Metric for an optimal pipeline:

We will be searching for optimal pipeline for each trace. We are considering best IPC with the lowest resource utilization as the optimal pipeline.

By resources, I am considering FU units as priority. So, one metric for optimal pipeline can be defined as

$$= \frac{\text{IPC}}{\#\text{FU}}$$

For each trace we are considering the given constraints and looking into the search space using an shell script that run the simulator for each configs and save the stats which is 300 simulation for each trace. We are calculating the metric from the stats and presenting the best optimal configs as follows:

Initially, we plot whole IPC profile for all configs for all 5 traces Fig. 1. Then correlation with FUs (A+M+L. Then we can lower the resources that not crucial for higher IPC.
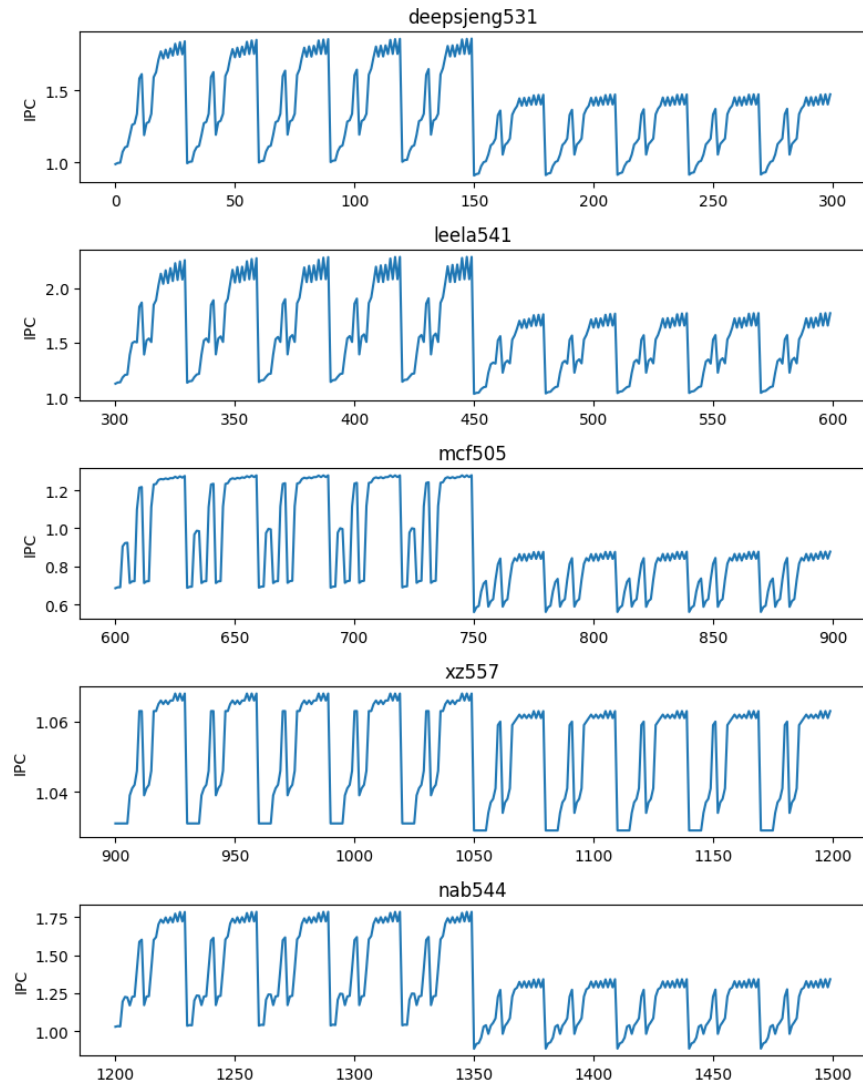
Fig. 1 IPC from different trace on probable configuration. (300 configs for each, total 1500 run). One interesting thing to notice for each trace we observe some specific config performs best.

We get max IPC in the following configs:

For deepsjeng531:

```
IPC                   1.858
ROB entries              256.000
Num. SchedQ entries per FU      8.000
Num. ALU FUs             4.000
Num. MUL FUs             3.000
Num. LSU FUs             2.000
Fetch width           8.000
Dispatch width           8.000
Retire width             8.000
```

For leela541:

```
IPC                      2.285
ROB entries              256.000
Num. SchedQ entries per FU     7.000
Num. ALU FUs             4.000
Num. MUL FUs             3.000
Num. LSU FUs             2.000
Fetch width              8.000
Dispatch width           8.000
Retire width             8.000
Name: 419, dtype: float64
```

For mcf505:

```
IPC                      1.279
ROB entries              256.000
Num. SchedQ entries per FU     8.000
Num. ALU FUs             4.000
Num. MUL FUs             3.000
Num. LSU FUs             2.000
Fetch width              8.000
Dispatch width           8.000
Retire width             8.000
Name: 749, dtype: float64
```

For xz557:

```
IPC                      1.068
ROB entries              256.000
Num. SchedQ entries per FU     4.000
Num. ALU FUs             4.000
Num. MUL FUs             1.000
Num. LSU FUs             2.000
Fetch width              8.000
Dispatch width           8.000
Retire width             8.000
Name: 925, dtype: float64
```

For nab544:

```
 IPC                     1.785
ROB entries              256.000
Num. SchedQ entries per FU     5.000
Num. ALU FUs             4.000
Num. MUL FUs             3.000
Num. LSU FUs             2.000
Fetch width              8.000
Dispatch width           8.000
Retire width             8.000
Name: 1259, dtype: float64
```

Now we measured the IPCpFU metric and plot for all the 5 trace. Fig. 2 shows that.
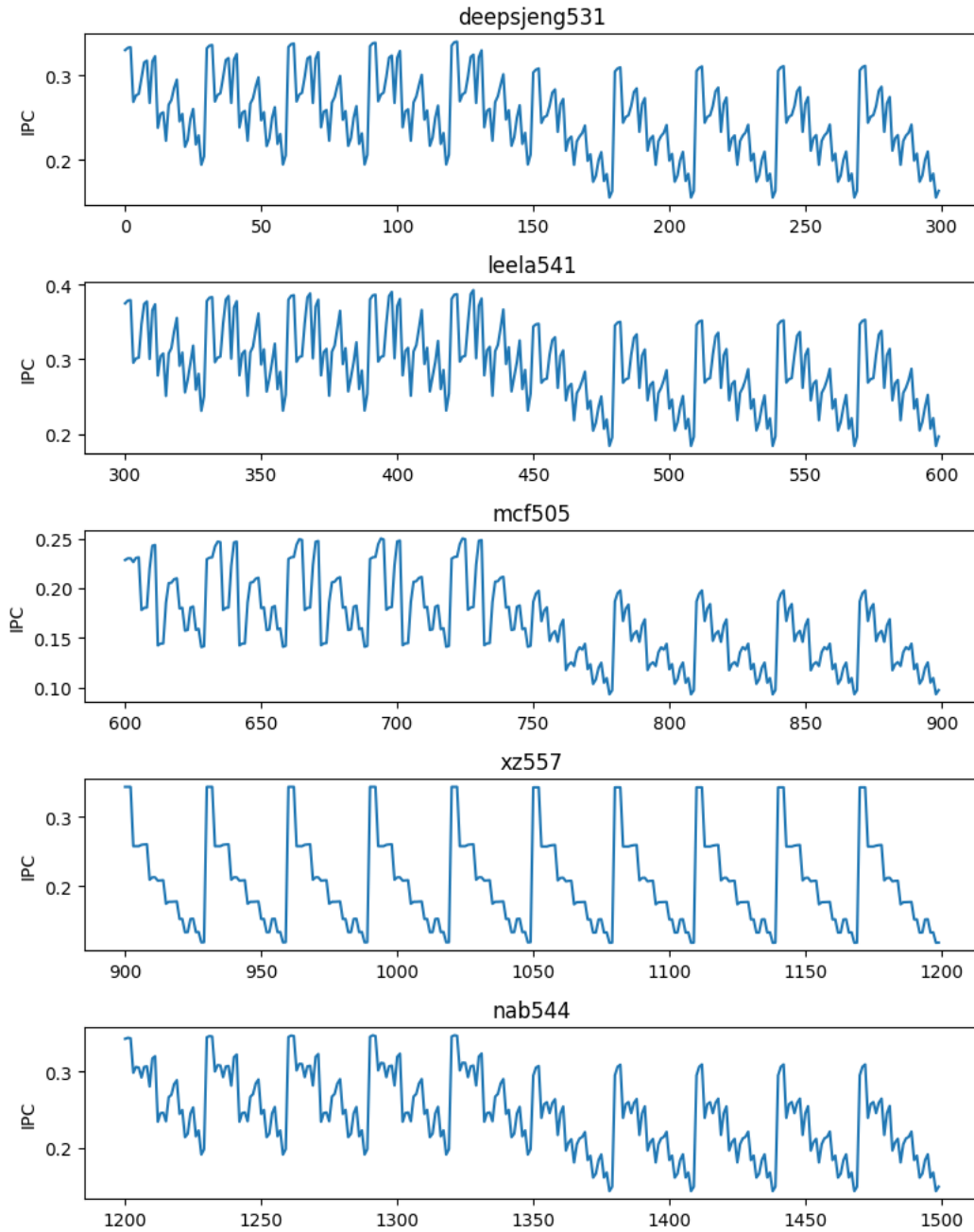

Fig.2 IPC per FU metric distribution for all the 5 trace for all selected configs.

Now we find max IPC per FU configs for the traces:

For deepsjeng531:

```
IPC                      1.019000
ROB entries              256.000000
Num. SchedQ entries per FU    8.000000
Num. ALU FUs             1.000000
Num. MUL FUs             1.000000
Num. LSU FUs             1.000000
Fetch width              8.000000
Dispatch width           8.000000
Retire width             8.000000
IPCpFU                   0.339667
```

For leela541:

```
IPC                      1.5700
ROB entries              256.0000
Num. SchedQ entries per FU    8.0000
Num. ALU FUs             2.0000
Num. MUL FUs             1.0000
Num. LSU FUs             1.0000
Fetch width              8.0000
Dispatch width           8.0000
Retire width             8.0000
IPCpFU                   0.3925
```

For mcf505:

```
 IPC                     1.00
ROB entries              128.00
Num. SchedQ entries per FU    7.00
Num. ALU FUs             1.00
Num. MUL FUs             1.00
Num. LSU FUs             2.00
Fetch width              4.00
Dispatch width           4.00
Retire width             4.00
IPCpFU                   0.25
```

For xz557:

```
IPC                      1.031000
ROB entries              64.000000
Num. SchedQ entries per FU    4.000000
Num. ALU FUs             1.000000
Num. MUL FUs             1.000000
Num. LSU FUs             1.000000
Fetch width              2.000000
Dispatch width           2.000000
Retire width             2.000000
IPCpFU                   0.343667
Name: 900, dtype: float64
```

For nab544:

```
IPC                          1.044
ROB entries                128.000
Num. SchedQ entries per FU     7.000
Num. ALU FUs                 1.000
Num. MUL FUs                 1.000
Num. LSU FUs                 1.000
Fetch width                  4.000
Dispatch width               4.000
Retire width                 4.000
IPCpFU                       0.348
Name: 1291, dtype: float64
```
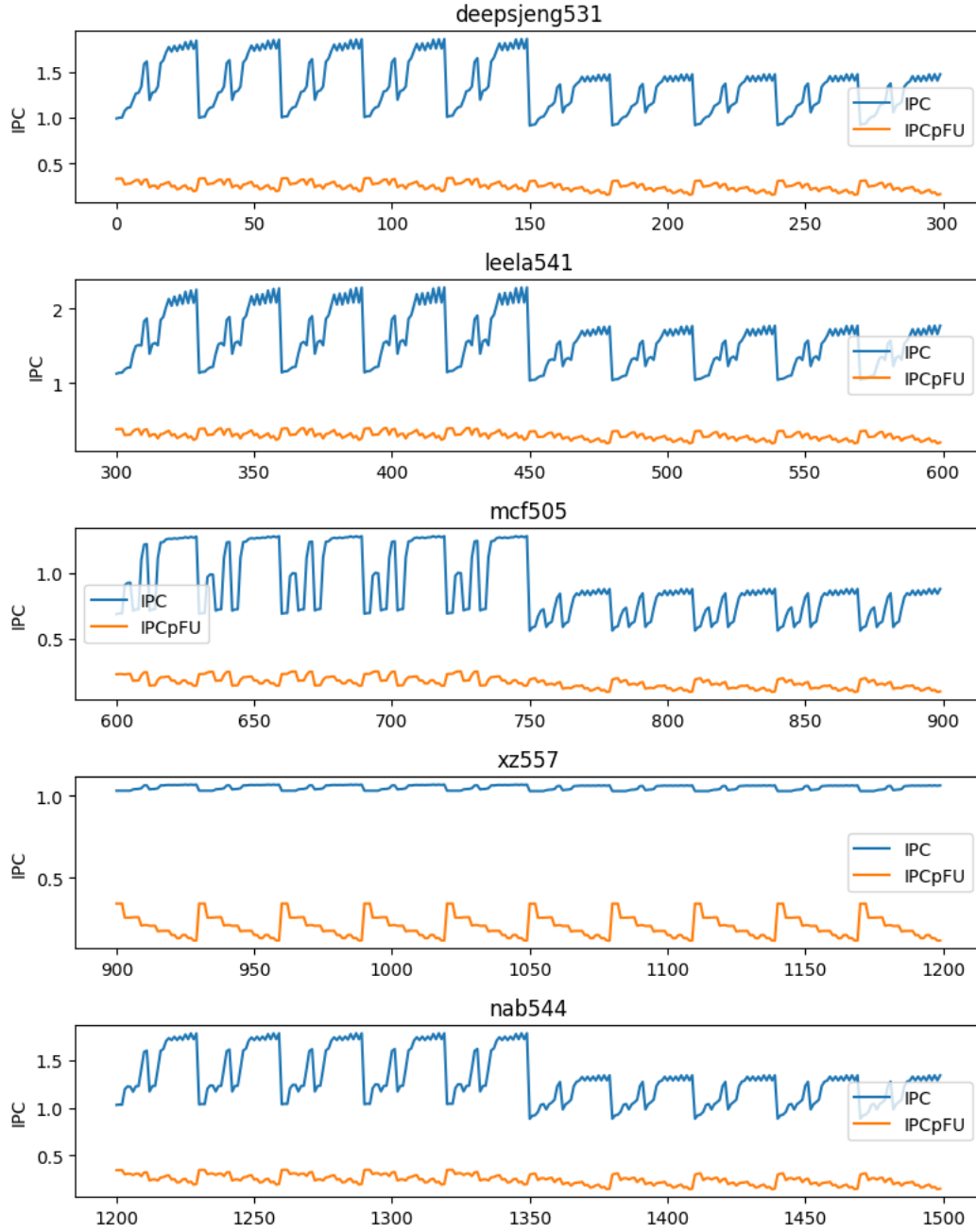
Fig. 3 IPC and IPCpFU distribution plot among configs.

Optimized Configs:

Now we plot both IPC and IPCpFU in same window to find an optimized config. We don't want to loose IPC but want to minimize the resource usage. This Fig.3 will help us to decide the config for different trace. Following are the optimized configs. Note that optimized configs offer good IPC with lower number of resources compared to max IPC with higher resources usage.

For deepsjeng531:

```
IPC                  1.81400
ROB entries            256.00000
Num. SchedQ entries per FU     8.00000
Num. ALU FUs            3.00000
Num. MUL FUs             3.00000
Num. LSU FUs            2.00000
Fetch width            8.00000
Dispatch width          8.00000
Retire width           8.00000
IPCpFU               0.22675
Name: 143, dtype: float64
```

For leela541:

```
IPC                  2.275
ROB entries            256.000
Num. SchedQ entries per FU     8.000
Num. ALU FUs            4.000
Num. MUL FUs             1.000
Num. LSU FUs            2.000
Fetch width            8.000
Dispatch width          8.000
Retire width           8.000
IPCpFU               0.325
```

For mcf505:

```
IPC                  1.278000
ROB entries            256.000000
Num. SchedQ entries per FU     8.000000
Num. ALU FUs            4.000000
Num. MUL FUs             1.000000
Num. LSU FUs            2.000000
Fetch width            8.000000
Dispatch width          8.000000
Retire width           8.000000
IPCpFU               0.182571
```

For xz557:

```
output
IPC                  1.068000
ROB entries            256.000000
Num. SchedQ entries per FU     8.000000
Num. ALU FUs            4.000000
Num. MUL FUs             1.000000
Num. LSU FUs            2.000000
Fetch width            8.000000
Dispatch width          8.000000
Retire width           8.000000
```

IPCpFU	0.152571

For nab544:

IPC	1.778
ROB entries	256.000
Num. SchedQ entries per FU	8.000
Num. ALU FUs	4.000
Num. MUL FUs	1.000
Num. LSU FUs	2.000
Fetch width	8.000
Dispatch width	8.000
Retire width	8.000
IPCpFU	0.254