Randomized l-stars

Compute an average time and score for each distinct pair of k and l:

```
randomized <- randomized %>%
  group_by(k, l, eps) %>%
  mutate(avg_time = mean(time), avg_score = mean(score)) %>%
  ungroup()
```

A table summarizes the average score for each pair of k and l:

```
randomized %>%
  group_by(k, l) %>%
  summarise(average_score=mean(score)) %>%
  spread(l, average_score) %>%
  kable()
```

k	2	3	4
3	84.6	81.000	
4			162.300
5	299.8	291.675	
7	650.7	626.650	617.950
9	1138.0	1136.425	
10			1396.750
11	1793.0	1794.850	
13	2509.6	2514.825	2494.875

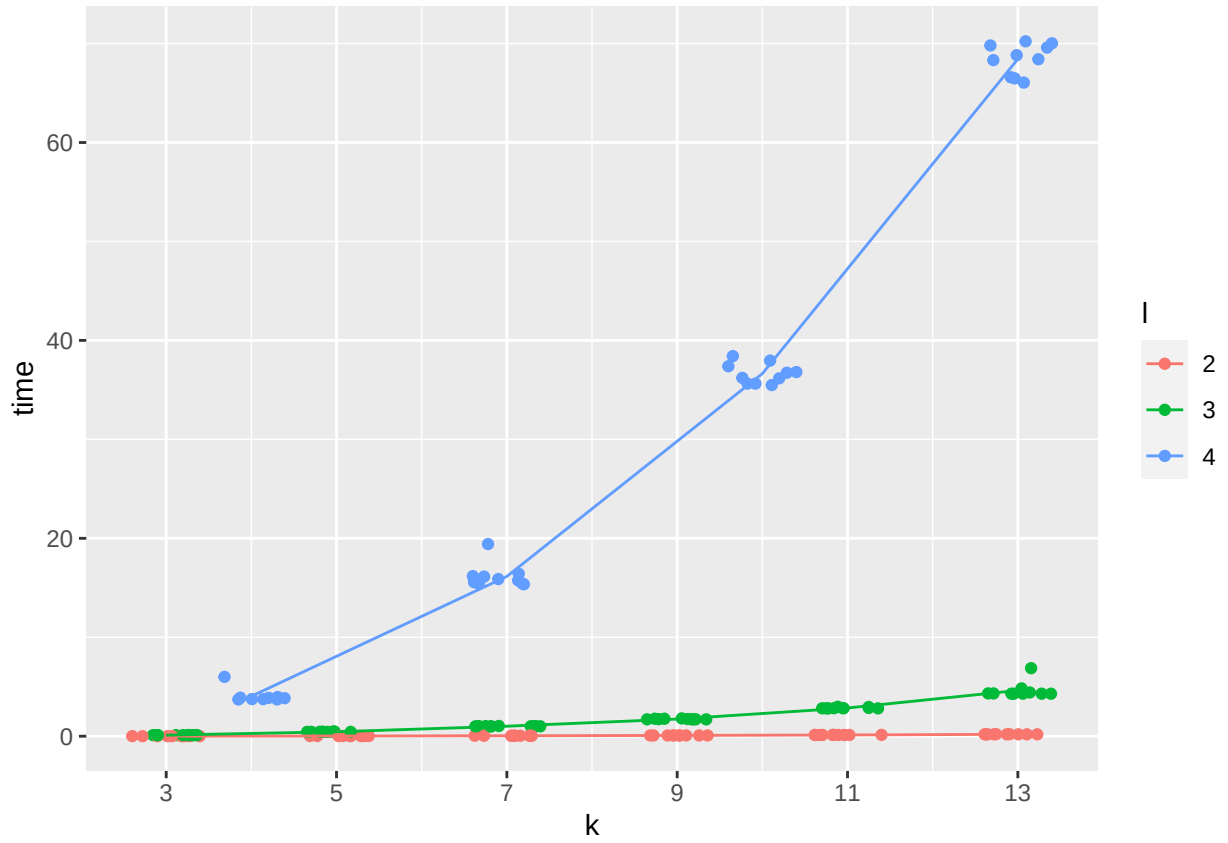
A table summarizes the average running time(s) for each pair of k and l:

```
randomized %>%
  group_by(k, l) %>%
  summarise(average_time=mean(time)) %>%
  spread(l, average_time) %>%
  kable()
```

k	2	3	4
3	0.0037410	0.0691764	
4			2.552521
5	0.0138204	0.2952708	
7	0.0320227	0.6974272	10.968828
9	0.0557413	1.2328964	
10			25.947399
11	0.0943120	2.0967800	
13	0.1363006	3.1105206	47.361191

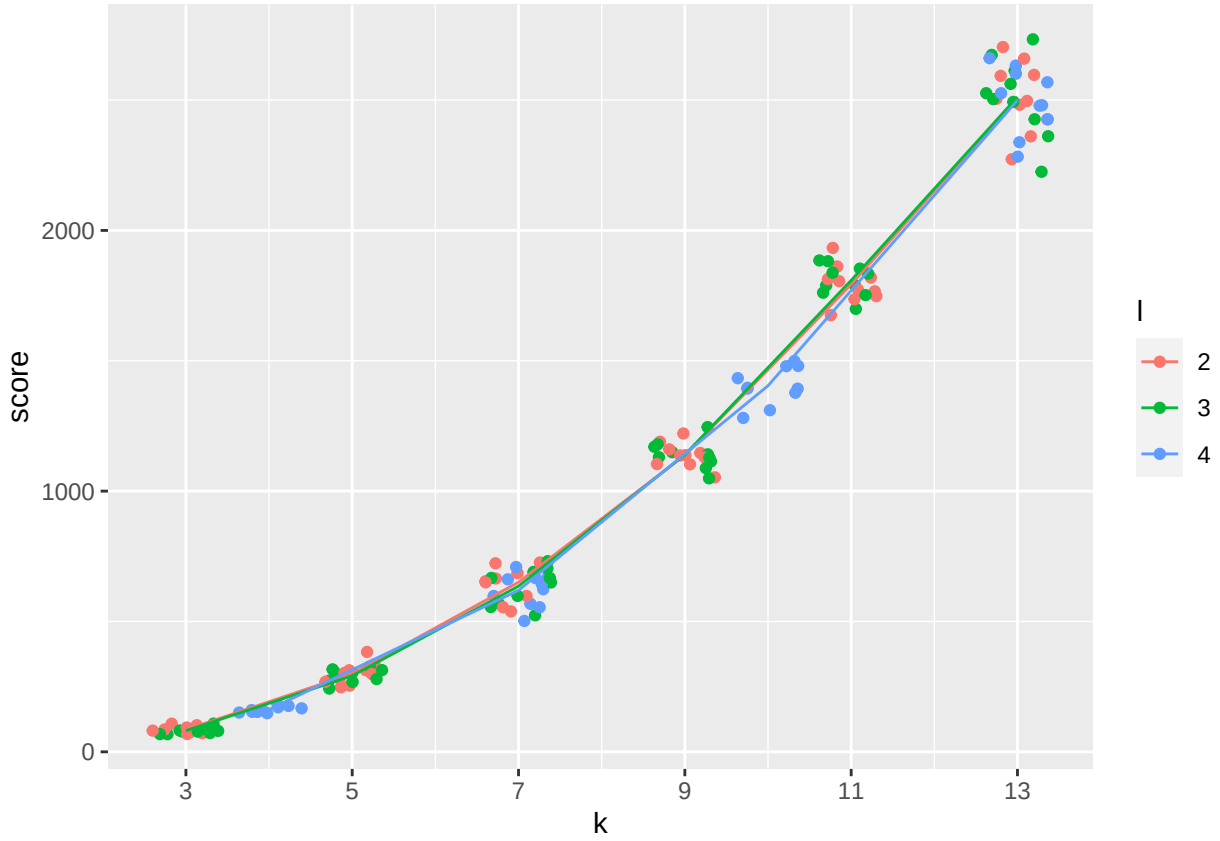
Running time against the number of sequences k (eps=0.1)

```
randomized %>%
  filter(eps==0.1) %>%
  mutate(l=as.factor(l)) %>%
  ggplot(aes(k, time)) +
  geom_jitter(aes(color=l)) +
  geom_line(aes(k, avg_time, color=l)) +
  scale_x_continuous(breaks=c(3,5,7,9,11,13))
```



SP score against the number of sequences k

```
randomized %>%
  filter(eps==0.1) %>%
  mutate(l=as.factor(l)) %>%
  ggplot(aes(k, score)) +
  geom_jitter(aes(color=l)) +
  geom_line(aes(k, avg_score, color=l)) +
  scale_x_continuous(breaks=c(3,5,7,9,11,13))
```



When l = 4, a table summarizes the average score for each pair of k and epsilon:

```
randomized %>%
  filter(l==4) %>%
  group_by(k, eps) %>%
  summarise(average_score=mean(score)) %>%
  spread(eps, average_score) %>%
  kable()
```

k	0.1	0.3	0.6	0.9
4	162.3	162.3	162.3	162.3
7	619.5	616.6	616.9	618.8
10	1404.1	1391.0	1405.4	1386.5
13	2499.4	2500.0	2494.3	2485.8

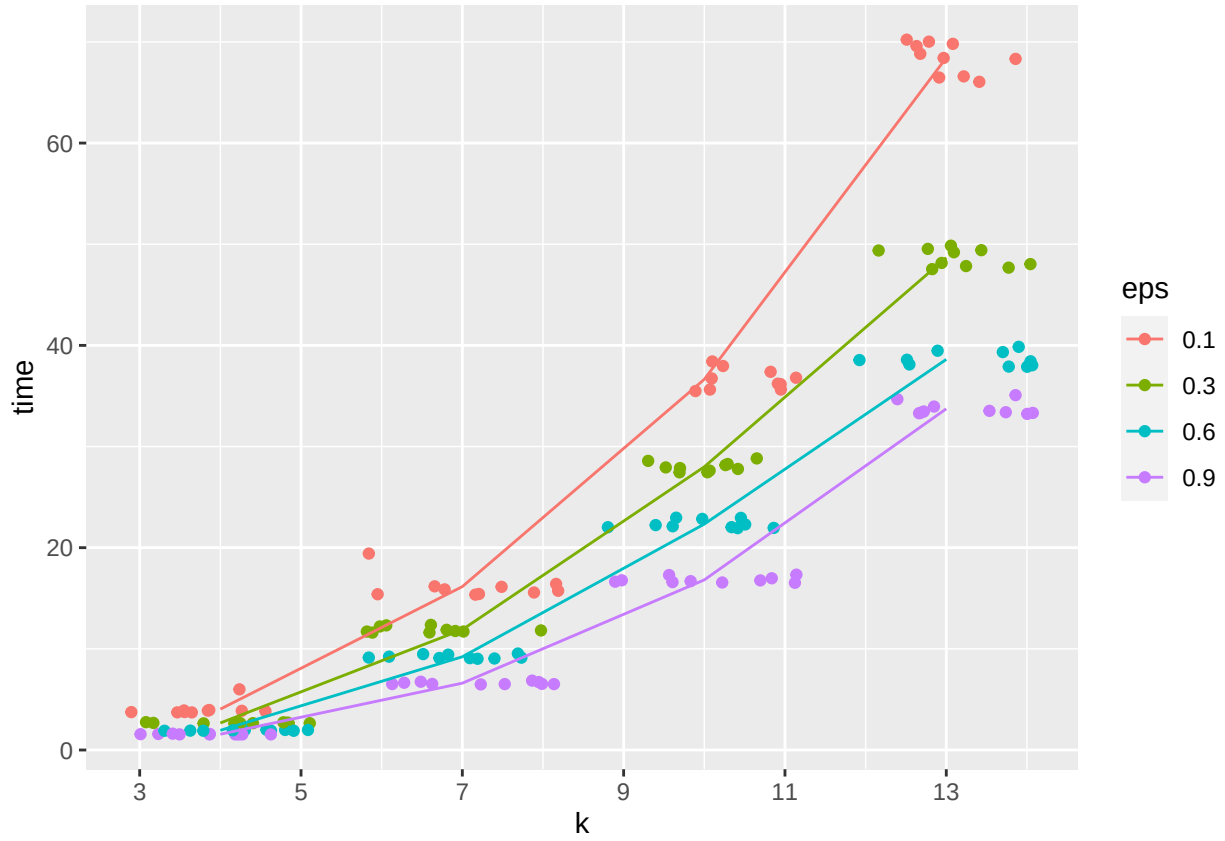
When l = 4, a table summarizes the average time for each pair of k and epsilon:

```
randomized %>%
  filter(l==4) %>%
  group_by(k, eps) %>%
  summarise(average_time=mean(time)) %>%
  spread(eps, average_time) %>%
  kable()
```

k	0.1	0.3	0.6	0.9
4	4.039749	2.670902	1.940969	1.558463
7	16.152144	11.900376	9.216258	6.606534
10	36.642168	27.996650	22.334511	16.816268
13	68.434450	48.664306	38.616601	33.729408

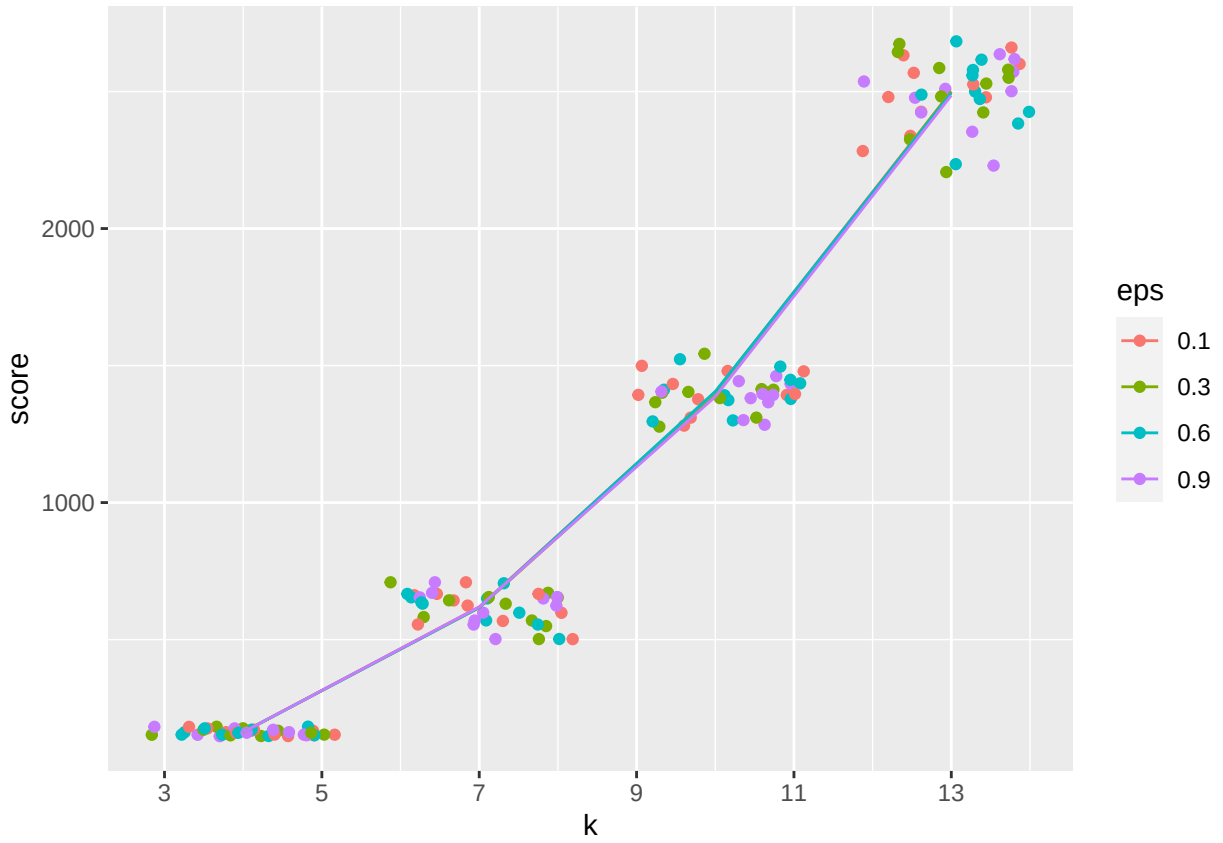
When l = 4, running time against the number of sequences k for different epsilon

```
randomized %>%
  filter(l==4) %>%
  mutate(eps=as.factor(eps)) %>%
  ggplot(aes(k, time)) +
  geom_jitter(aes(color=eps)) +
  geom_line(aes(k, avg_time, color=eps)) +
  scale_x_continuous(breaks=c(3,5,7,9,11,13))
```



When l = 4, score against the number of sequences k for different epsilon

```
randomized %>%
  filter(l==4) %>%
  mutate(eps=as.factor(eps)) %>%
  ggplot(aes(k, score)) +
  geom_jitter(aes(color=eps)) +
  geom_line(aes(k, avg_score, color=eps)) +
  scale_x_continuous(breaks=c(3,5,7,9,11,13))
```



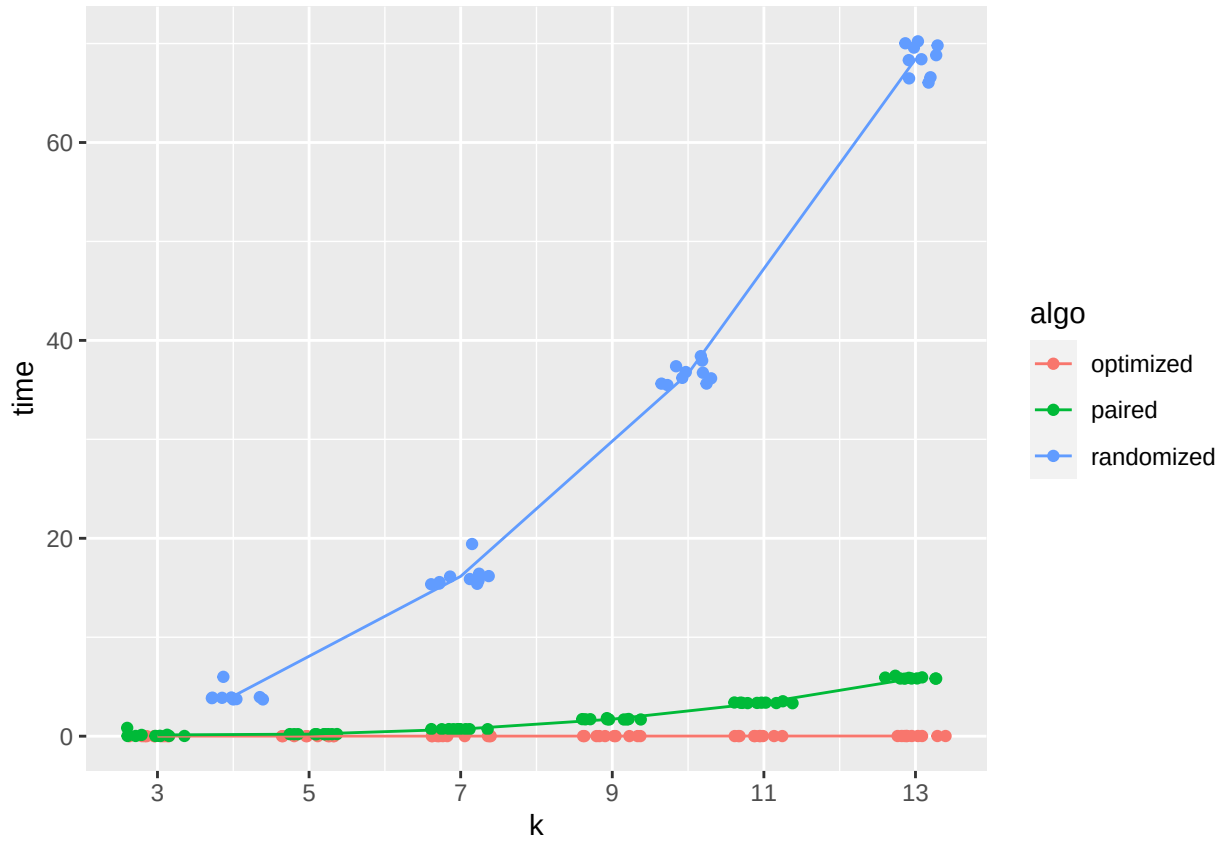
comparison

fixed approximation ratio For a fixed theoretical approximation ratio = 2-l/k - optimized: l=2 - (2l-1)-stars: l=2 - randomized: l=4, eps=0.1

```
optimized.2 <- optimized %>%
  filter(l==2) %>%
  mutate(algo="optimized")

paired.2 <- paired %>%
  filter(l==2) %>%
  mutate(algo="paired")

randomized.2 <- randomized %>%
  filter(l==4, eps==0.1) %>%
  select(-eps) %>%
  mutate(algo="randomized")

df <- rbind(optimized.2, paired.2, randomized.2)
```

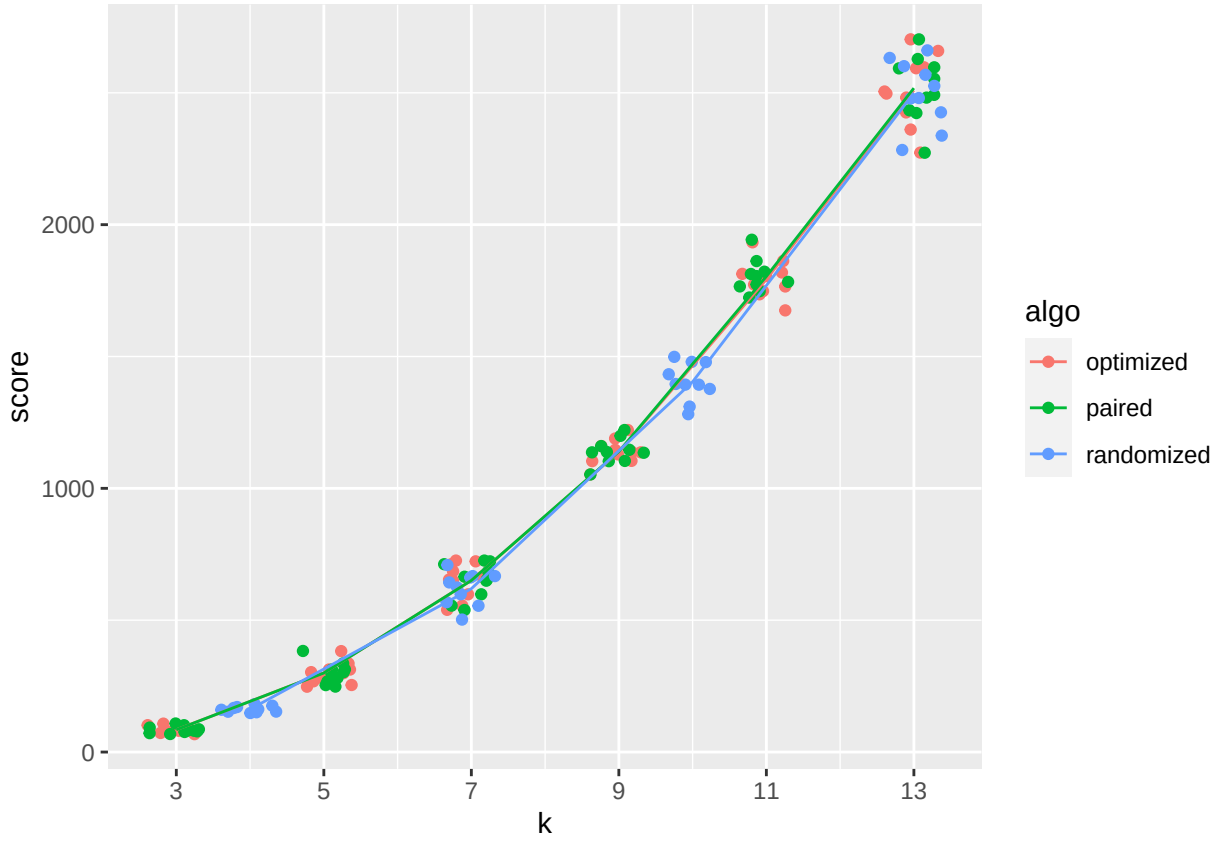
Running time against the number of sequences k

```
df %>%
  ggplot(aes(k, time)) +
  geom_jitter(aes(color=algo)) +
  geom_line(aes(k, avg_time, color=algo)) +
  scale_x_continuous(breaks=c(3,5,7,9,11,13))
```



SP score against the number of sequences k

```
df %>%
  ggplot(aes(k, score)) +
  geom_jitter(aes(color=algo)) +
  geom_line(aes(k, avg_score, color=algo)) +
  scale_x_continuous(breaks=c(3,5,7,9,11,13))
```

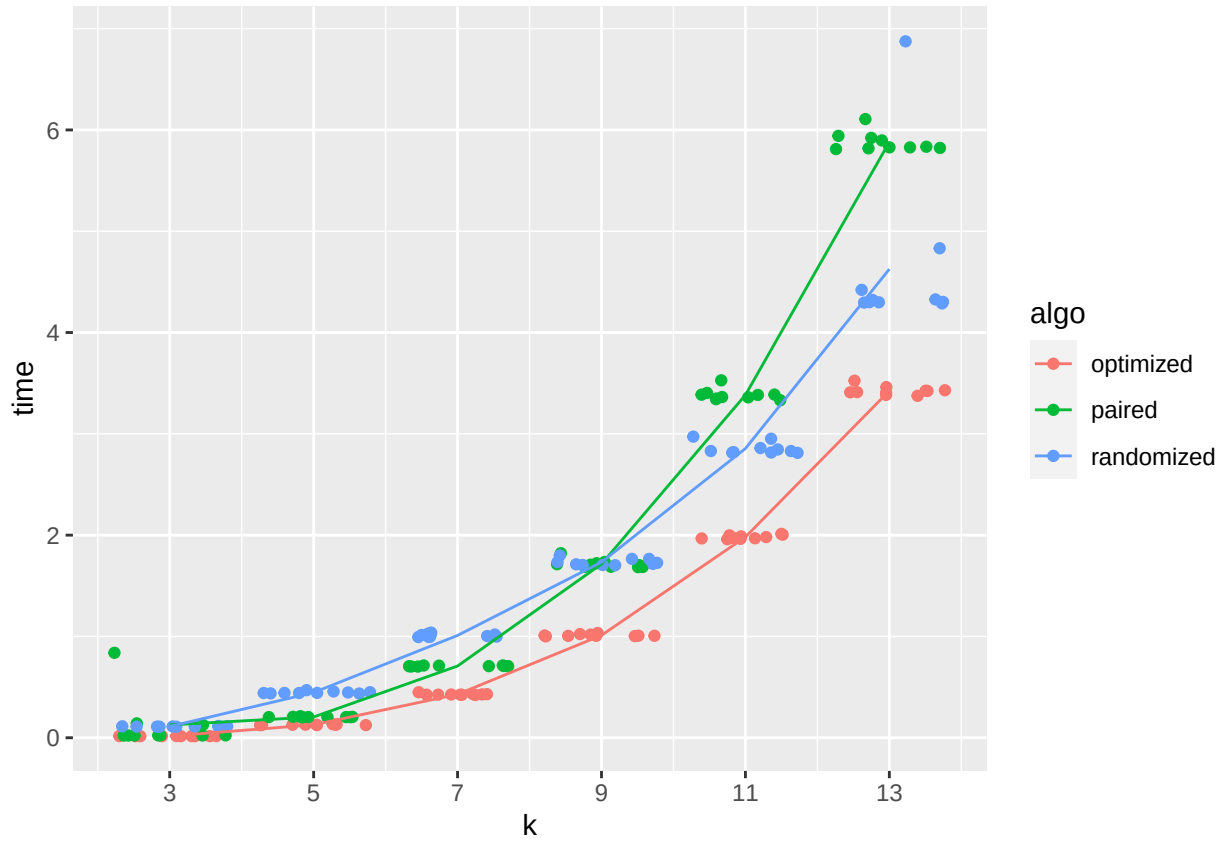


fixed clique size For a fixed clique size l - optimized: l=3 - (2l-1)-stars: l=2 - randomized: l=3, eps=0.1

```
optimized.3 <- optimized %>%
  filter(l==3) %>%
  mutate(algo="optimized")

paired.3 <- paired %>%
  filter(l==2) %>%
  mutate(algo="paired")

randomized.3 <- randomized %>%
  filter(l==3, eps==0.1) %>%
  select(-eps) %>%
  mutate(algo="randomized")

df.3 <- rbind(optimized.3, paired.3, randomized.3)
```

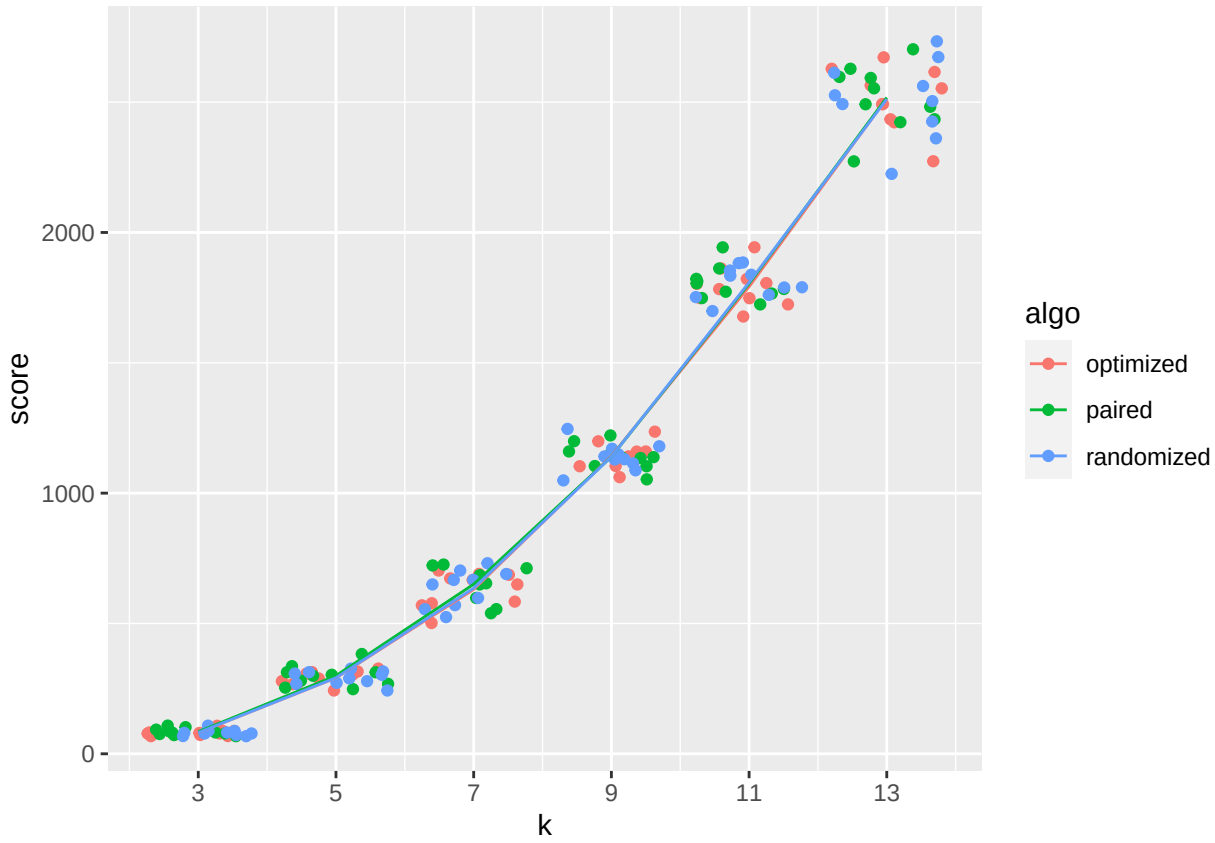
Running time against the number of sequences k

```
df.3 %>%
  ggplot(aes(k, time)) +
  geom_jitter(aes(color=algo)) +
  geom_line(aes(k, avg_time, color=algo)) +
  scale_x_continuous(breaks=c(3,5,7,9,11,13))
```



SP score against the number of sequences k

```
df.3 %>%
  ggplot(aes(k, score)) +
  geom_jitter(aes(color=algo)) +
  geom_line(aes(k, avg_score, color=algo)) +
  scale_x_continuous(breaks=c(3,5,7,9,11,13))
```


score
2000
1000
0
3
5
7
9
11
13
k
algo
optimized
paired
randomized