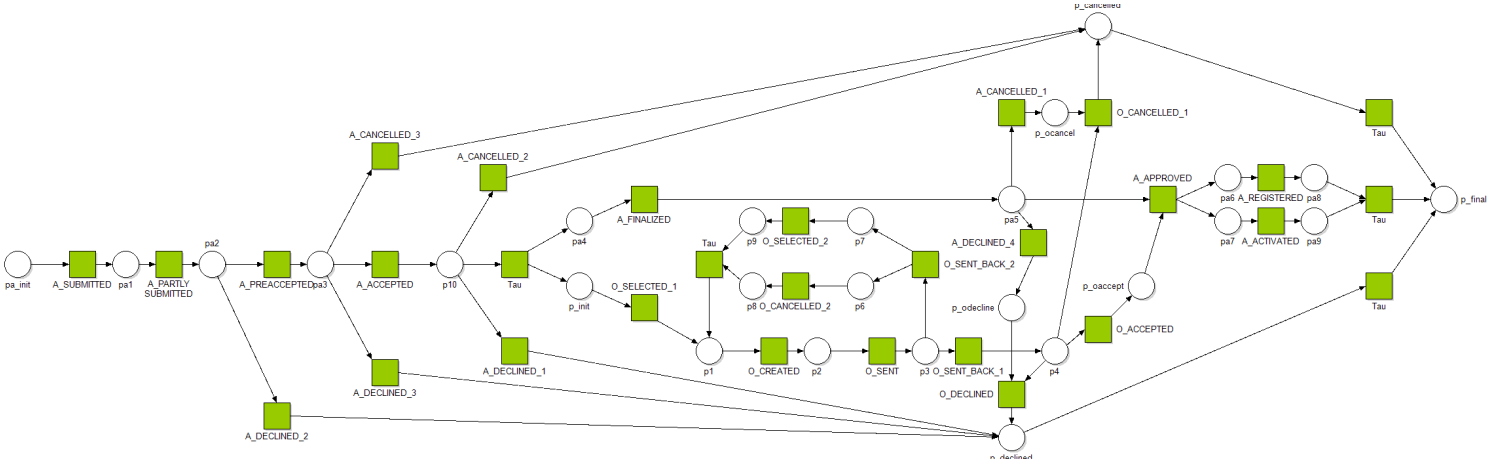
Appendix 1

.1 Process Models.

In this section, we provide the reference process models for the BPIC'12 real-event data [34] and the synthetic event data of [26].


p_cancelled
A_CANCELLED_1
p_ocancel
O_CANCELLED_1
Tau
A_CANCELLED_3
A_CANCELLED_2
A_APPROVED
pa6
A_REGISTERED
pa8
p_final
pa5
pa7
A_ACTIVATED
pa9
Tau
A_FINALIZED
pa4
Tau
p9
O_SELECTED_2
p7
A_DECLINED_4
O_SENT_BACK_2
pa2
p_init
pa1
A_SUBMITTED
A_PARTLY SUBMITTED
A_PREACCEPTED
pa3
A_ACCEPTED
p10
Tau
p_init
O_SELECTED_1
p8
O_CANCELLED_2
p6
p_odecline
p_oaccept
O_ACCEPTED
Tau
A_DECLINED_1
p1
O_CREATED
p2
O_SENT
p3
O_SENT_BACK_1
p4
A_DECLINED_3
O_DECLINED
A_DECLINED_2
p_declined

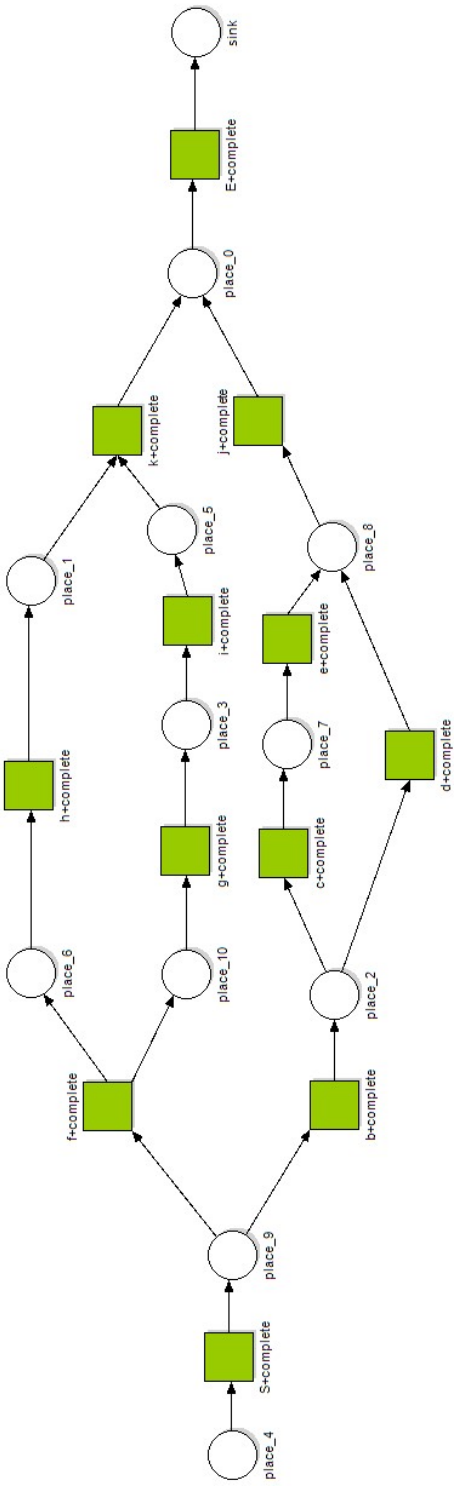
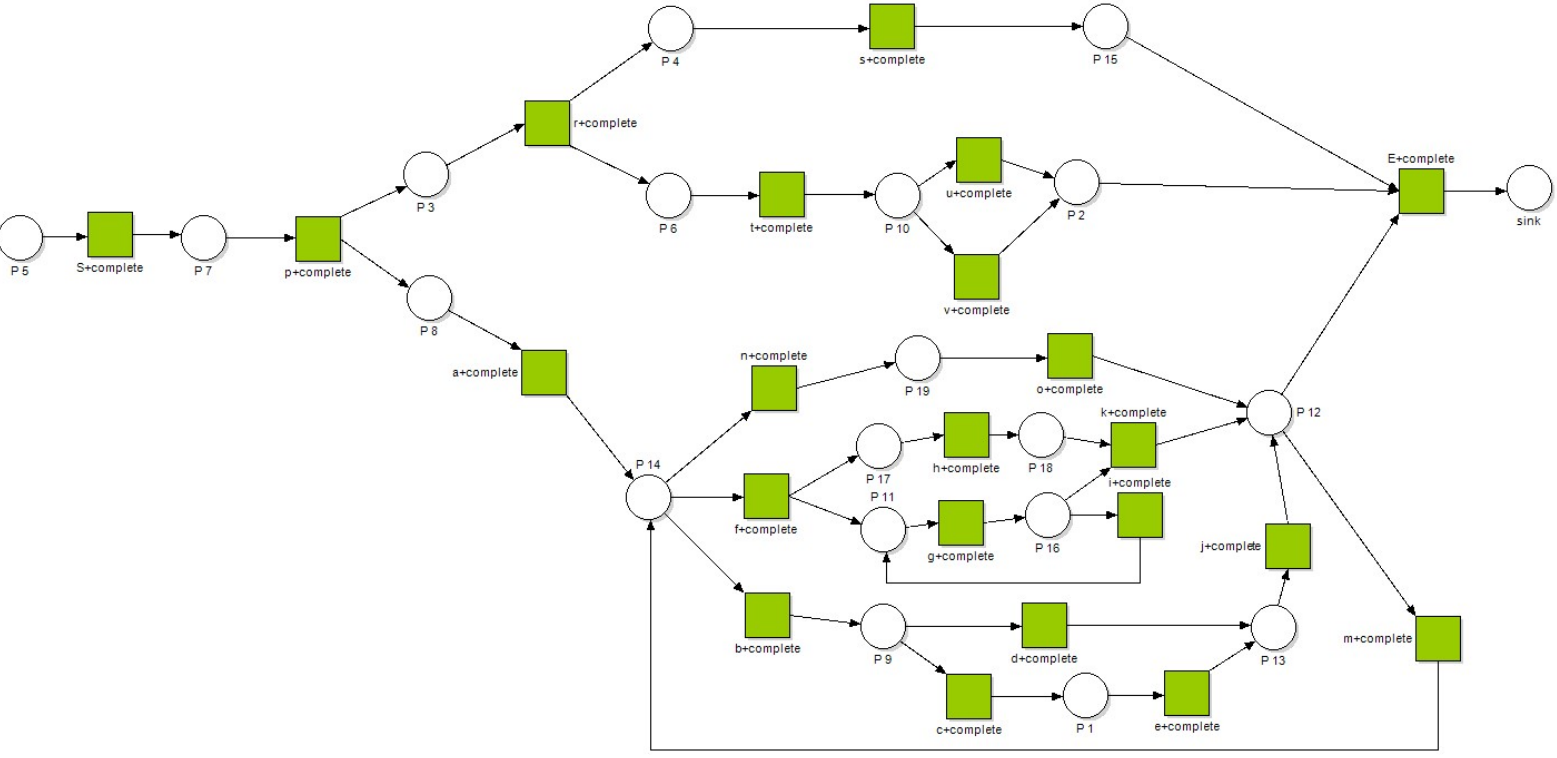


Figure 2: Process model of *a12* synthetic event data [26].


P 5
S+complete
P 7
p+complete
P 3
r+complete
P 4
s+complete
P 15
P 6
t+complete
P 10
u+complete
v+complete
P 2
E+complete
sink
P 8
a+complete
P 14
n+complete
P 19
o+complete
P 12
k+complete
P 17
h+complete
P 18
i+complete
P 11
f+complete
g+complete
P 16
j+complete
b+complete
P 9
d+complete
P 13
m+complete
c+complete
P 1
e+complete

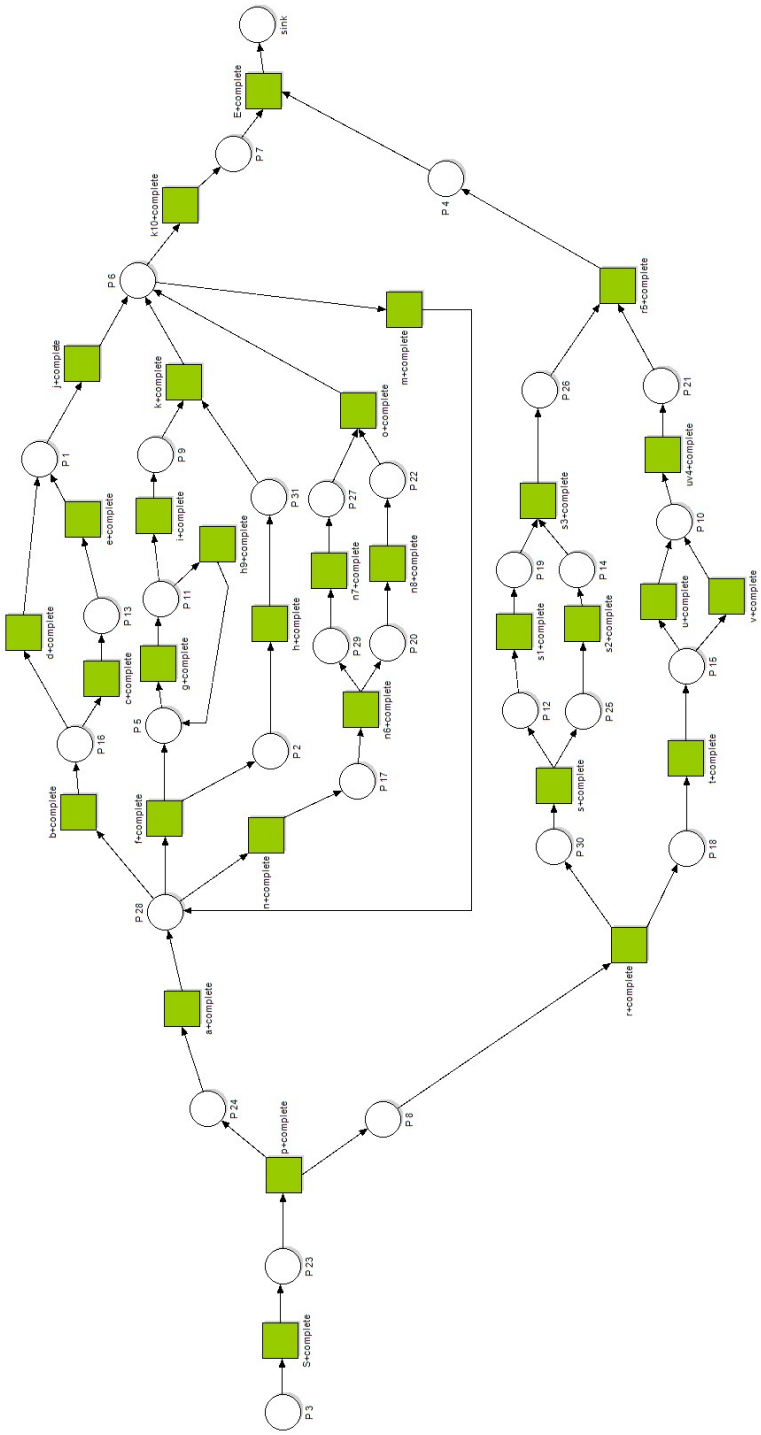


Figure 4: Process model of *a32* synthetic event data [26].

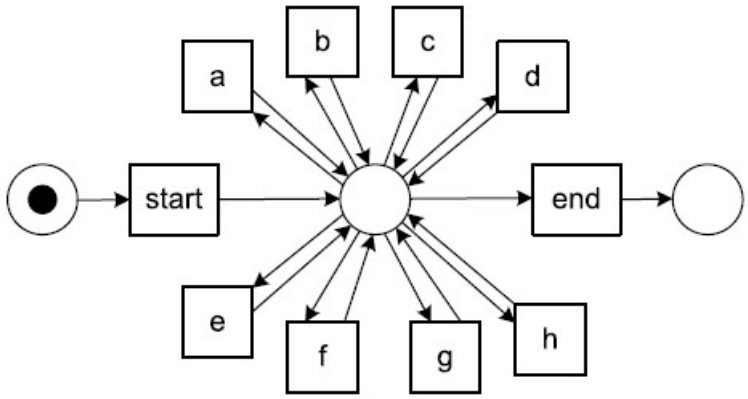
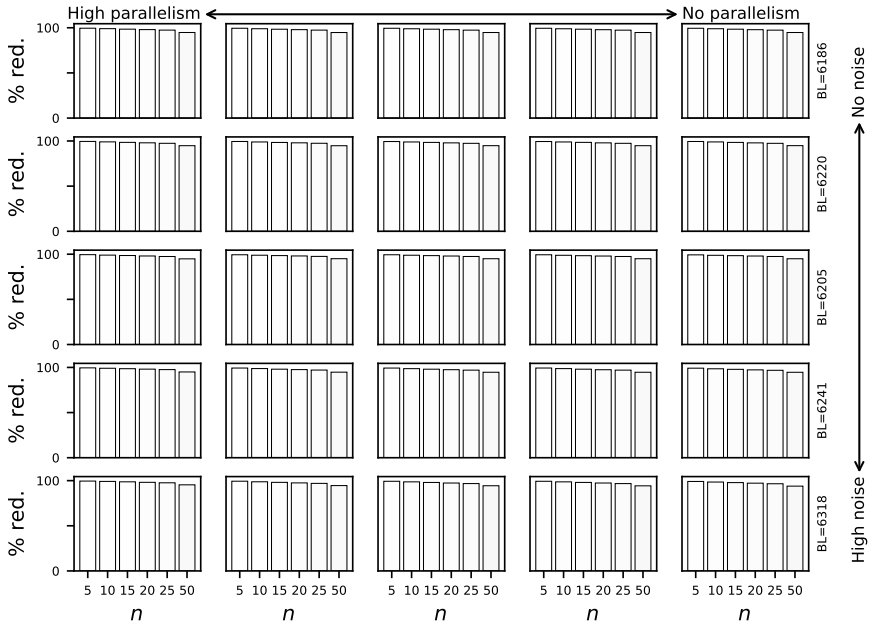


Figure 5: An example flower process model.

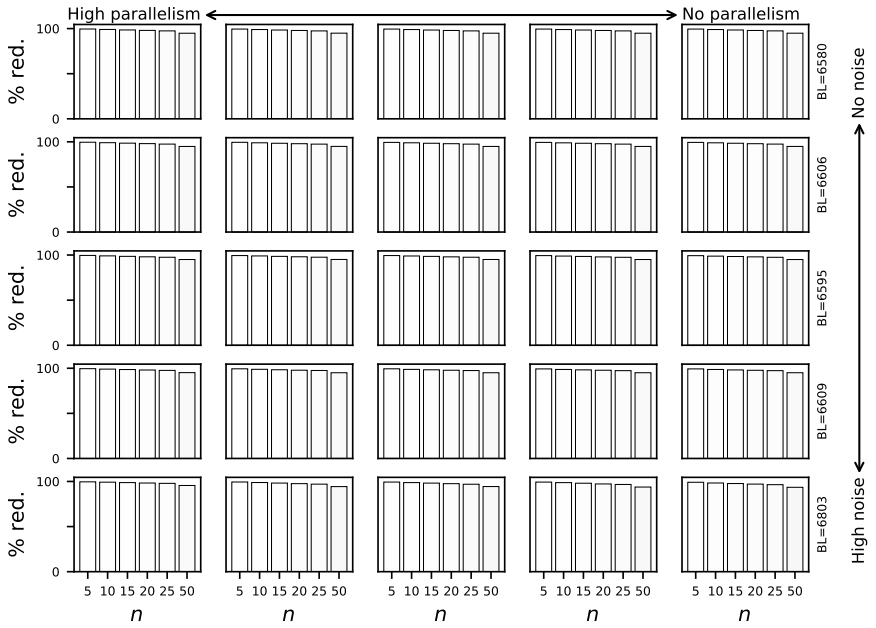
Appendix 2

.1 Model-Based Prefix Imputation(PMc).

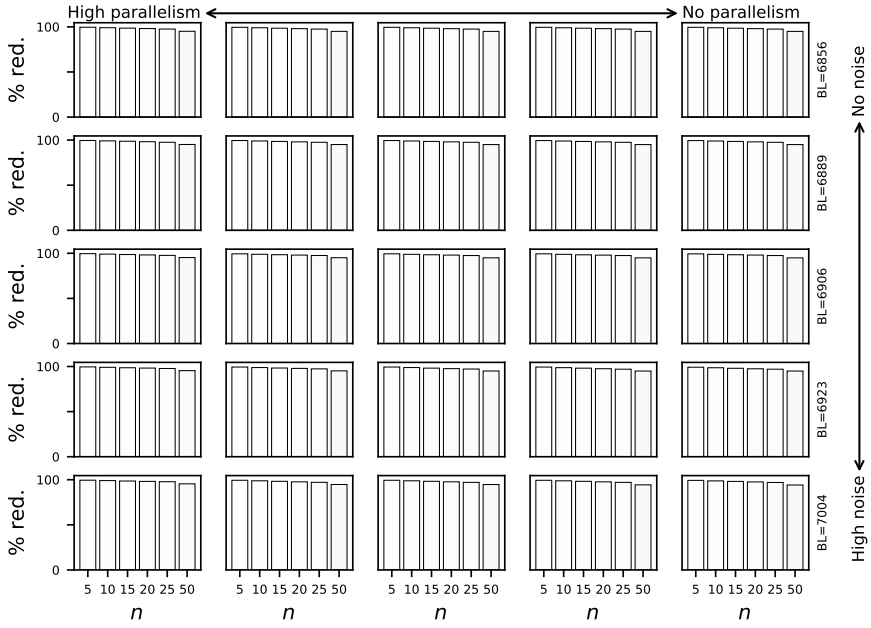
In this section, we provide the complete set of results for the experiments with $a12$, $a22$, and $a32$ synthetic events logs for the PMc stateless approach.



(a) Skewness of decisions level 0

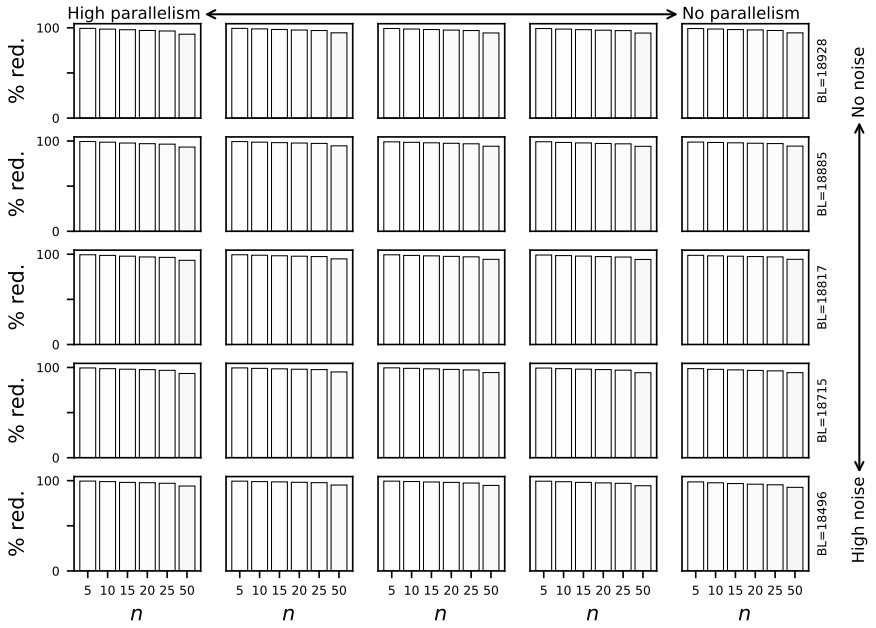


(b) Skewness of decisions level 1

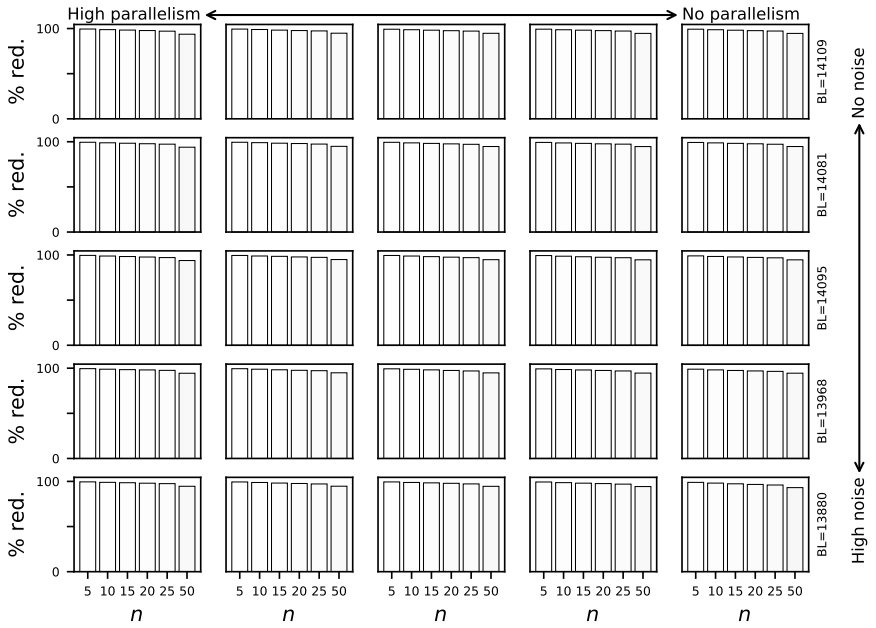


(c) Skewness of decisions level 2

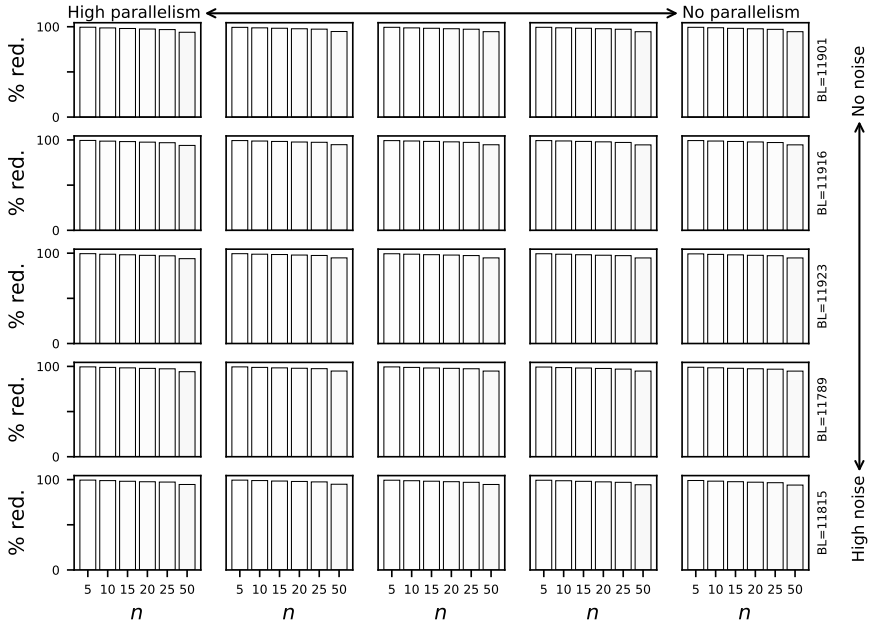
Figure 6: Percentage reduction in memory footprint w.r.t. the baseline (BL) for $a12$ event logs with different skewness of decisions and noise levels with PMc as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The value n on the X-axis is the maximum number of cases allowed to be retained in D_C. The number on the secondary Y-axis is the maximum states consumed by the baseline (BL).



(a) Skewness of decisions level 0

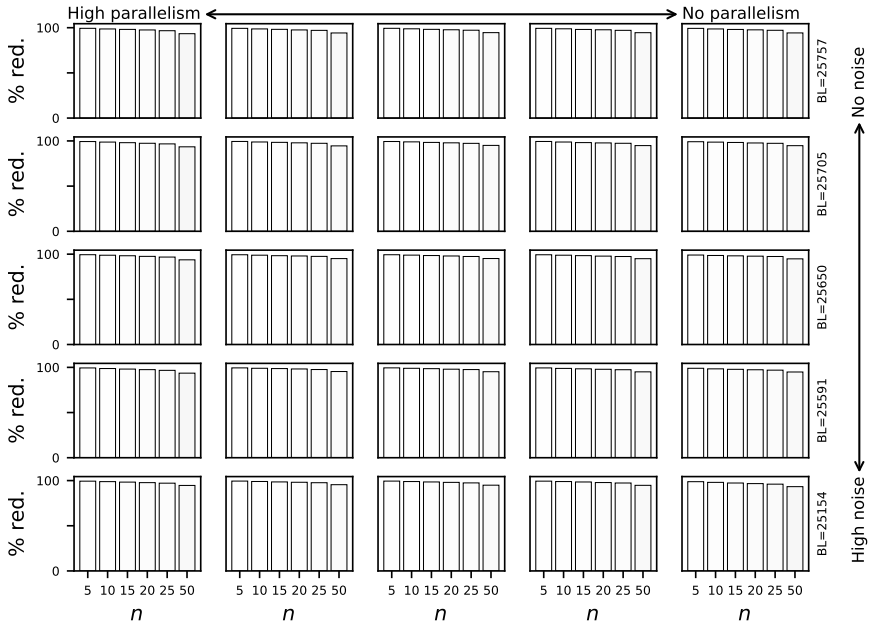


(b) Skewness of decisions level 1

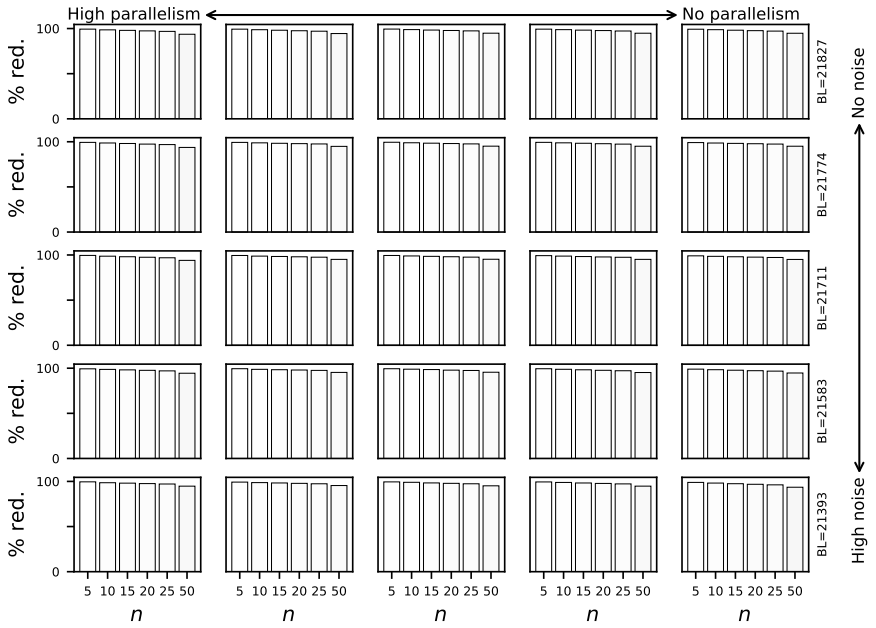


(c) Skewness of decisions level 2

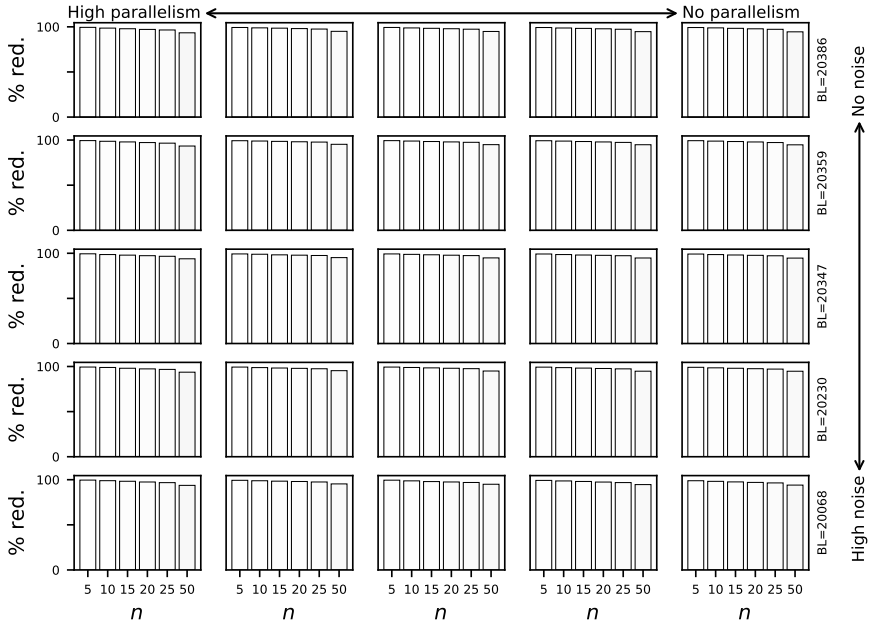
Figure 7: Percentage reduction in memory footprint w.r.t. the baseline (BL) for $a22$ event logs with different skewness of decisions and noise levels with PMc as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The value n on the X-axis is the maximum number of cases allowed to be retained in D_C. The number on the secondary Y-axis is the maximum states consumed by the baseline (BL).



(a) Skewness of decisions level 0

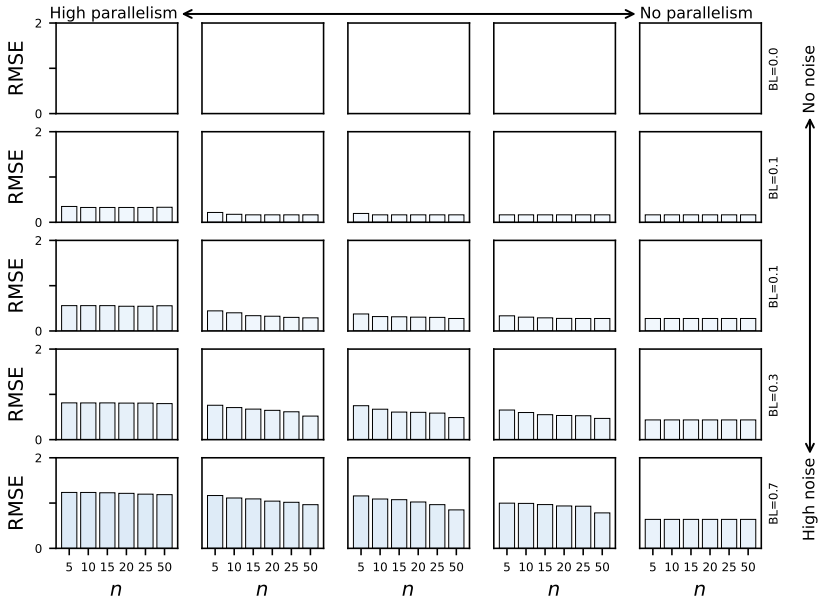


(b) Skewness of decisions level 1

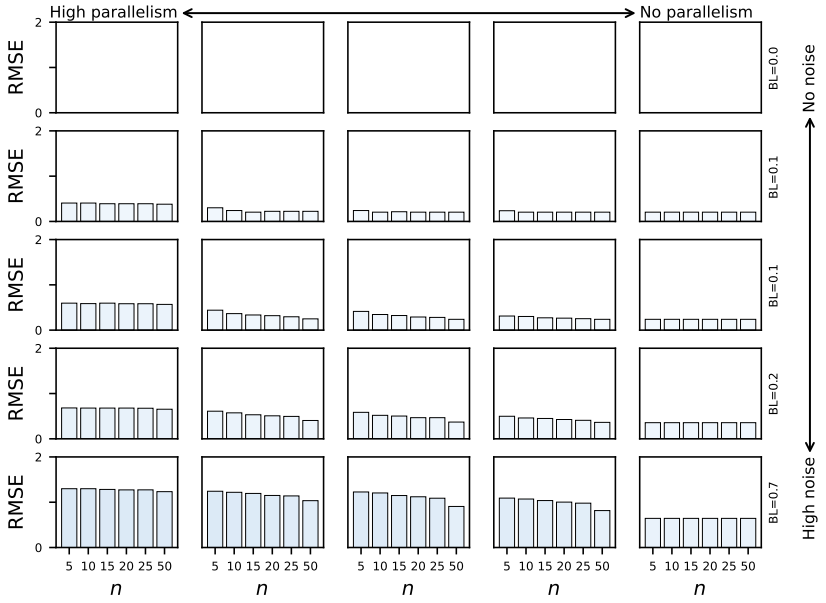


(c) Skewness of decisions level 2

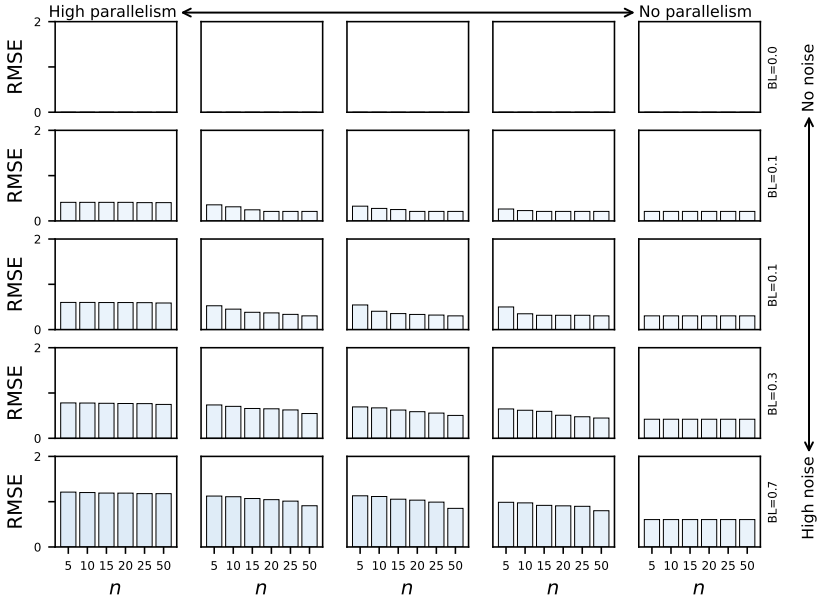
Figure 8: Percentage reduction in memory footprint w.r.t. the baseline (BL) for $a32$ event logs with different skewness of decisions and noise levels with PMc as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The value n on the X-axis is the maximum number of cases allowed to be retained in D_C. The number on the secondary Y-axis is the maximum states consumed by the baseline (BL).



(a) Skewness of decisions level 0

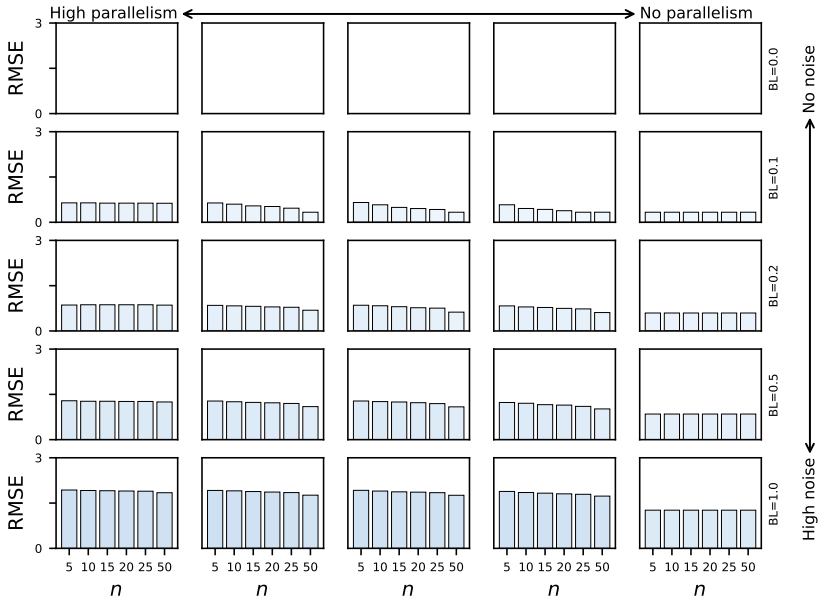


(b) Skewness of decisions level 1

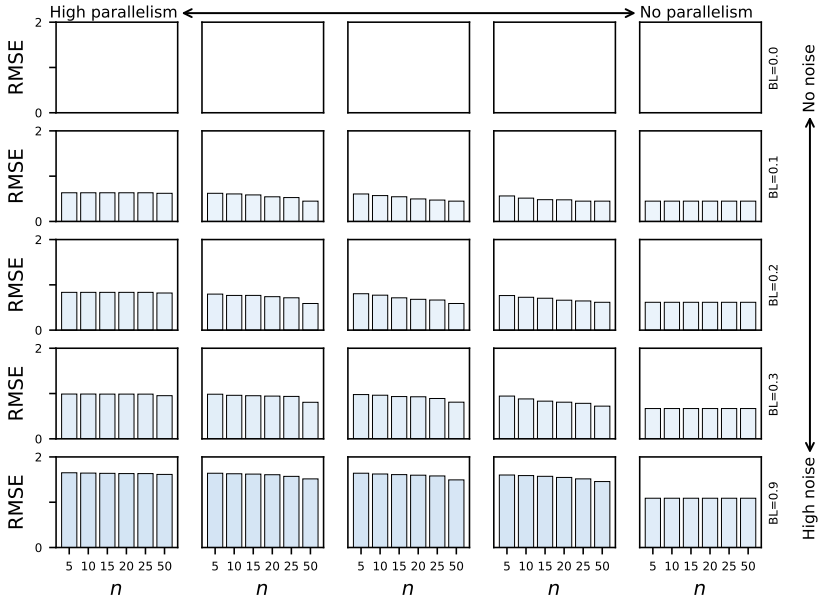


(c) Skewness of decisions level 2

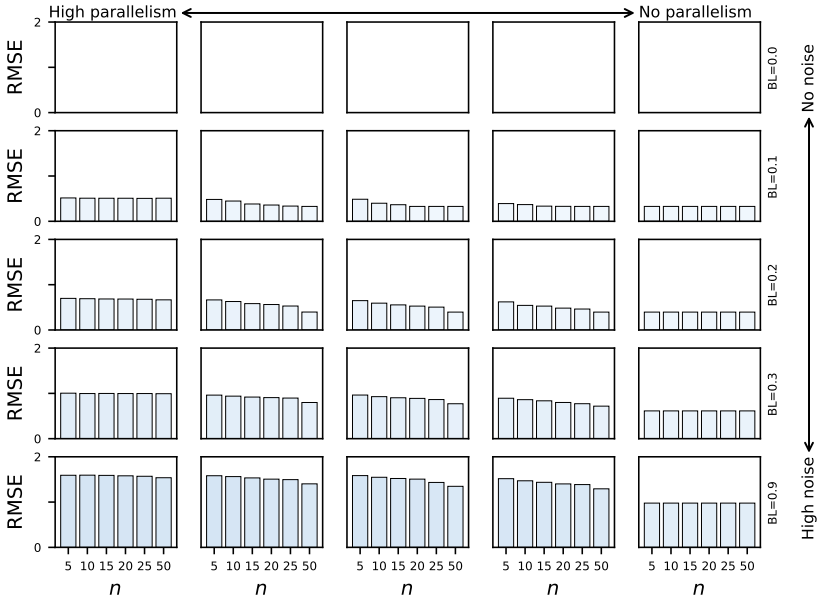
Figure 9: RMSE for $a12$ event logs with different decision skewness and noise levels with PMc as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The number on the secondary Y-axis is the avg. trace fitness cost over the log by the baseline(BL).



(a) Skewness of decisions level 0

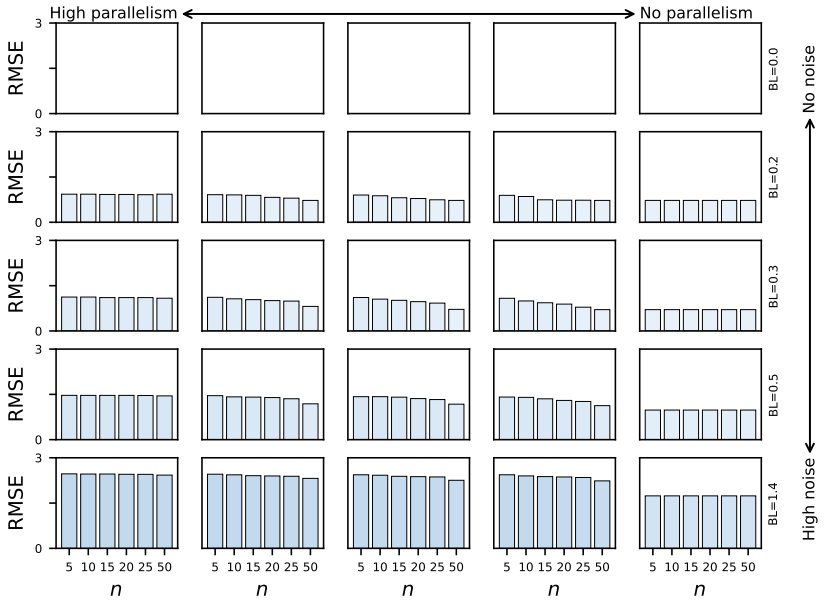


(b) Skewness of decisions level 1

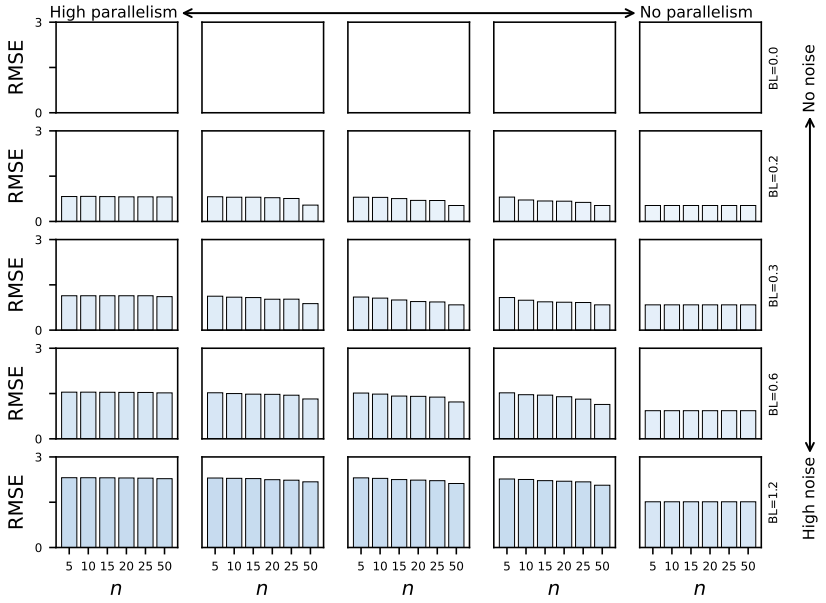


(c) Skewness of decisions level 2

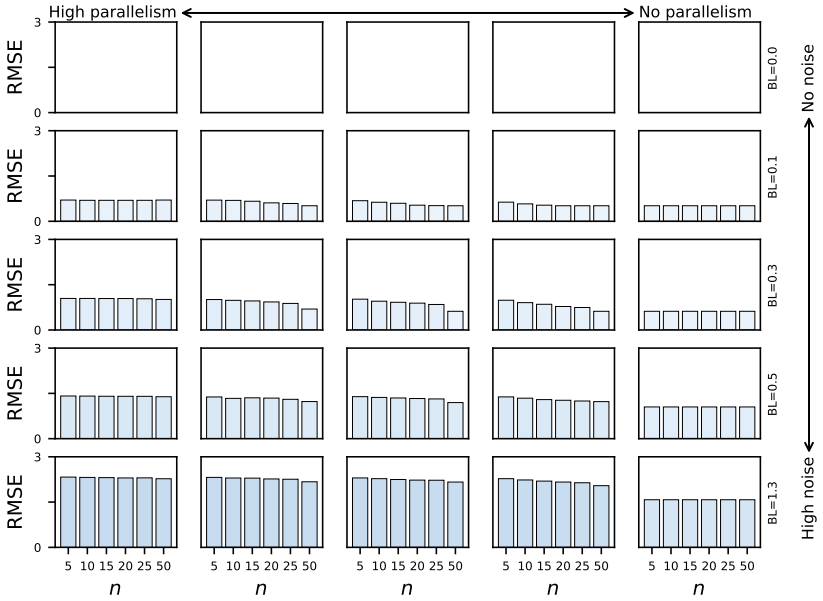
Figure 10: RMSE for *a22* event logs with different decision skewness and noise levels with PMc as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The number on the secondary Y-axis is the avg. trace fitness cost over the log by the baseline(BL).



(a) Skewness of decisions level 0

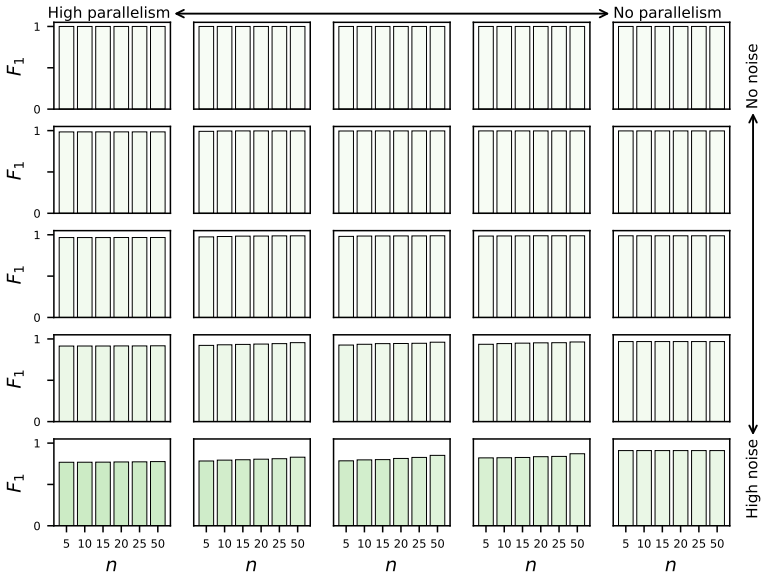


(b) Skewness of decisions level 1

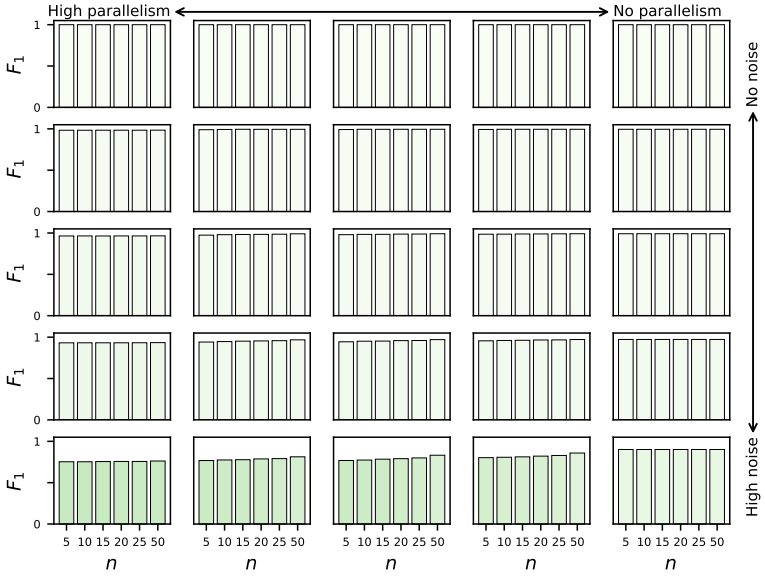


(c) Skewness of decisions level 2

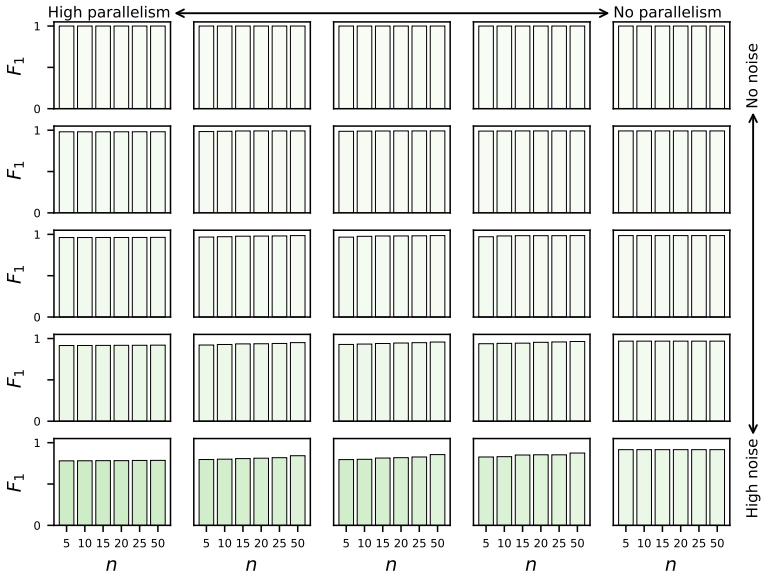
Figure 11: RMSE for $a32$ event logs with different decision skewness and noise levels with PMc as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The number on the secondary Y-axis is the avg. trace fitness cost over the log by the baseline(BL).



(a) Skewness of decisions level 0



(b) Skewness of decisions level 1

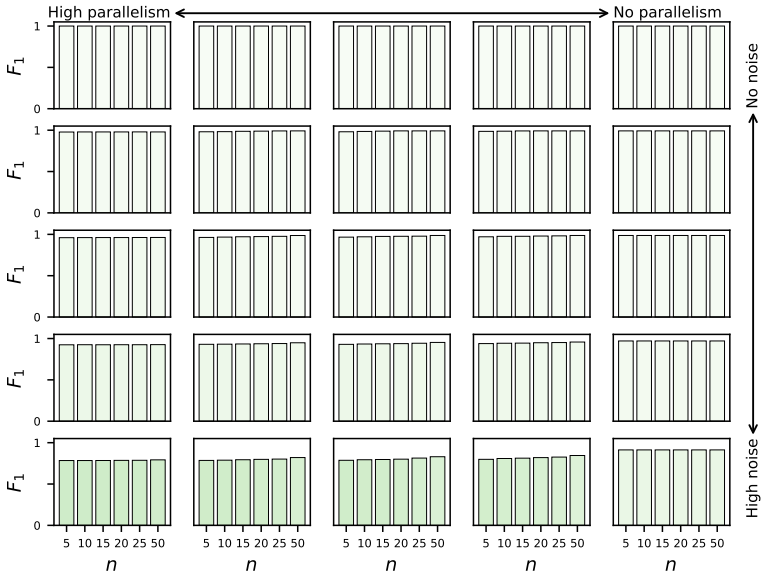


(c) Skewness of decisions level 2

Figure 12: F_1 for $a12$ event logs with different decision skewness and noise levels with PMc as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values.

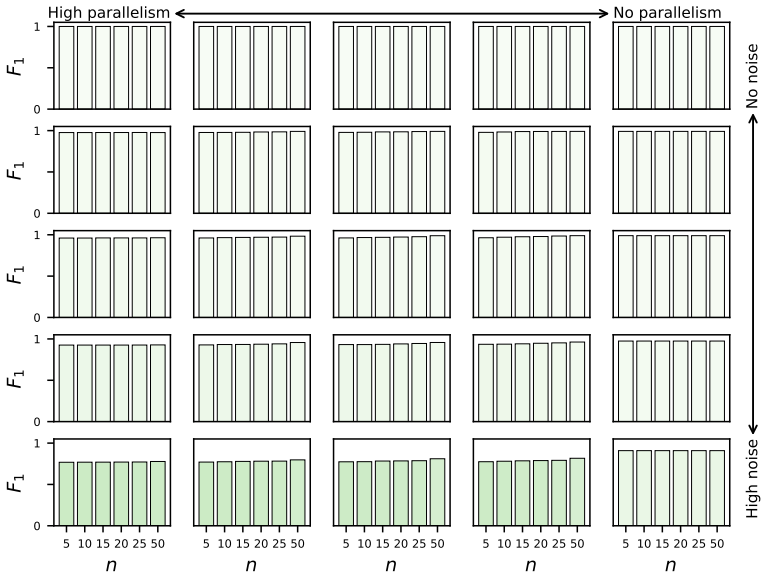
(a) Skewness of decisions level 0

(b) Skewness of decisions level 1



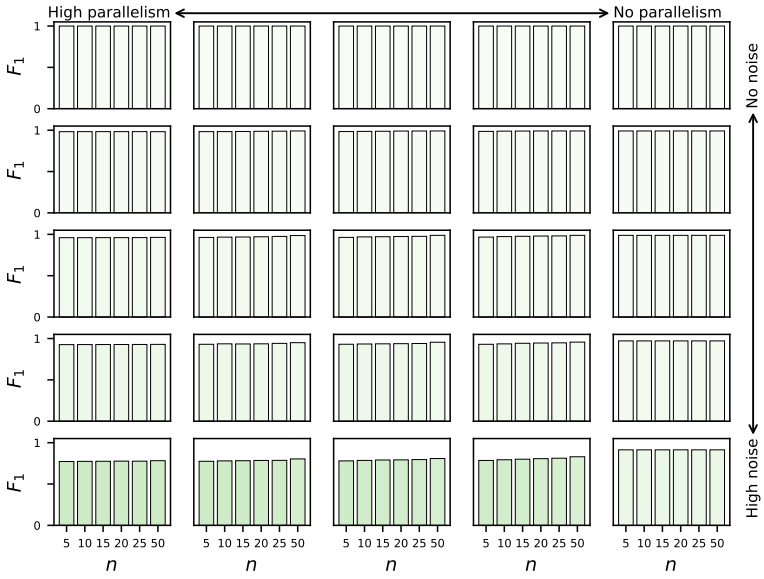
(c) Skewness of decisions level 2

Figure 13: F_1 for $a22$ event logs with different decision skewness and noise levels with PMc as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values.



(a) Skewness of decisions level 0

(b) Skewness of decisions level 1



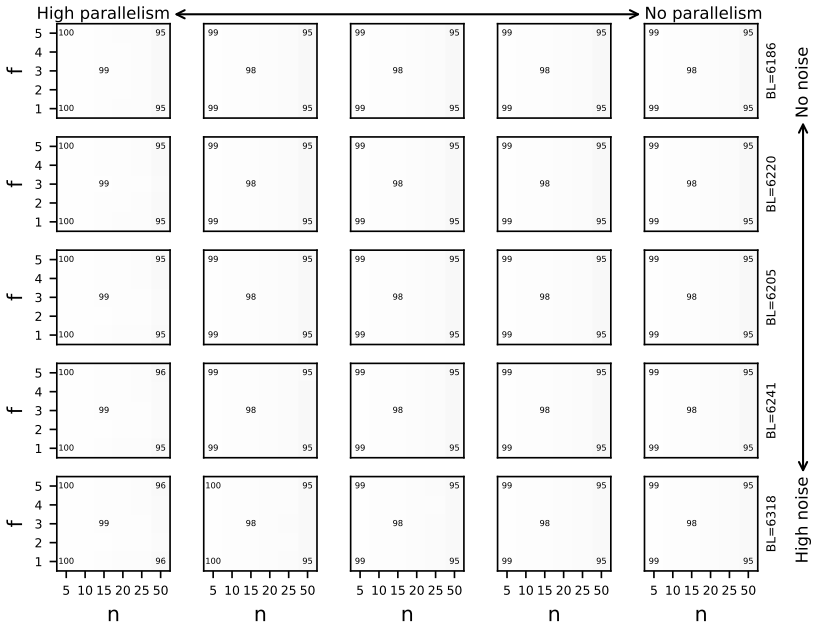
(c) Skewness of decisions level 2

Figure 14: F_1 for $a32$ event logs with different decision skewness and noise levels with PMc as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values.

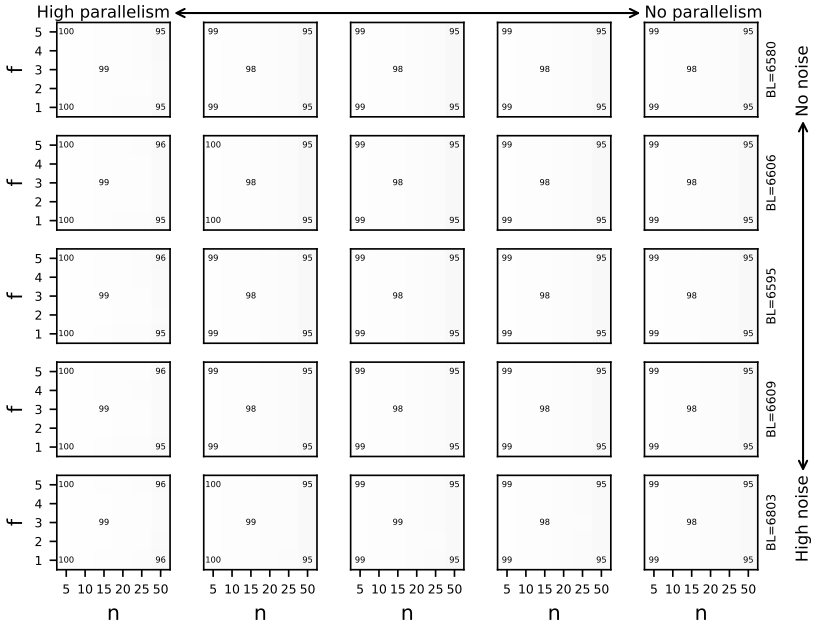
Appendix 3

.1 Machine Learning based Marking Prediction (MLc).

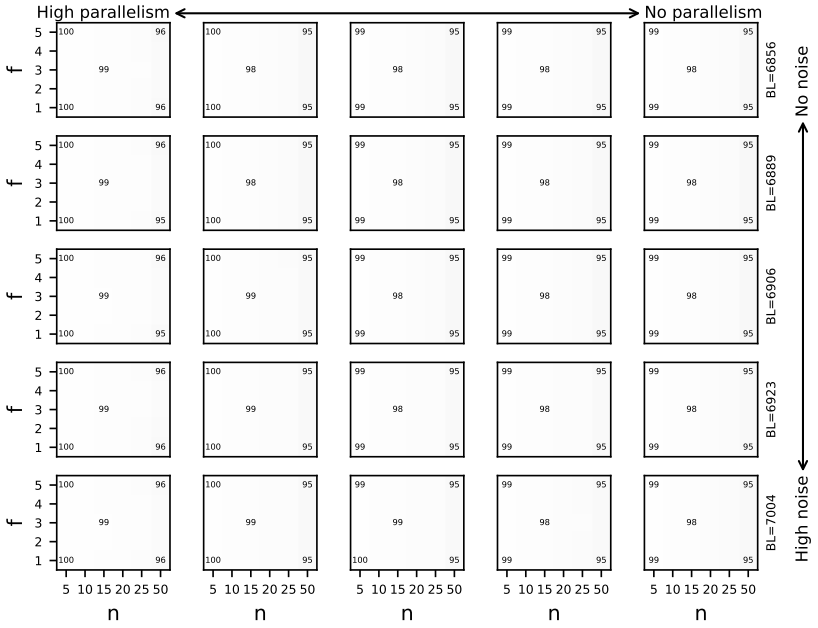
In this section, we provide the complete set of results for the experiments with $a12$, $a22$, and $a32$ synthetic events logs for the MLc stateless approach.



(a) Skewness of decisions level 0

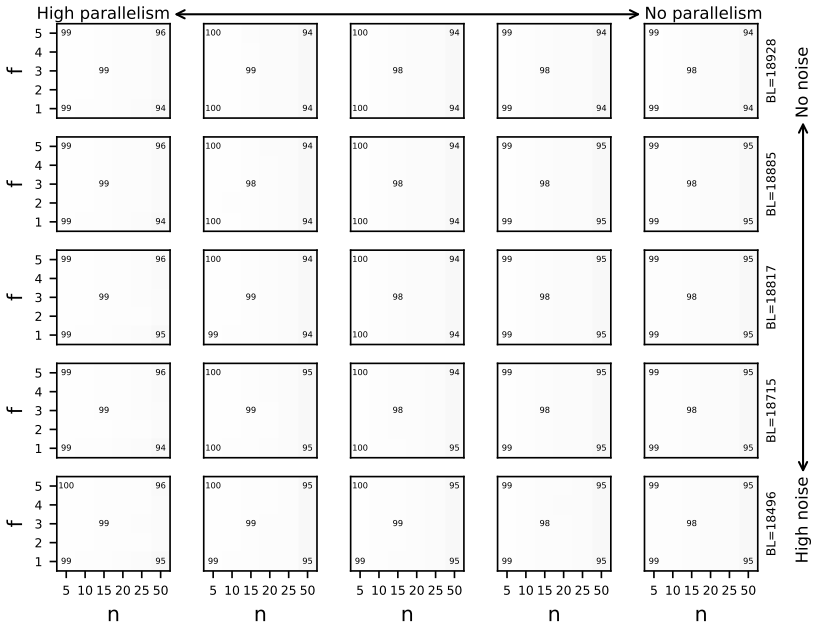


(b) Skewness of decisions level 1

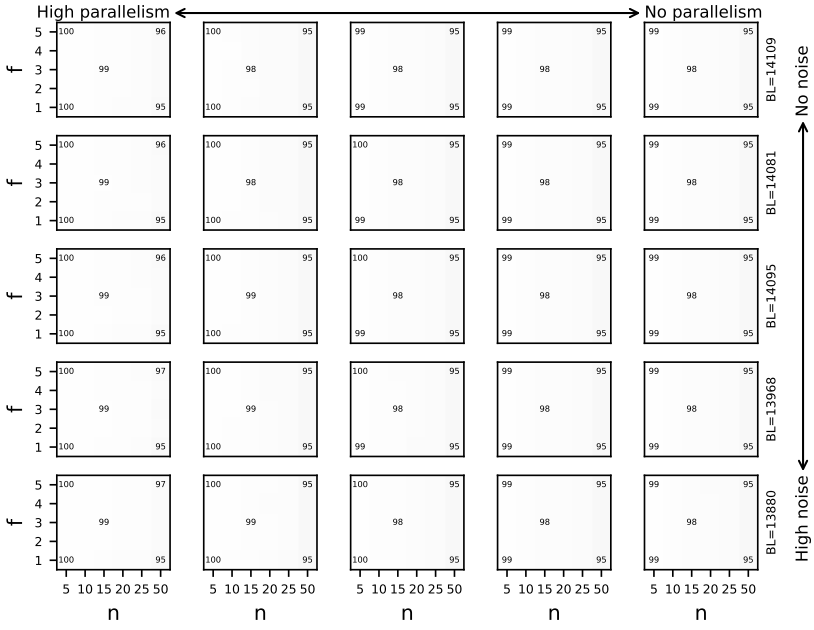


(c) Skewness of decisions level 2

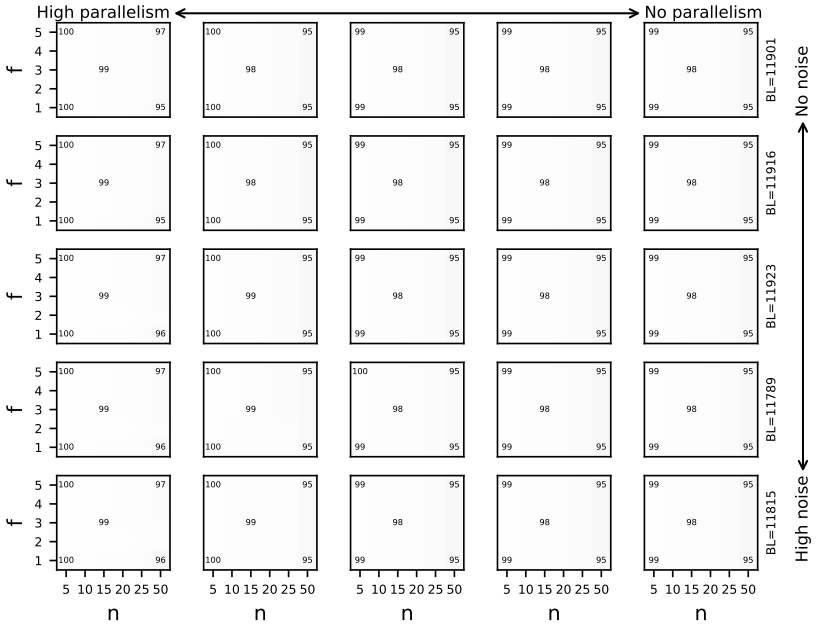
Figure 15: Percentage reduction in memory footprint w.r.t. the baseline (BL) for $a12$ event logs with different skewness of decisions and noise levels with MLc as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The value n on the X-axis is the maximum number of cases allowed to be retained in D_C. The number on the secondary Y-axis is the maximum states consumed by the baseline (BL).



(a) Skewness of decisions level 0

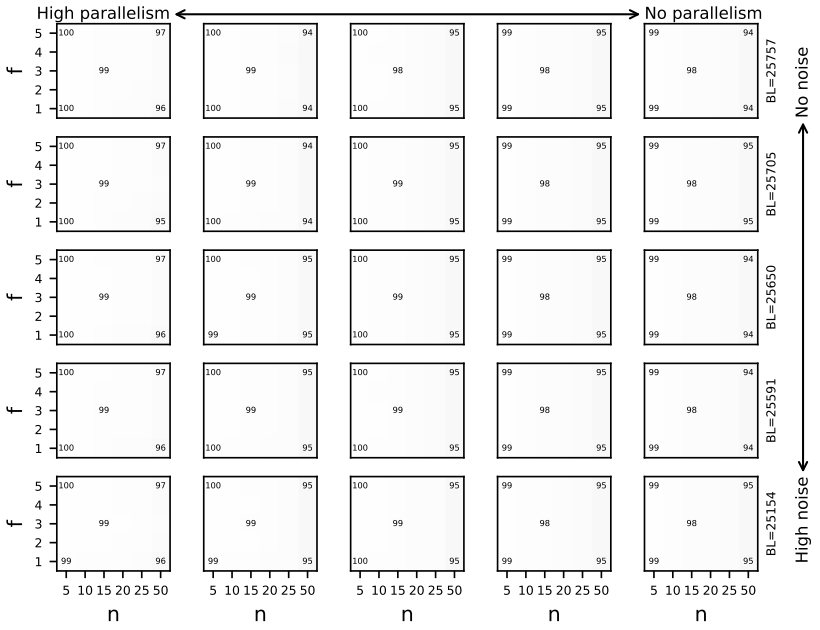


(b) Skewness of decisions level 1

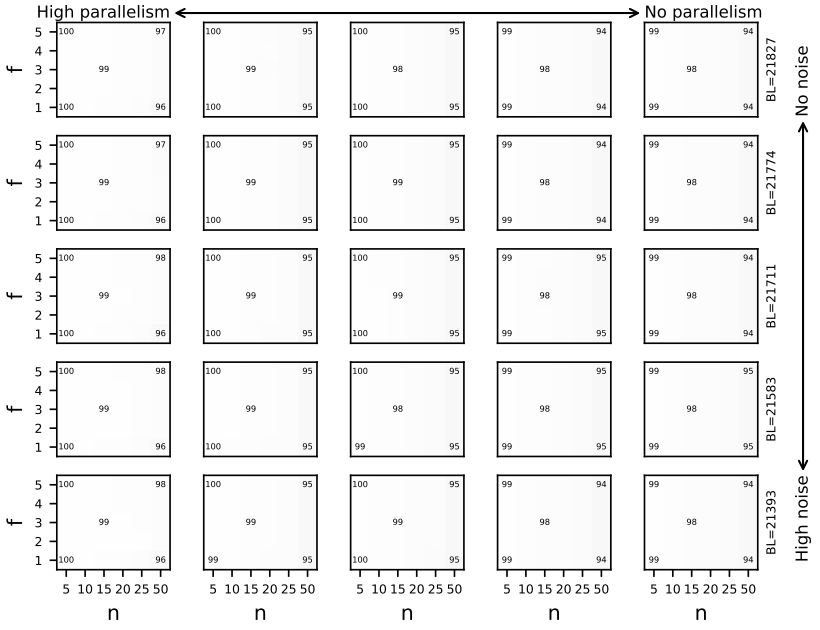


(c) Skewness of decisions level 2

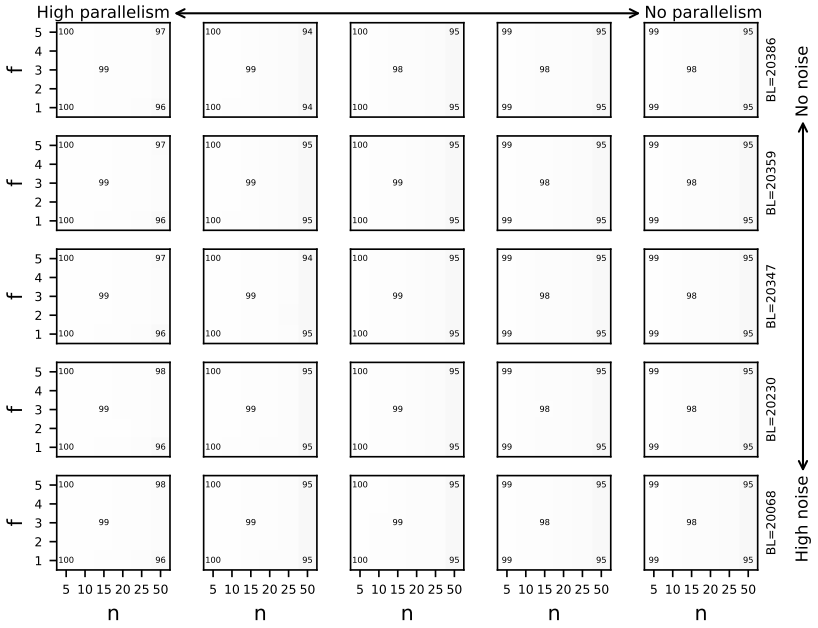
Figure 16: Percentage reduction in memory footprint w.r.t. the baseline (BL) for *a22* event logs with different skewness of decisions and noise levels with MLc as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The value n on the X-axis is the maximum number of cases allowed to be retained in D_C. The number on the secondary Y-axis is the maximum states consumed by the baseline (BL).



(a) Skewness of decisions level 0

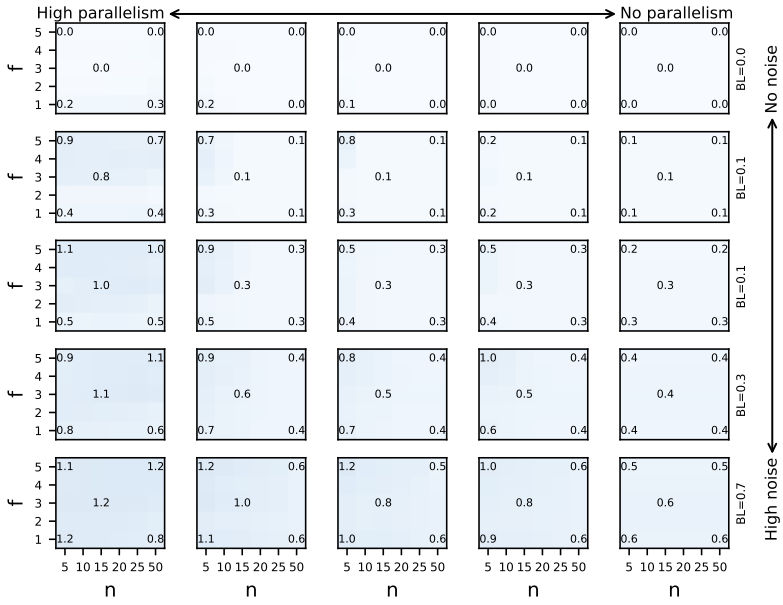


(b) Skewness of decisions level 1

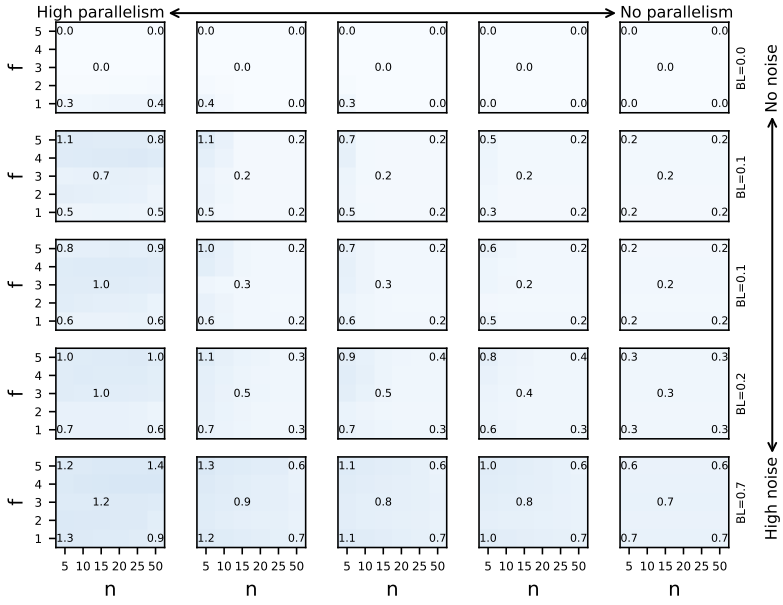


(c) Skewness of decisions level 2

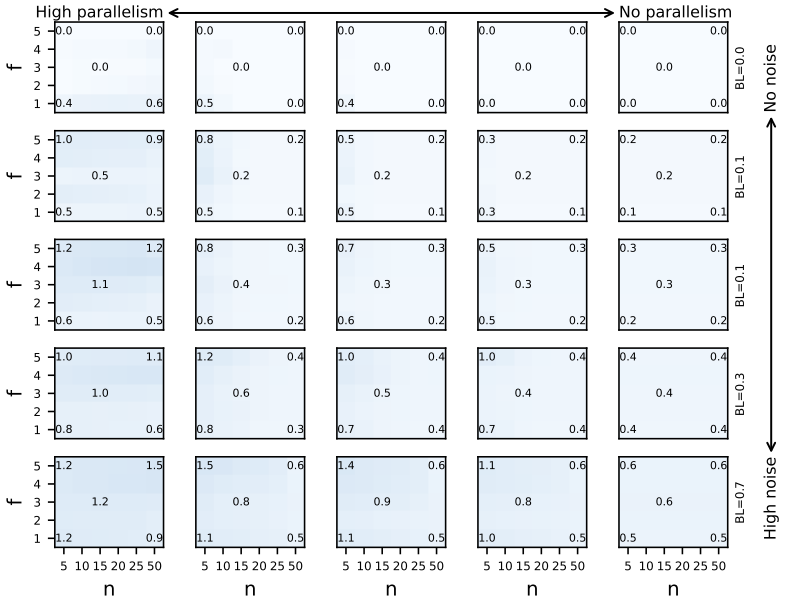
Figure 17: Percentage reduction in memory footprint w.r.t. the baseline (BL) for $a32$ event logs with different skewness of decisions and noise levels with MLc as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The value n on the X-axis is the maximum number of cases allowed to be retained in D_C. The number on the secondary Y-axis is the maximum states consumed by the baseline (BL).



(a) Skewness of decisions level 0

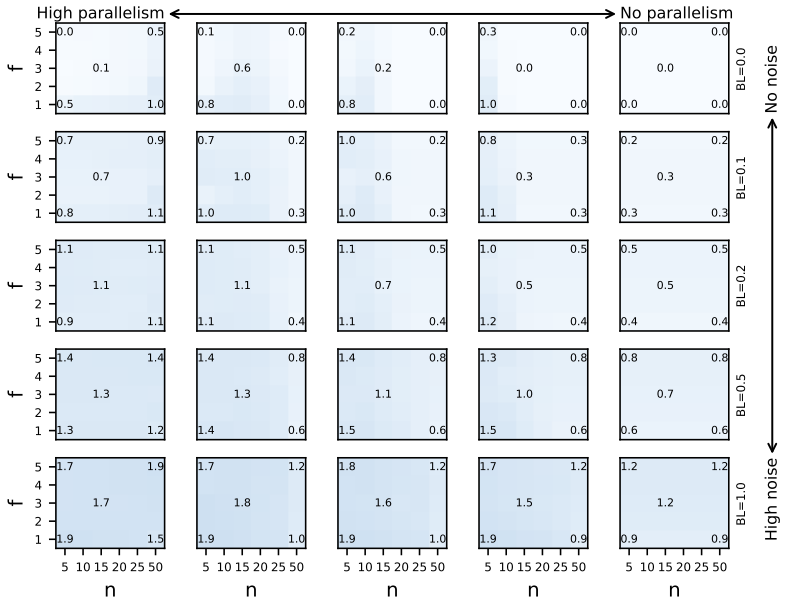


(b) Skewness of decisions level 1

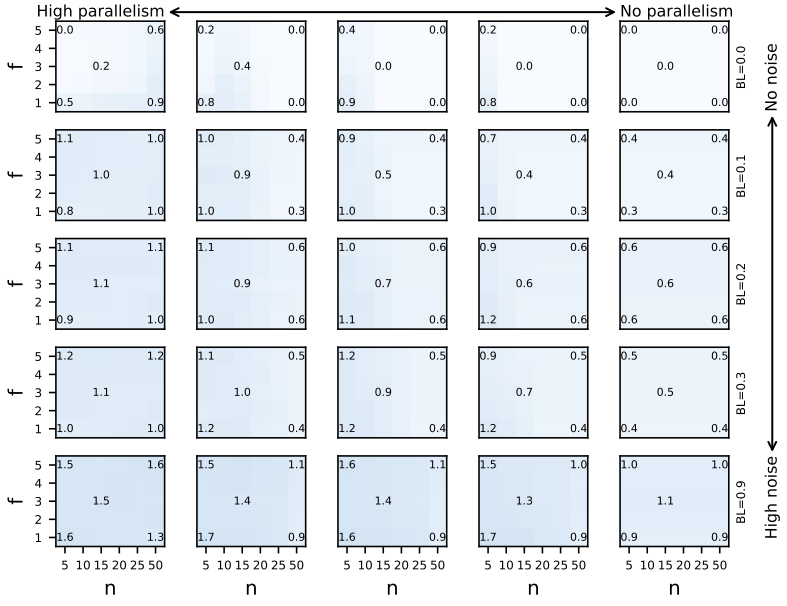


(c) Skewness of decisions level 2

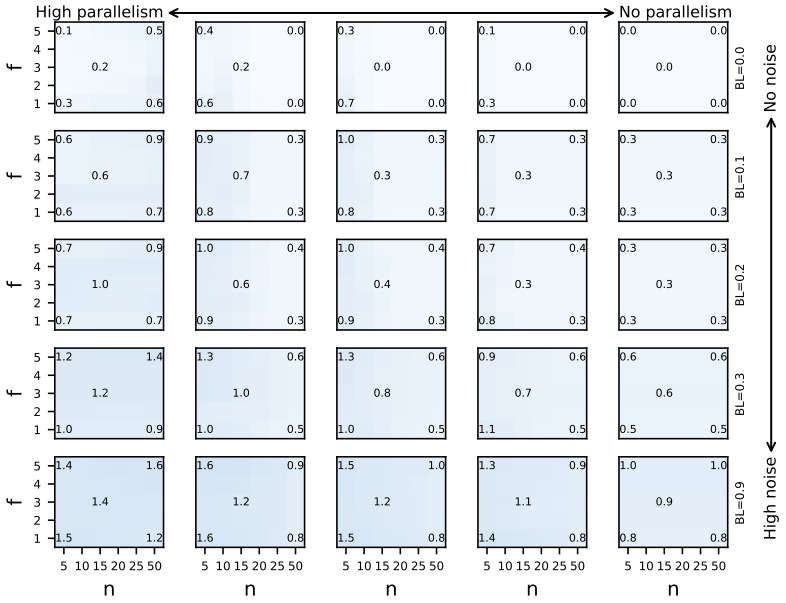
Figure 18: RMSE for *a*12 event logs with different decision skewness and noise levels with *MLc* as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The number on the secondary Y-axis is the avg. trace fitness cost over the log by the baseline(BL).



(a) Skewness of decisions level 0

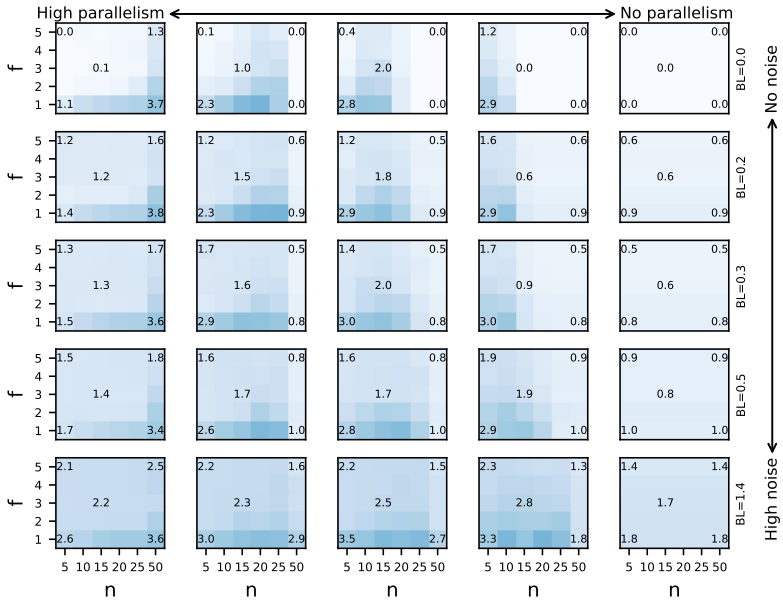


(b) Skewness of decisions level 1

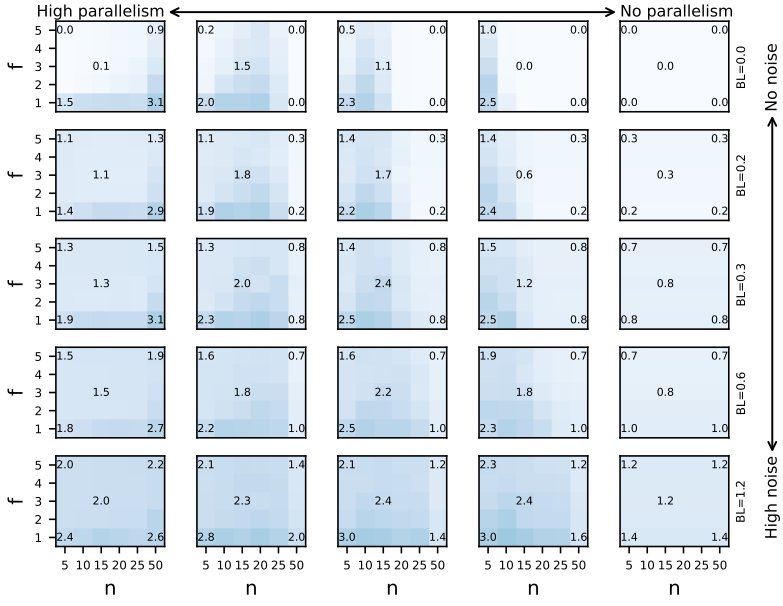


(c) Skewness of decisions level 2

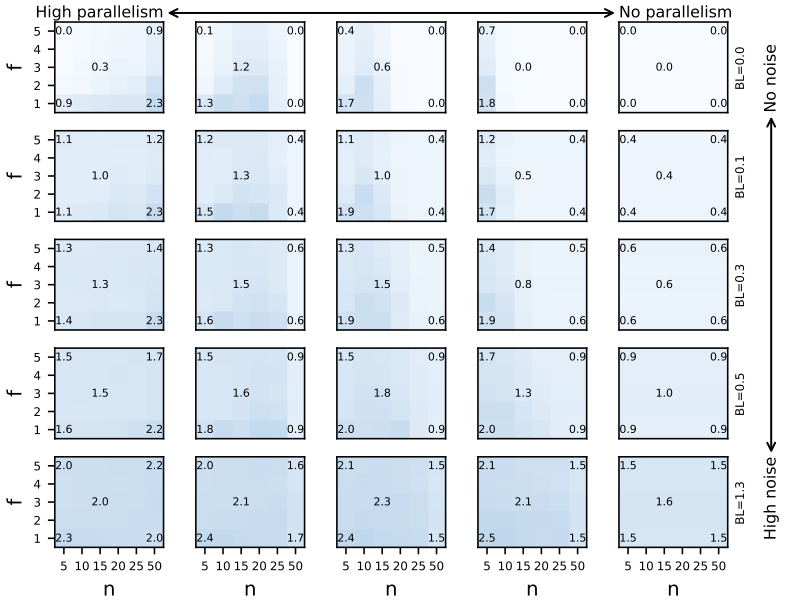
Figure 19: RMSE for *a*22 event logs with different decision skewness and noise levels with *MLc* as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The number on the secondary Y-axis is the avg. trace fitness cost over the log by the baseline(BL).



(a) Skewness of decisions level 0

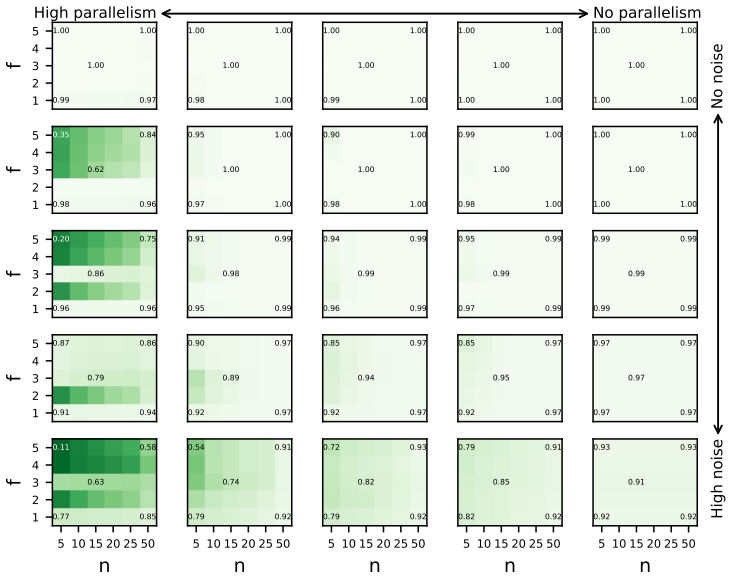


(b) Skewness of decisions level 1

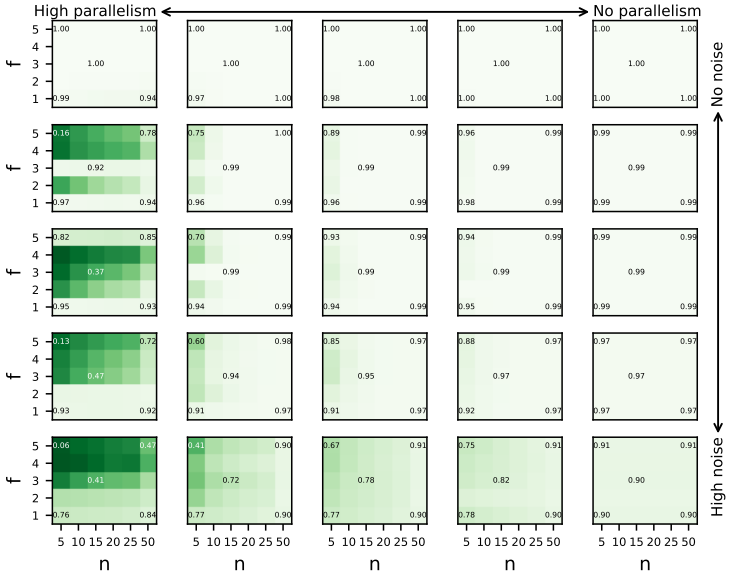


(c) Skewness of decisions level 2

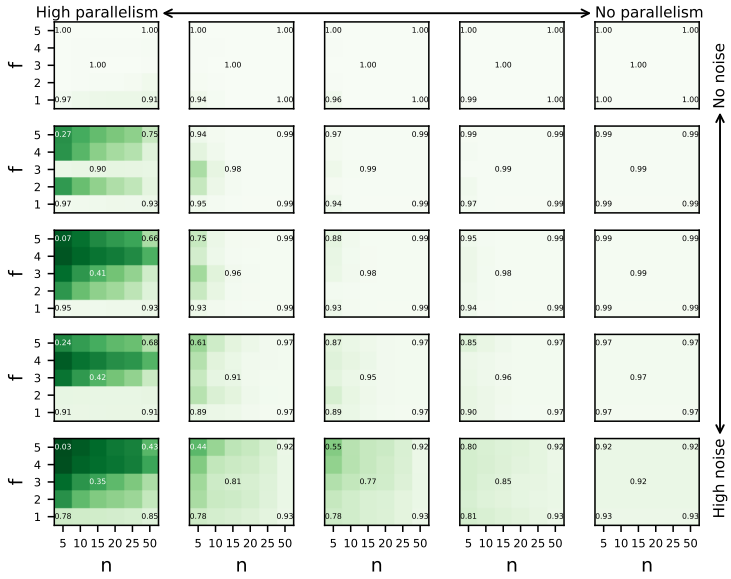
Figure 20: RMSE for *a*32 event logs with different decision skewness and noise levels with *MLc* as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The number on the secondary Y-axis is the avg. trace fitness cost over the log by the baseline(BL).



(a) Skewness of decisions level 0

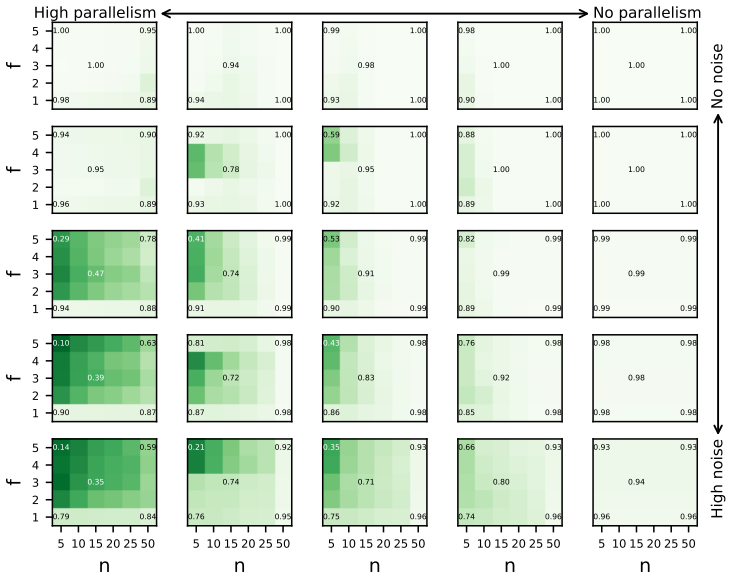


(b) Skewness of decisions level 1

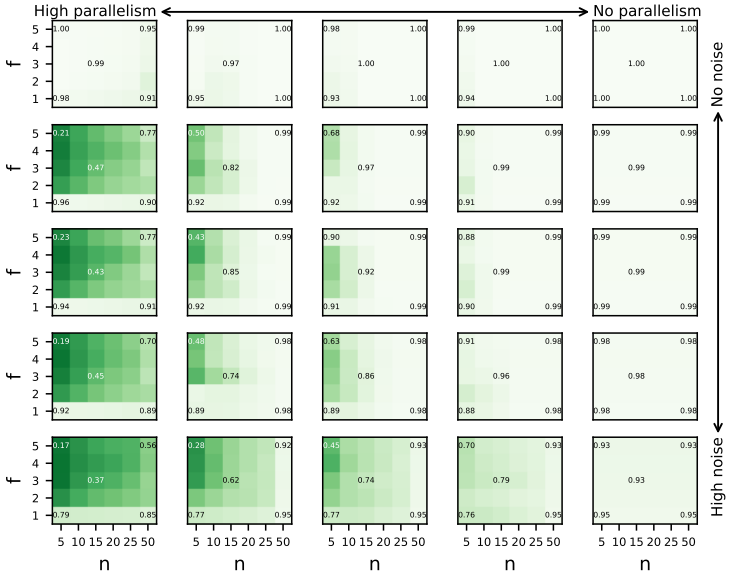


(c) Skewness of decisions level 2

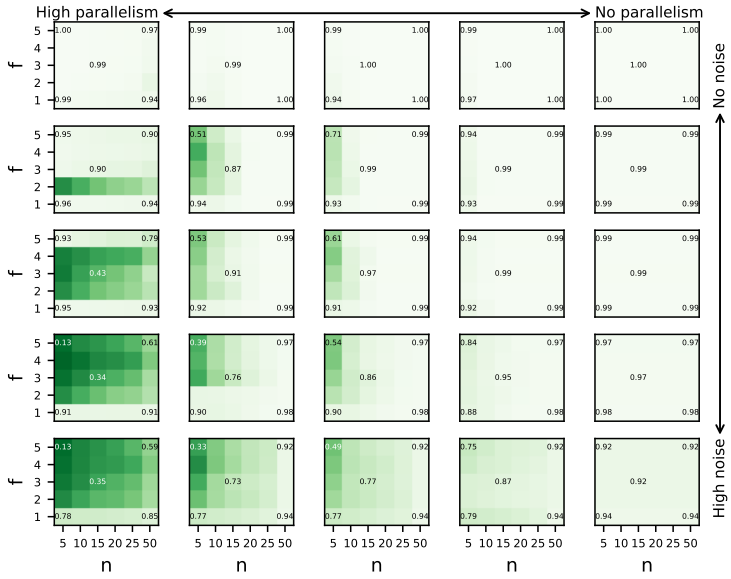
Figure 21: F_1 for $a12$ event logs with different decision skewness and noise levels with MLc as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values.



(a) Skewness of decisions level 0

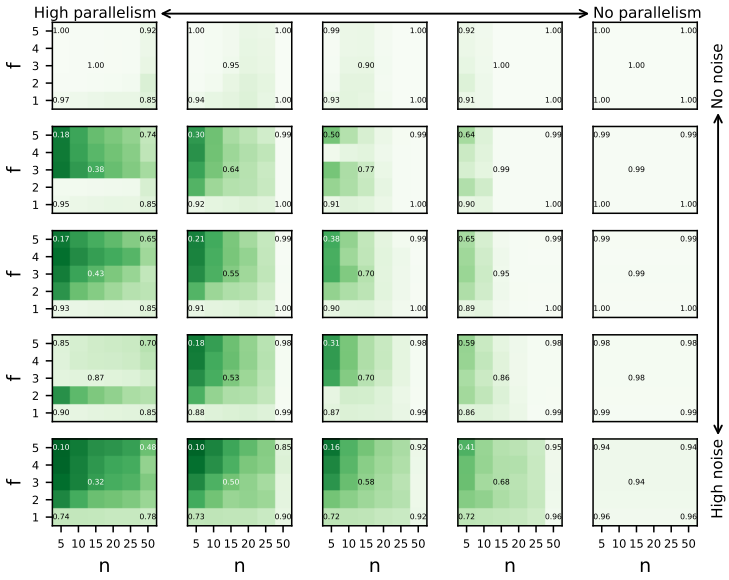


(b) Skewness of decisions level 1

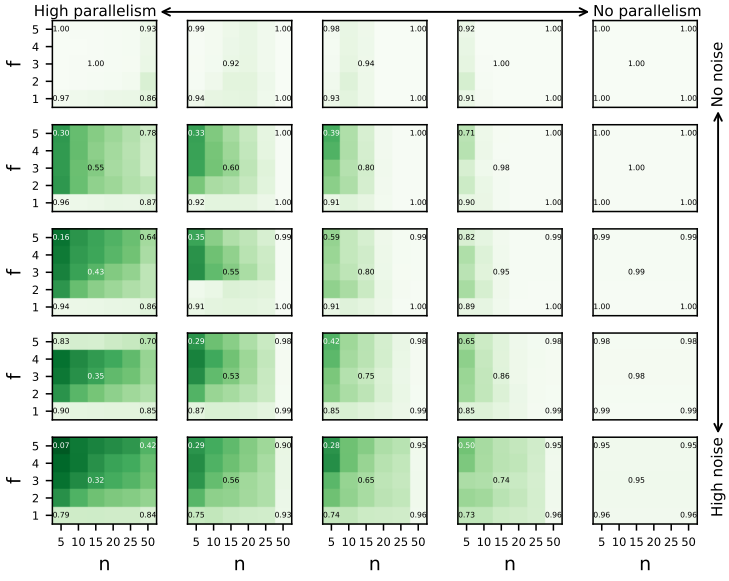


(c) Skewness of decisions level 2

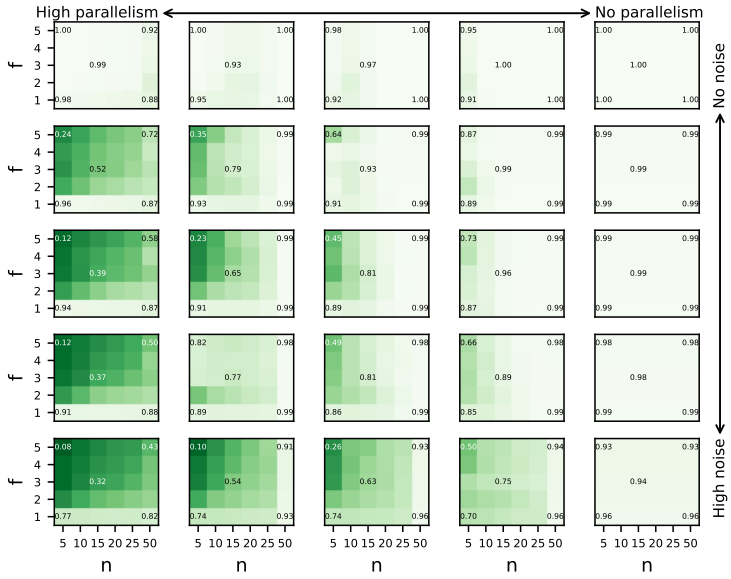
Figure 22: F_1 for $a22$ event logs with different decision skewness and noise levels with MLc as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values.



(a) Skewness of decisions level 0



(b) Skewness of decisions level 1



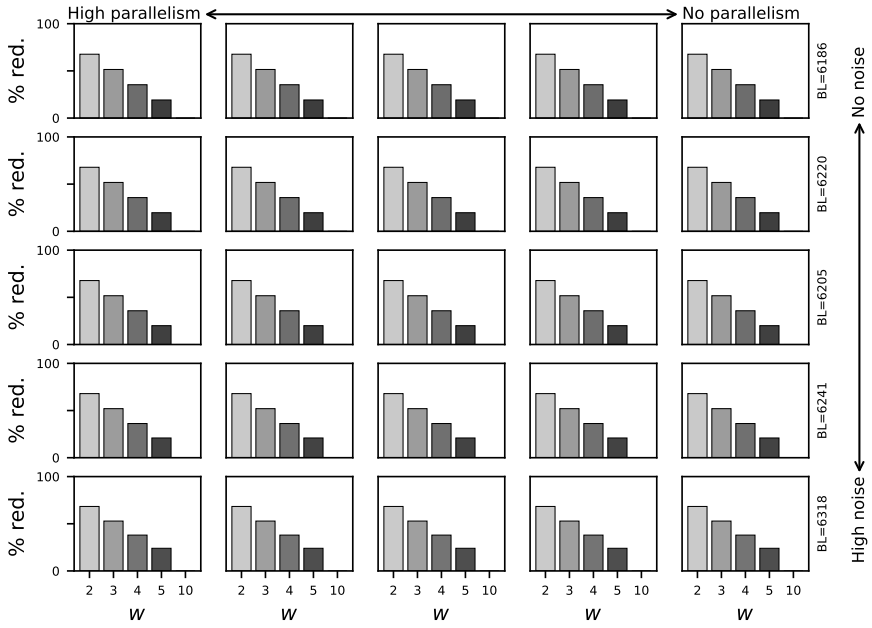
(c) Skewness of decisions level 2

Figure 23: F_1 for $a32$ event logs with different decision skewness and noise levels with MLc as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values.

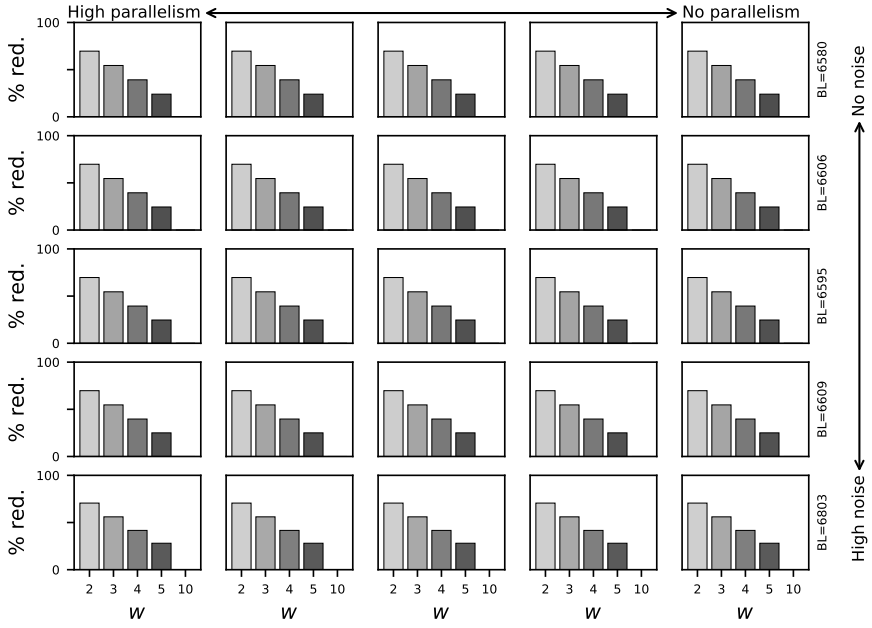
Appendix 4

.1 Bounding States with Carry-forward Marking and Cost(CFs).

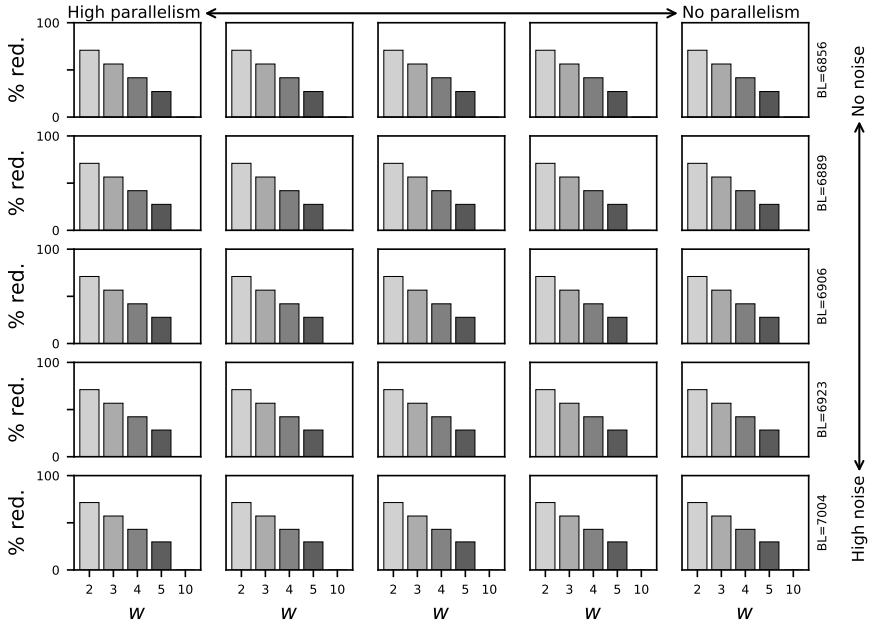
In this section, we provide the complete set of results for the experiments with $a12$, $a22$, and $a32$ synthetic events logs for the CFs stateful approach.



(a) Skewness of decisions level 0

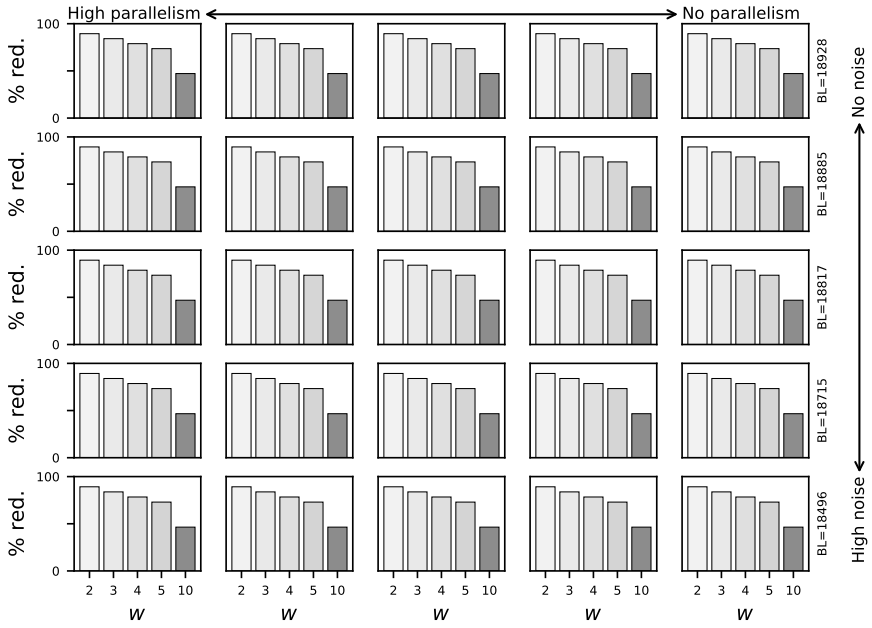


(b) Skewness of decisions level 1

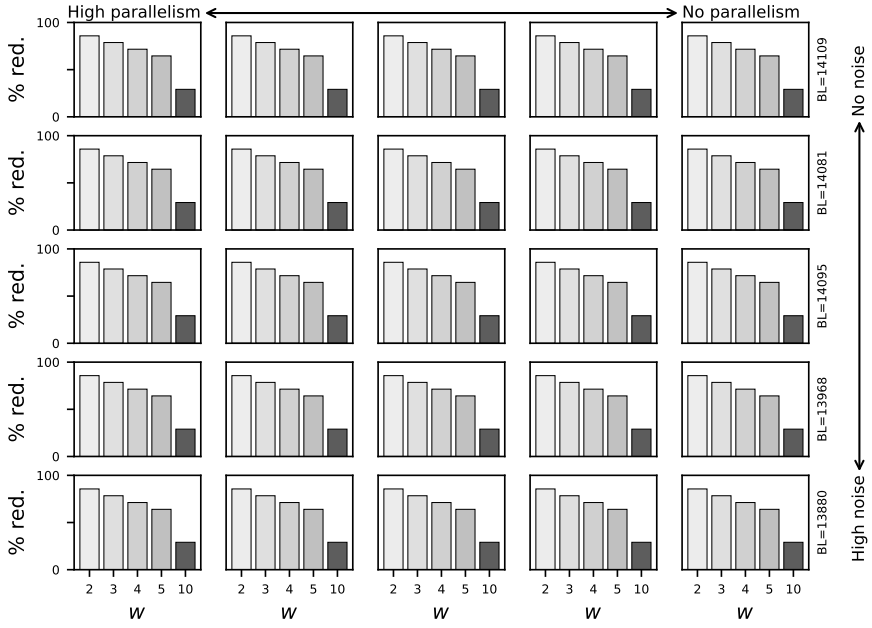


(c) Skewness of decisions level 2

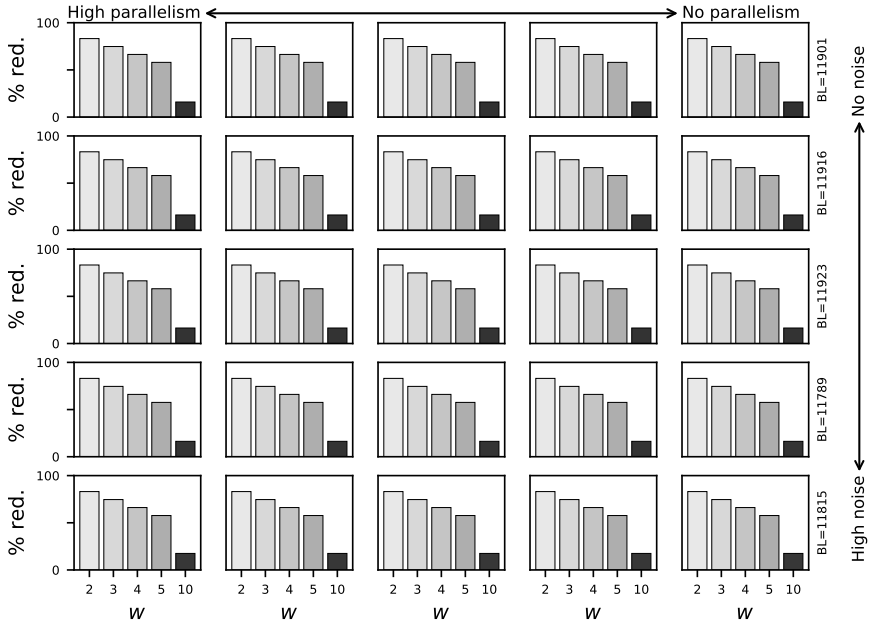
Figure 24: Percentage reduction in memory footprint w.r.t. the baseline (BL) for $a12$ event logs with different skewness of decisions and noise levels with CFs as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The value w on the X-axis is the maximum number of states allowed to be retained in D_C. The number on the secondary Y-axis is the maximum states consumed by the baseline (BL).



(a) Skewness of decisions level 0

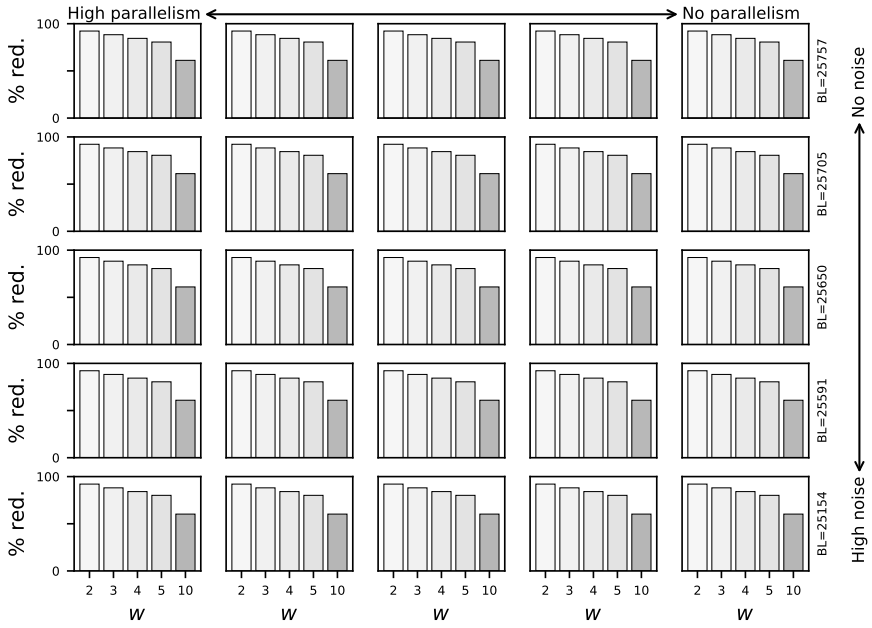


(b) Skewness of decisions level 1

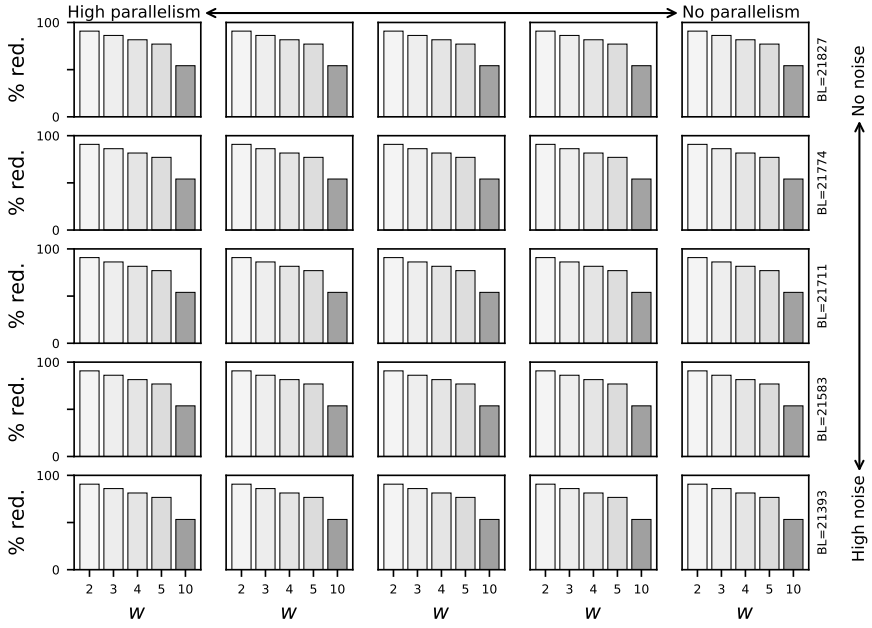


(c) Skewness of decisions level 2

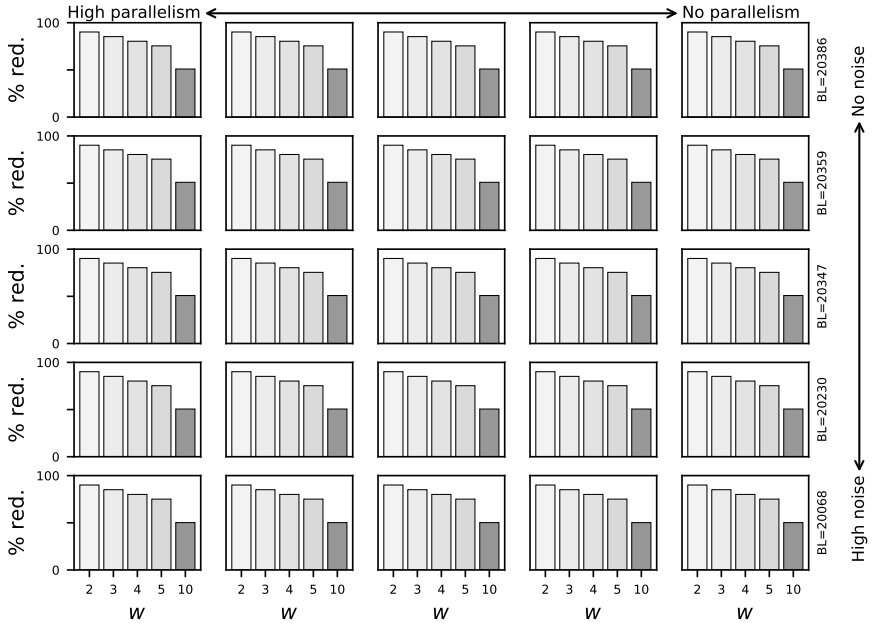
Figure 25: Percentage reduction in memory footprint w.r.t. the baseline (BL) for $a22$ event logs with different skewness of decisions and noise levels with CFs as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The value w on the X-axis is the maximum number of states allowed to be retained in D_C. The number on the secondary Y-axis is the maximum states consumed by the baseline (BL).



(a) Skewness of decisions level 0

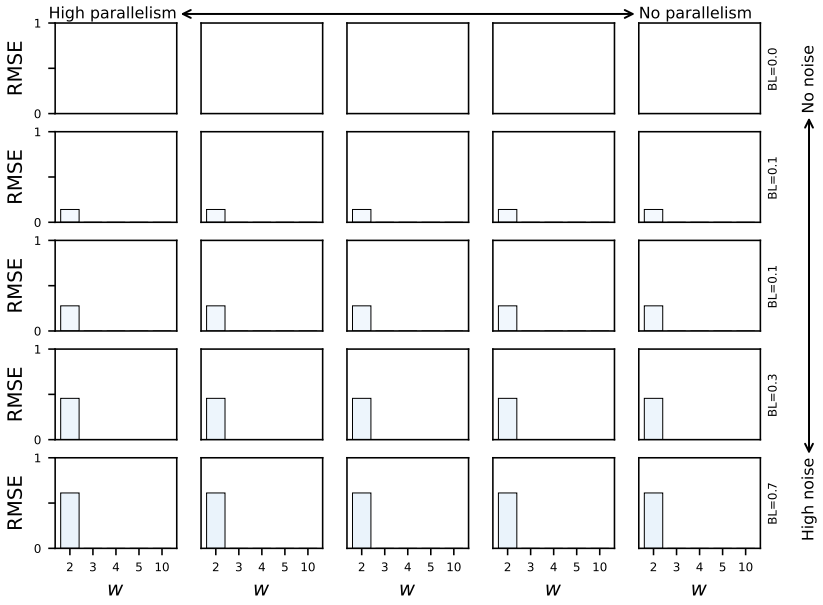


(b) Skewness of decisions level 1

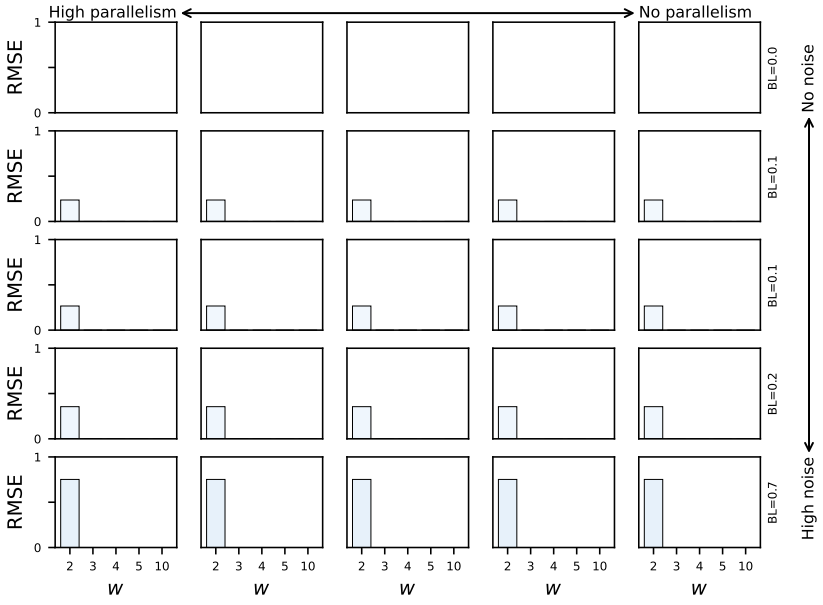


(c) Skewness of decisions level 2

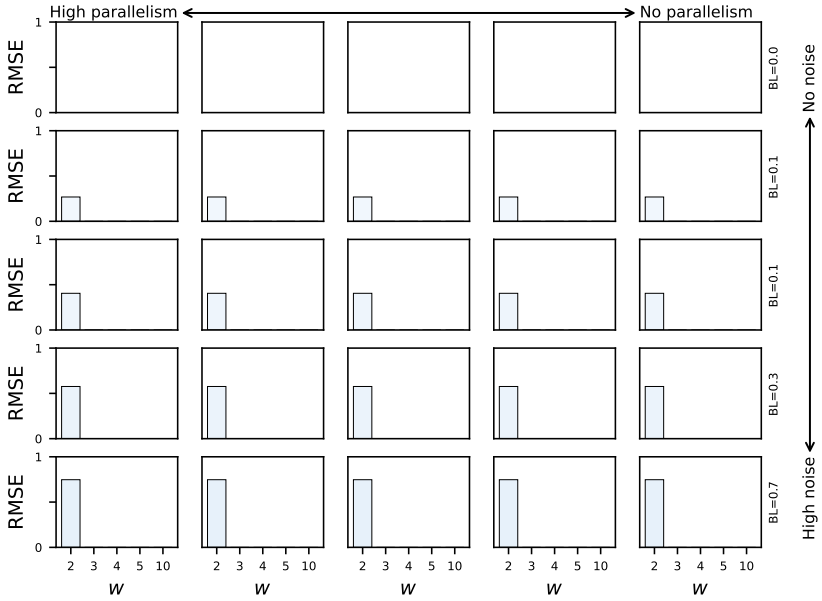
Figure 26: Percentage reduction in memory footprint w.r.t. the baseline (BL) for $a32$ event logs with different skewness of decisions and noise levels with CFs as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The value w on the X-axis is the maximum number of states allowed to be retained in D_C. The number on the secondary Y-axis is the maximum states consumed by the baseline (BL).



(a) Skewness of decisions level 0

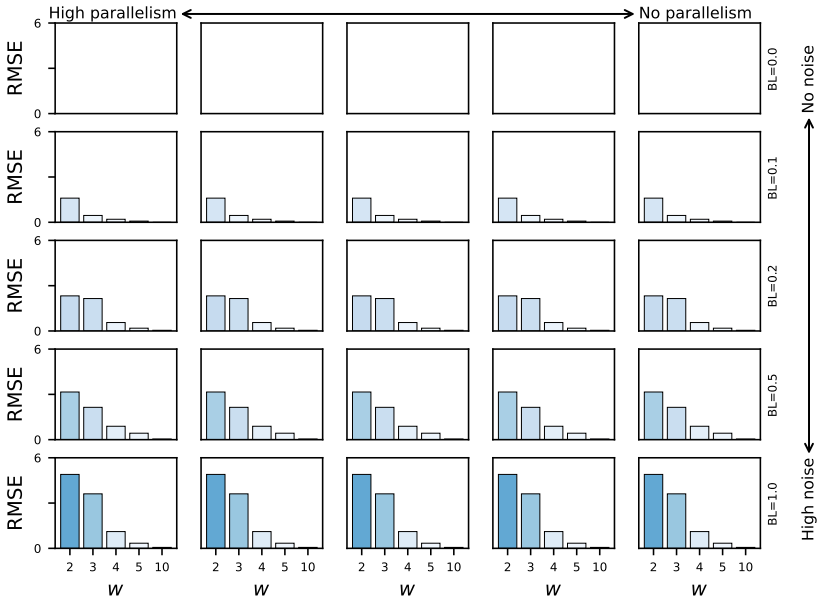


(b) Skewness of decisions level 1

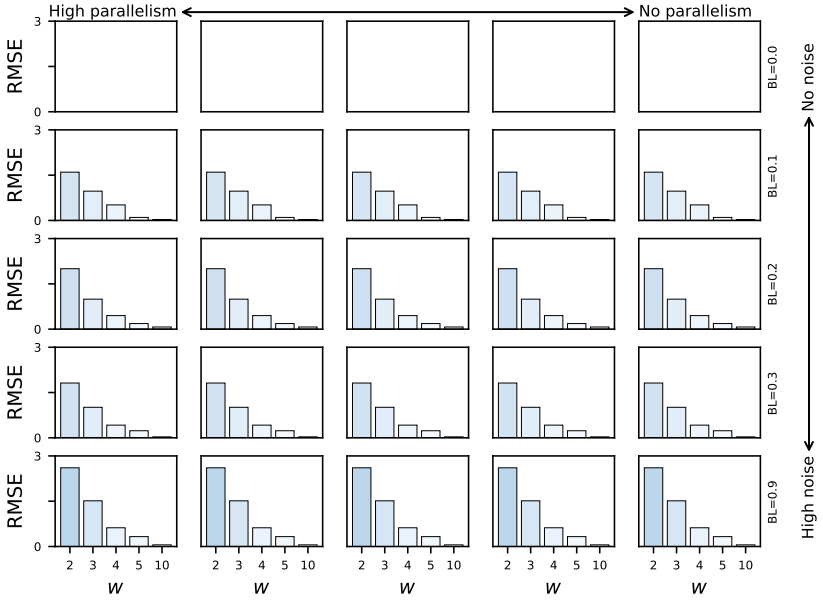


(c) Skewness of decisions level 2

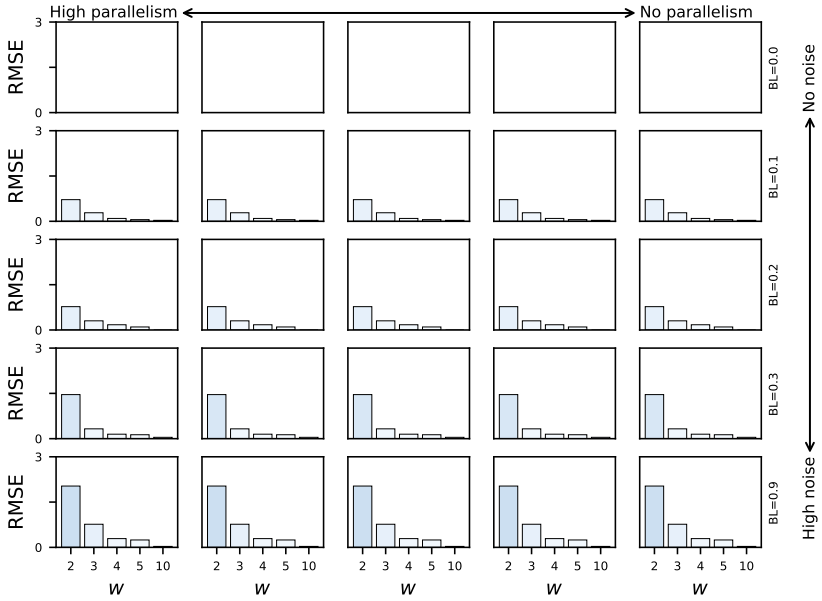
Figure 27: RMSE for $a12$ event logs with different decision skewness and noise levels with CFs as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The number on the secondary Y-axis is the avg. trace fitness cost over the log by the baseline(BL).



(a) Skewness of decisions level 0

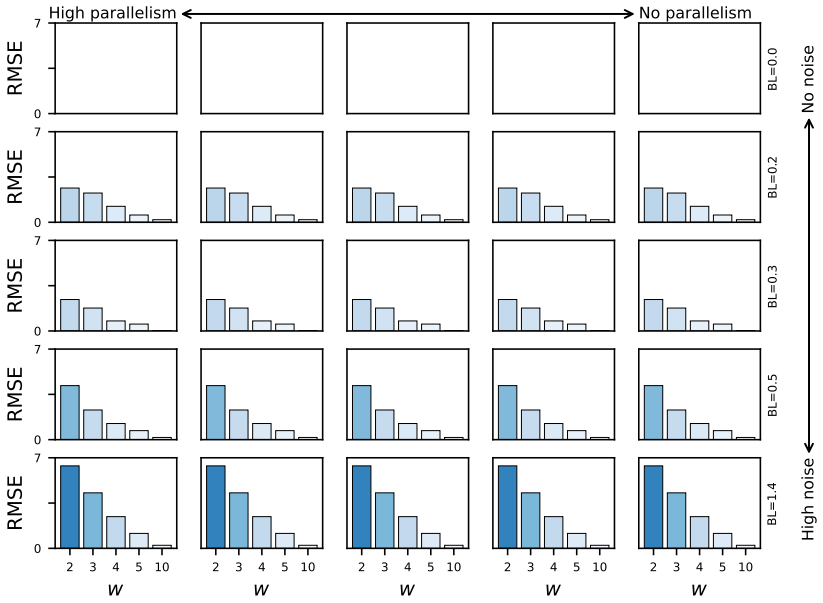


(b) Skewness of decisions level 1

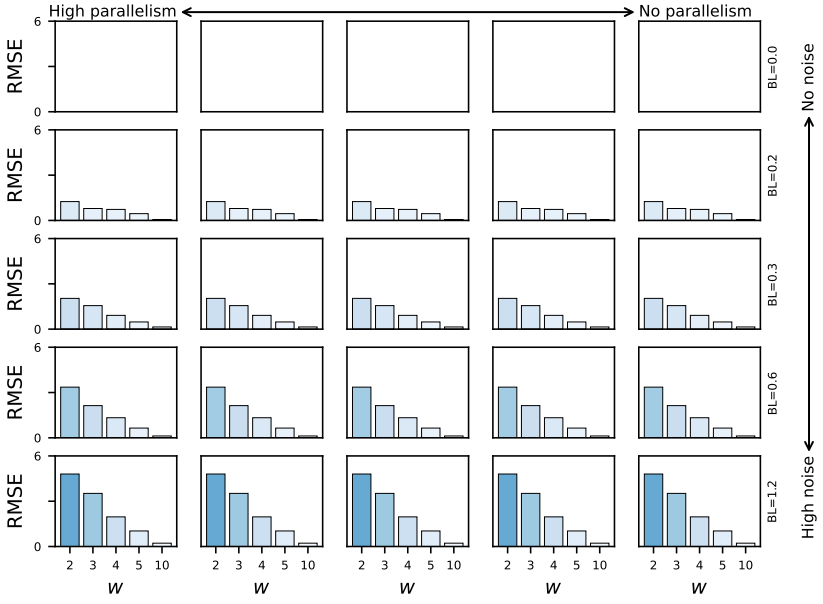


(c) Skewness of decisions level 2

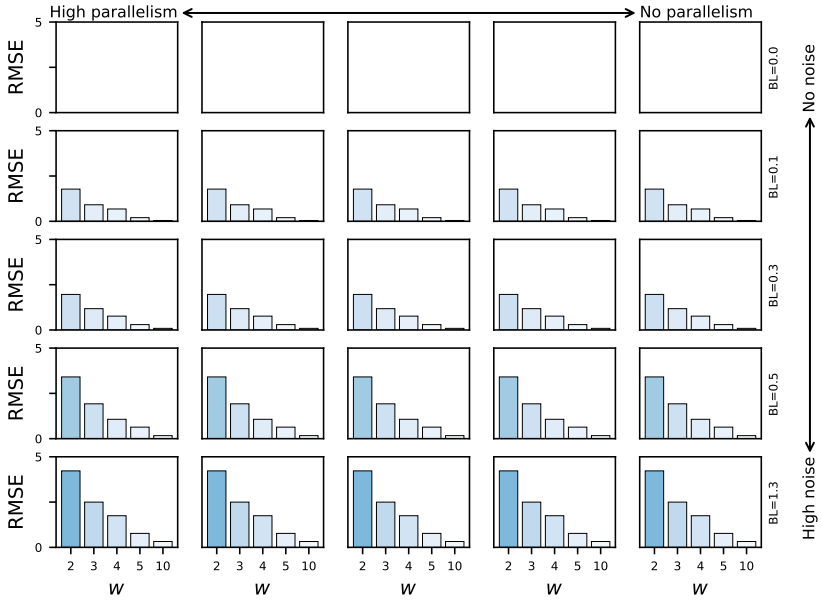
Figure 28: RMSE for $a22$ event logs with different decision skewness and noise levels with CFs as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The number on the secondary Y-axis is the avg. trace fitness cost over the log by the baseline(BL).



(a) Skewness of decisions level 0

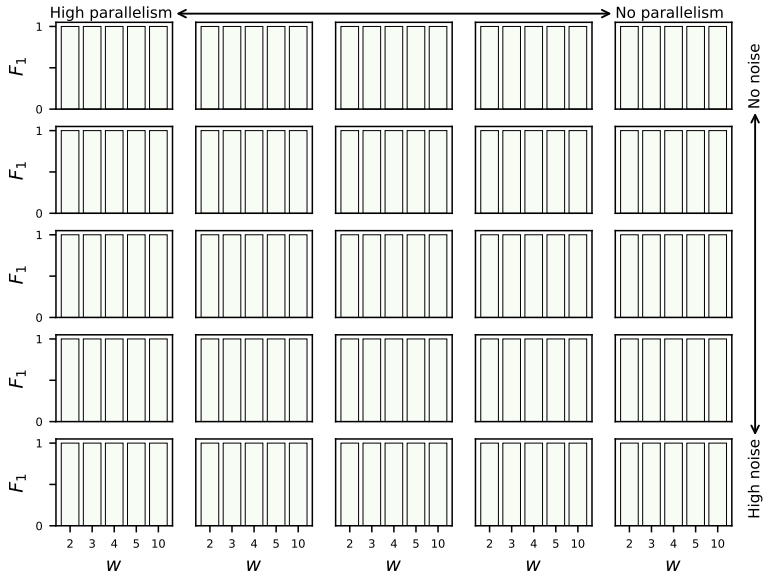


(b) Skewness of decisions level 1

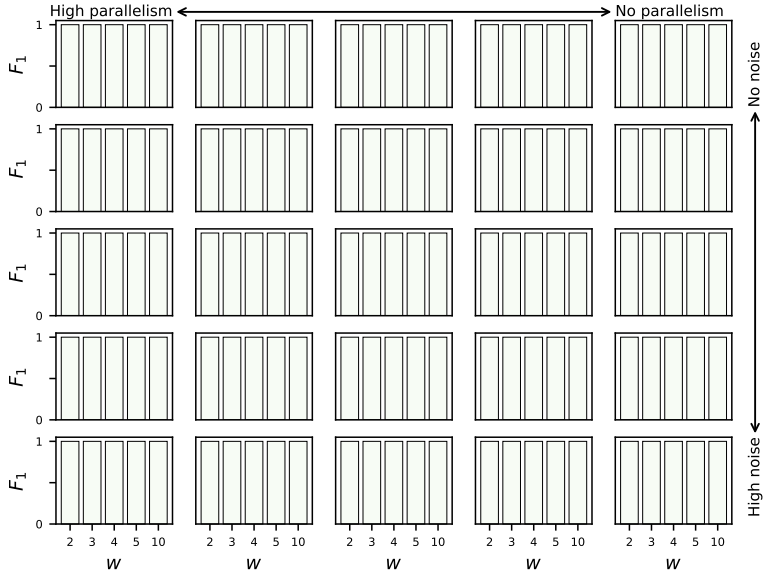


(c) Skewness of decisions level 2

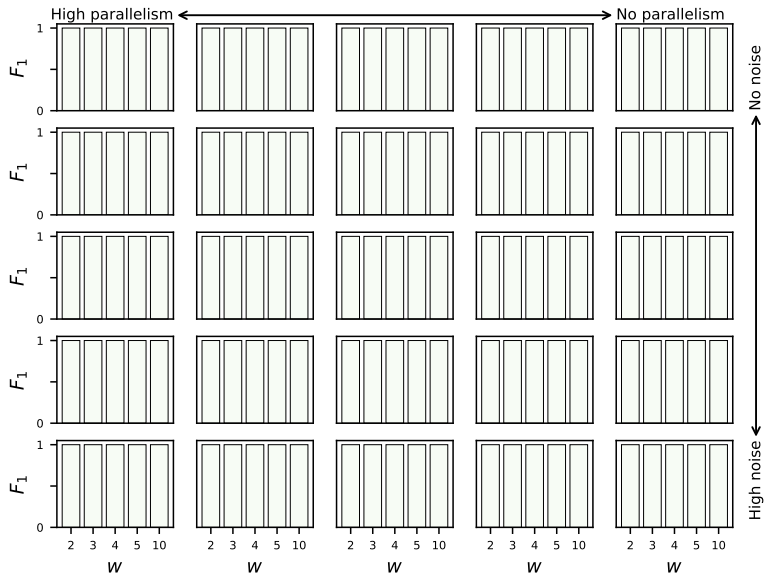
Figure 29: RMSE for $a32$ event logs with different decision skewness and noise levels with CFs as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The number on the secondary Y-axis is the avg. trace fitness cost over the log by the baseline(BL).



(a) Skewness of decisions level 0

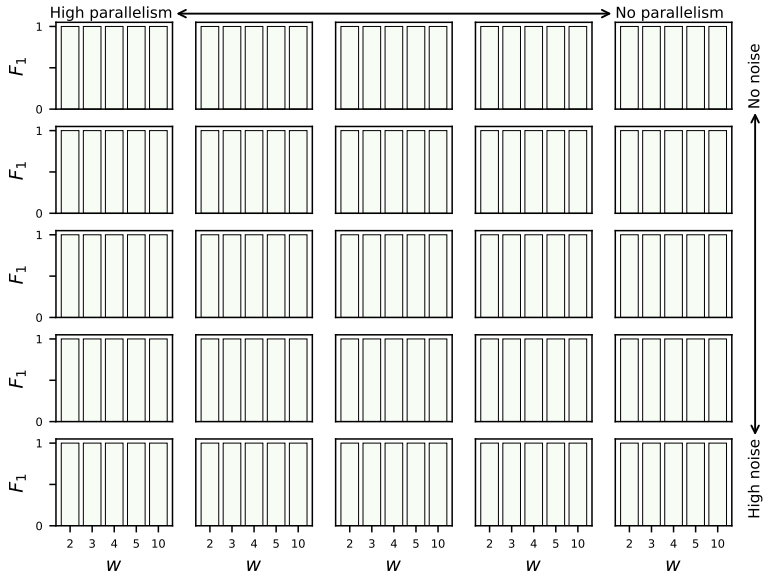


(b) Skewness of decisions level 1

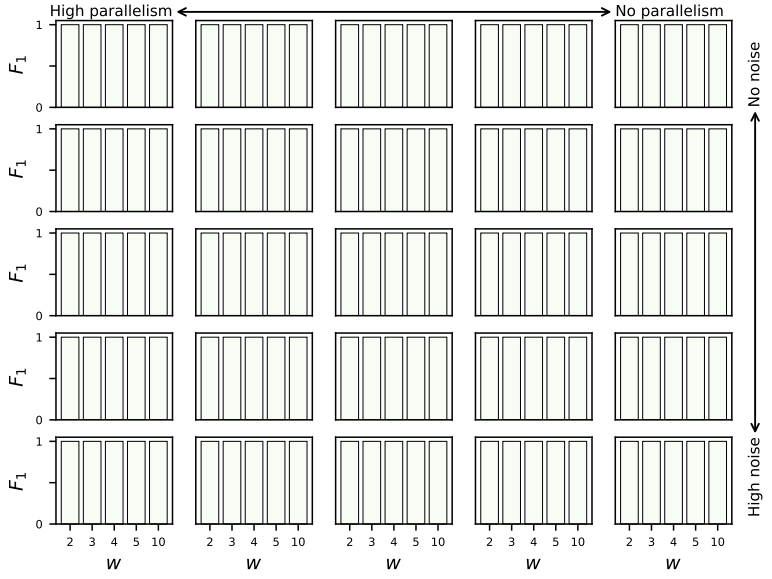


(c) Skewness of decisions level 2

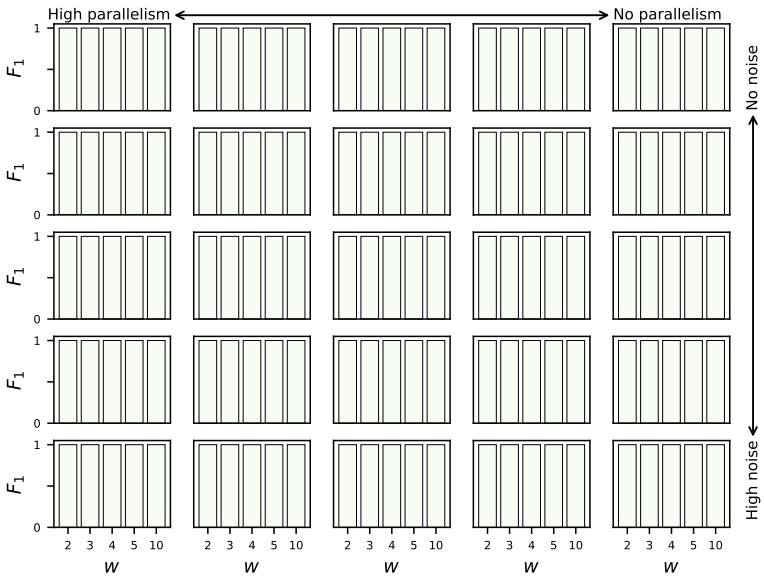
Figure 30: F_1 for $a12$ event logs with different decision skewness and noise levels with CFs as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values.



(a) Skewness of decisions level 0

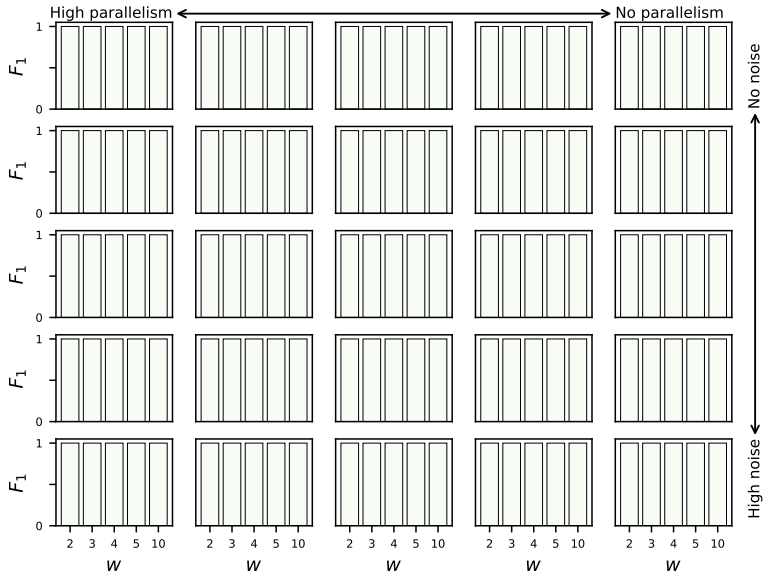


(b) Skewness of decisions level 1

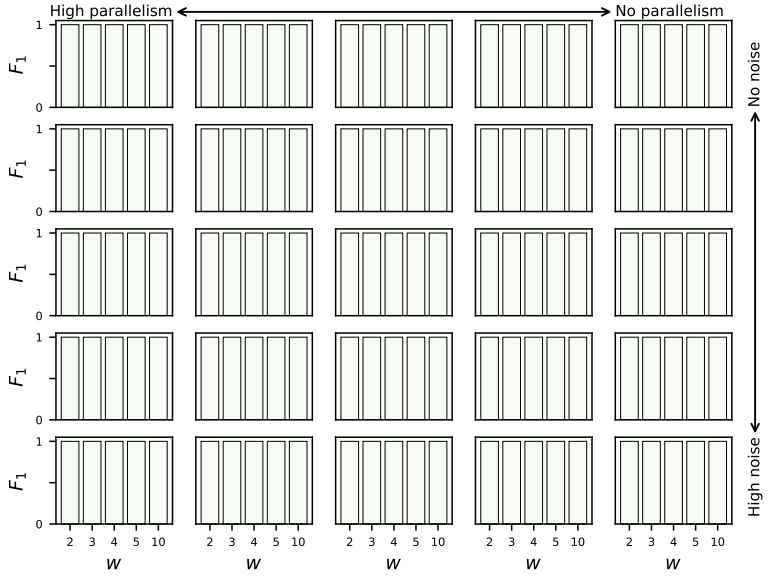


(c) Skewness of decisions level 2

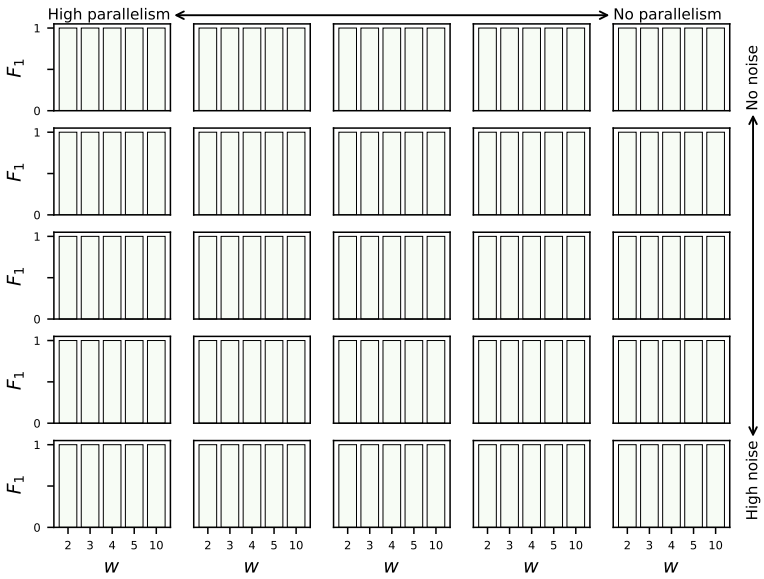
Figure 31: F_1 for $a22$ event logs with different decision skewness and noise levels with CFs as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values.



(a) Skewness of decisions level 0



(b) Skewness of decisions level 1



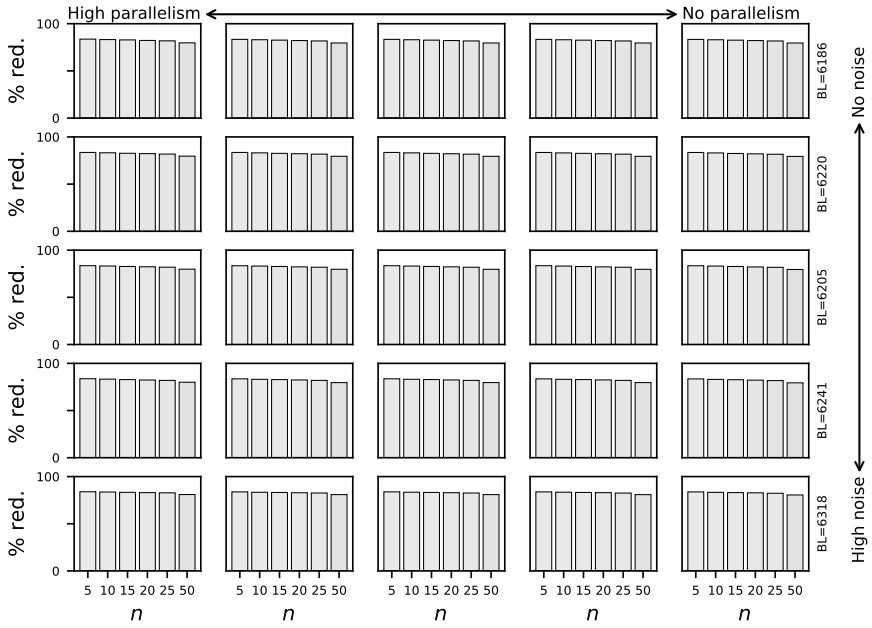
(c) Skewness of decisions level 2

Figure 32: F_1 for $a32$ event logs with different decision skewness and noise levels with CFs as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values.

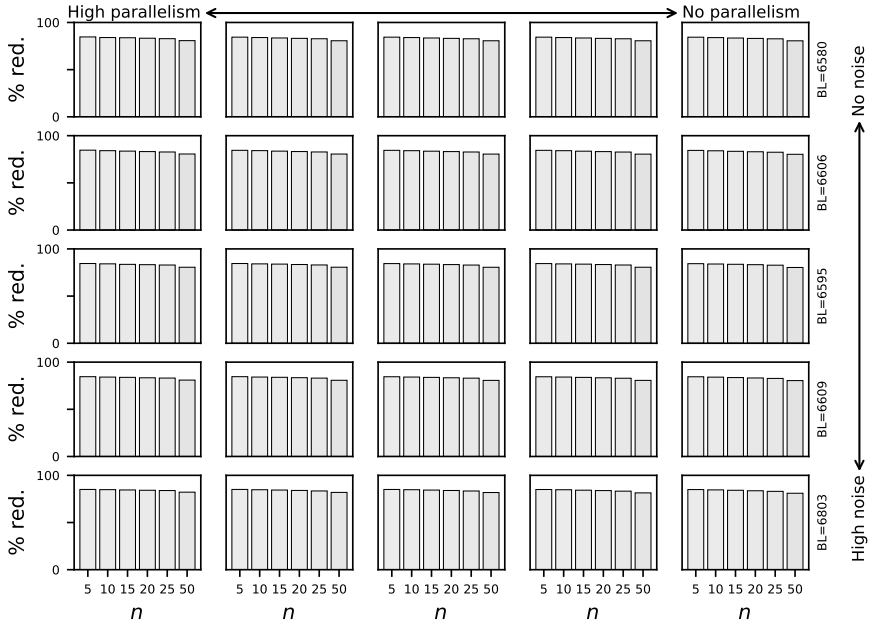
Appendix 5

.1 Bounding Cases with Carry-forward Marking and Cost(CFc).

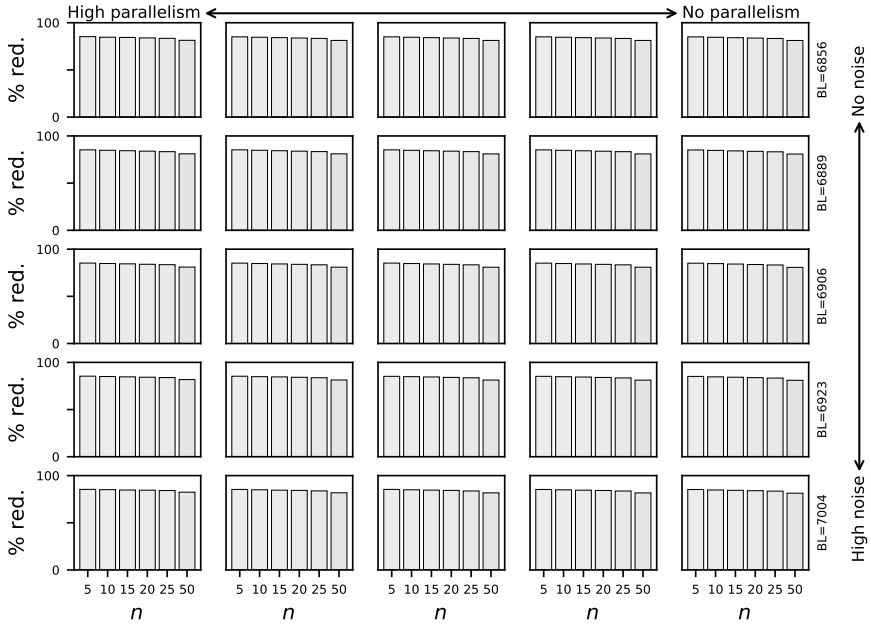
In this section, we provide the complete set of results for the experiments with $a12$, $a22$, and $a32$ synthetic events logs for the CFc stateful approach.



(a) Skewness of decisions level 0

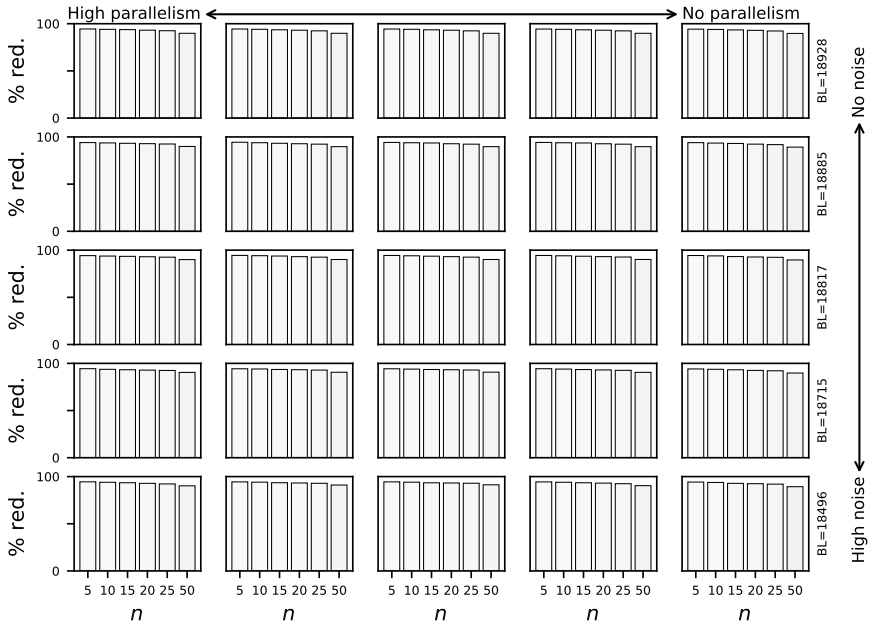


(b) Skewness of decisions level 1

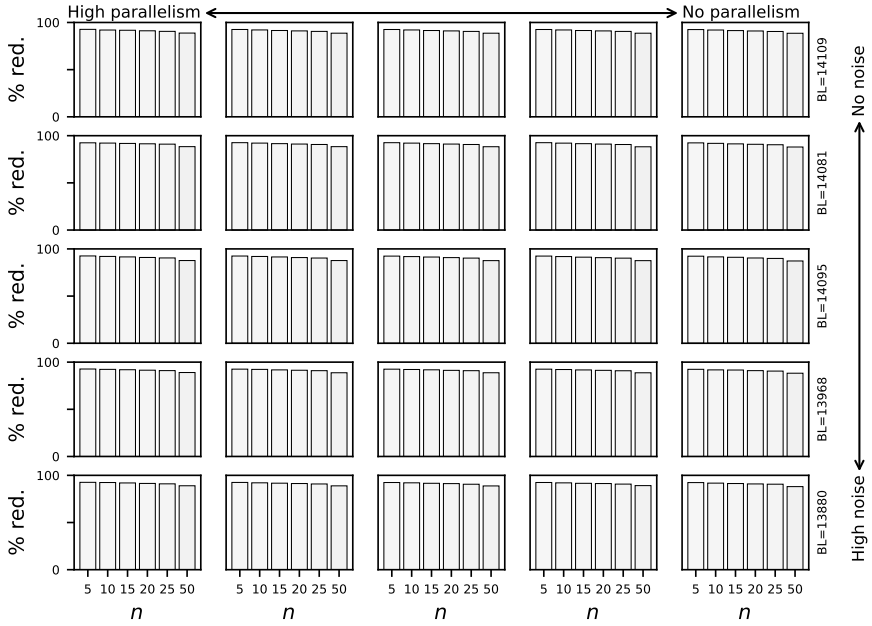


(c) Skewness of decisions level 2

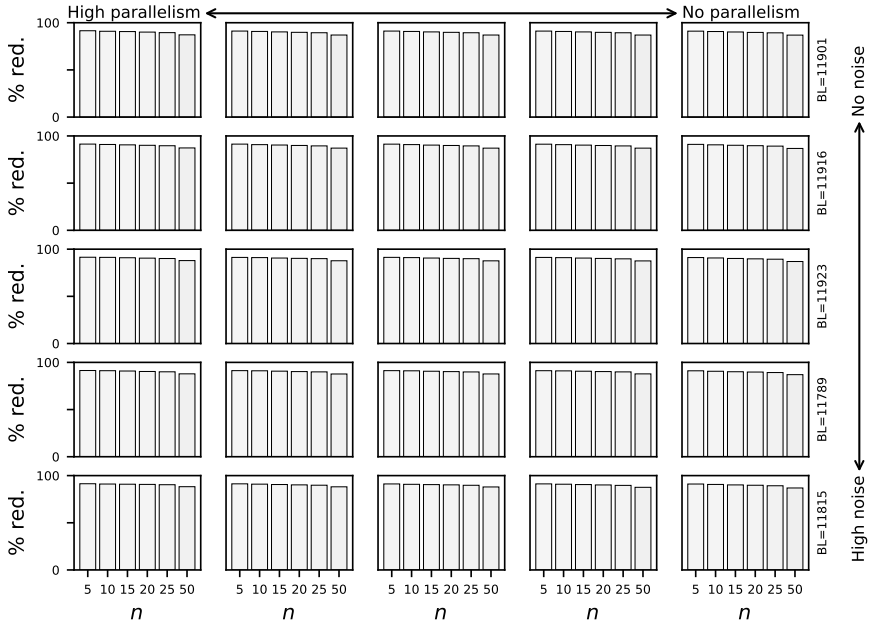
Figure 33: Percentage reduction in memory footprint w.r.t. the baseline (BL) for $a12$ event logs with different skewness of decisions and noise levels with CFc as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The value w on the X-axis is the maximum number of states allowed to be retained in D_C. The number on the secondary Y-axis is the maximum states consumed by the baseline (BL).



(a) Skewness of decisions level 0

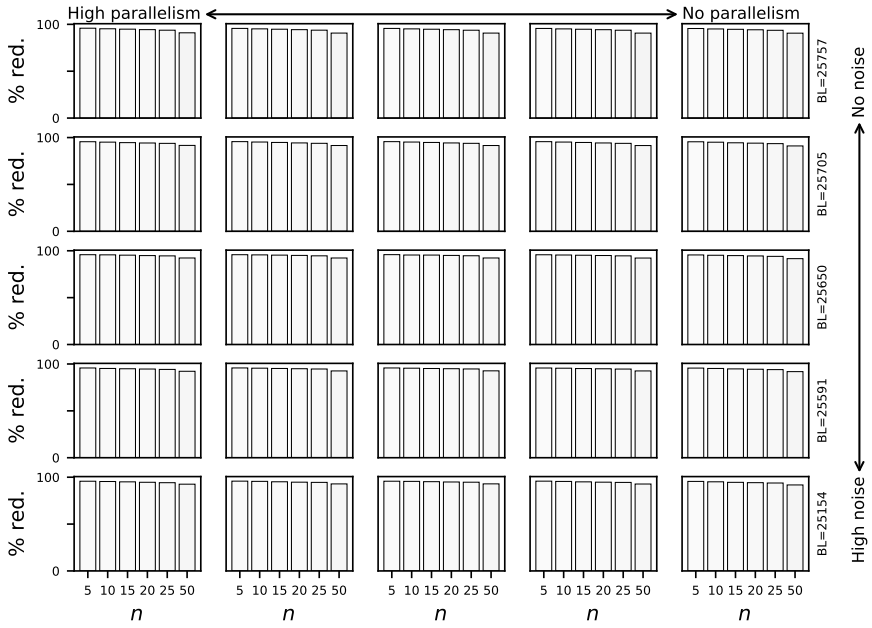


(b) Skewness of decisions level 1

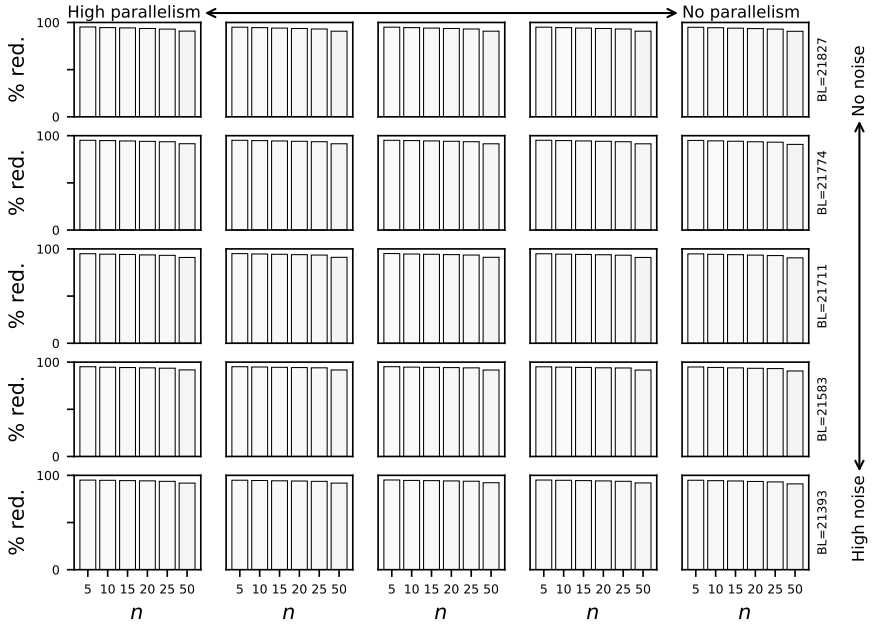


(c) Skewness of decisions level 2

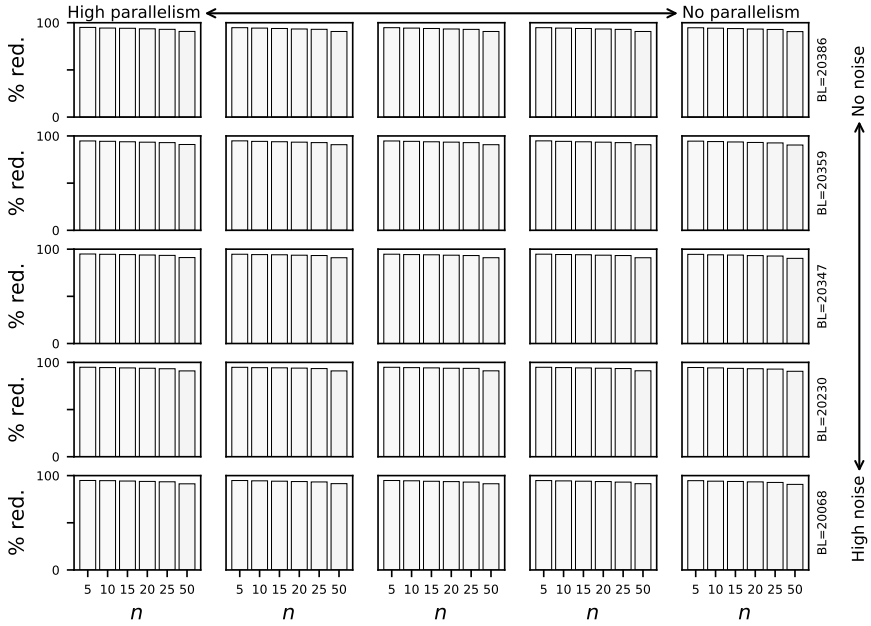
Figure 34: Percentage reduction in memory footprint w.r.t. the baseline (BL) for $a22$ event logs with different skewness of decisions and noise levels with CFc as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The value w on the X-axis is the maximum number of states allowed to be retained in D_C. The number on the secondary Y-axis is the maximum states consumed by the baseline (BL).



(a) Skewness of decisions level 0

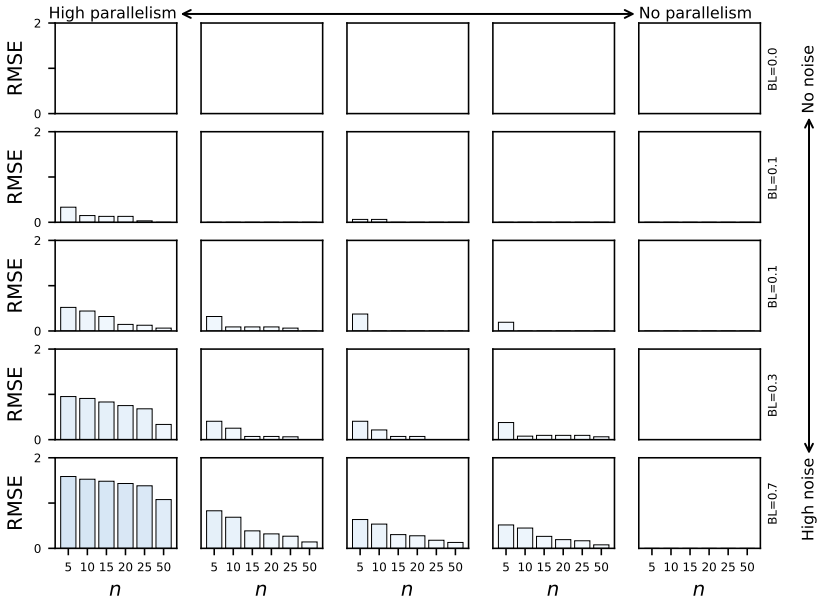


(b) Skewness of decisions level 1

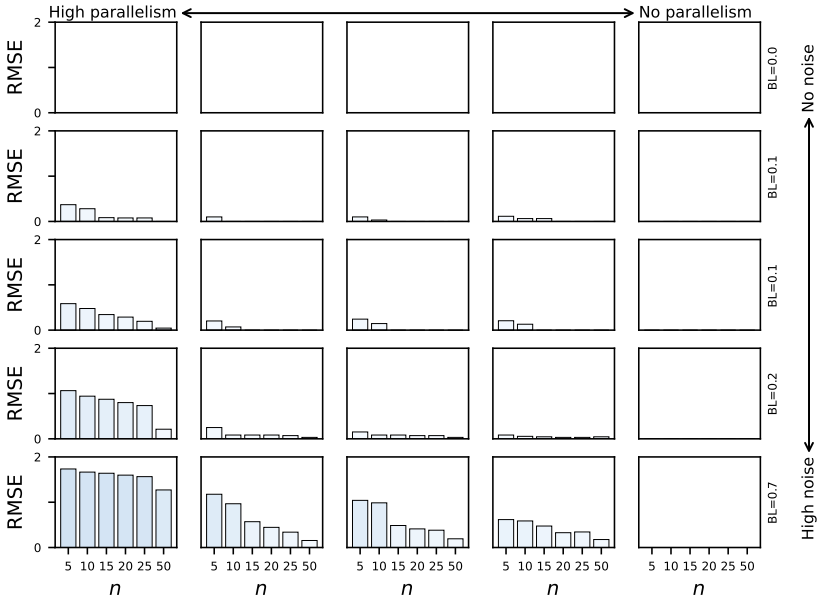


(c) Skewness of decisions level 2

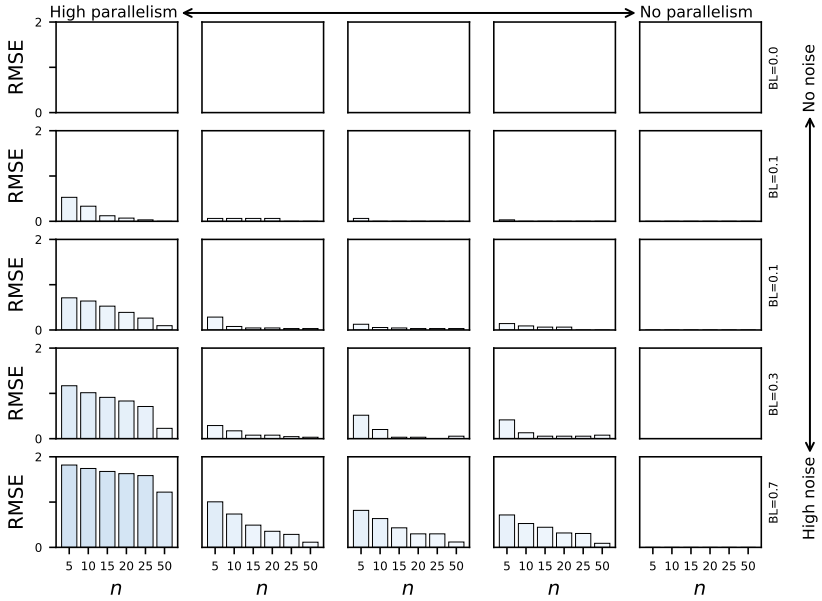
Figure 35: Percentage reduction in memory footprint w.r.t. the baseline (BL) for $a32$ event logs with different skewness of decisions and noise levels with CFc as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The value w on the X-axis is the maximum number of states allowed to be retained in D_C. The number on the secondary Y-axis is the maximum states consumed by the baseline (BL).



(a) Skewness of decisions level 0

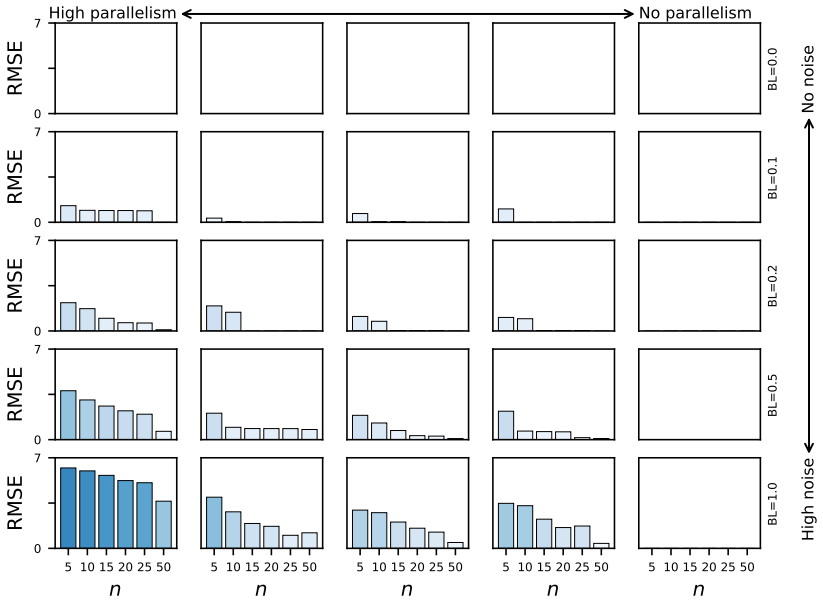


(b) Skewness of decisions level 1

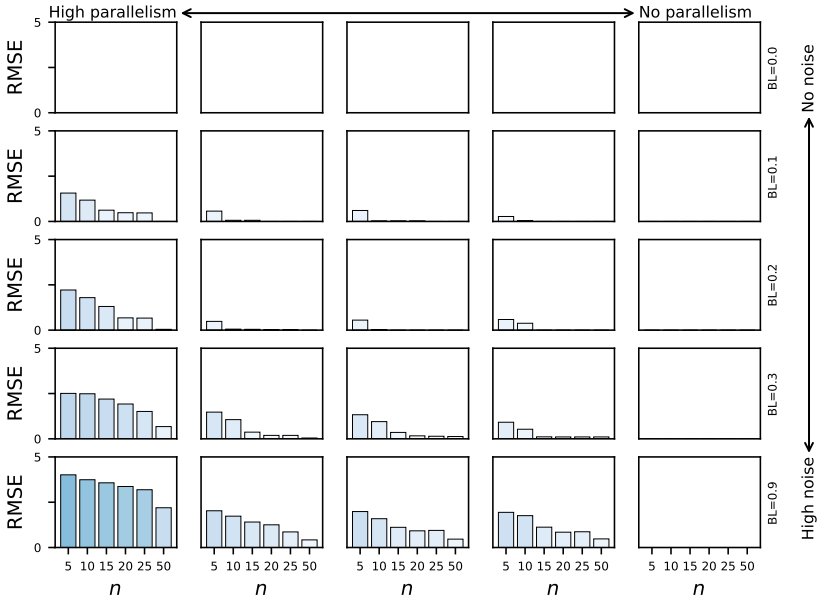


(c) Skewness of decisions level 2

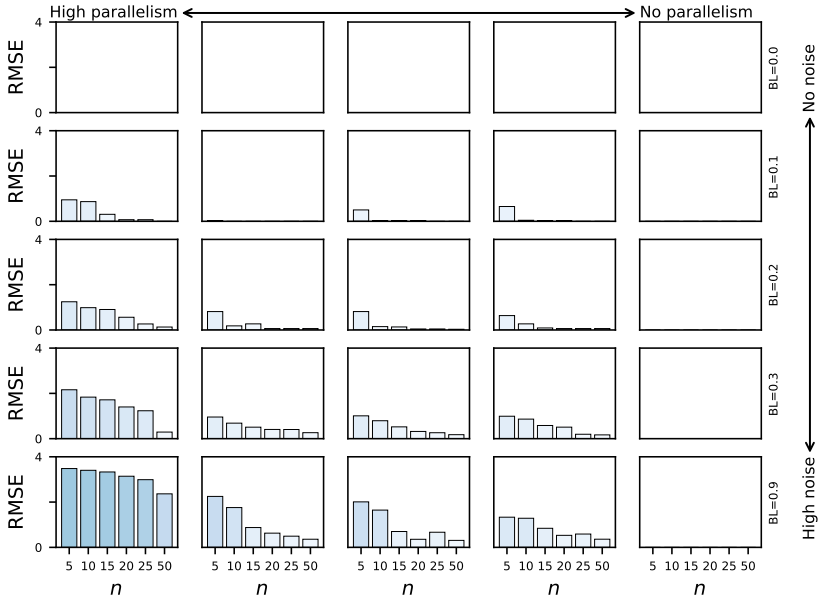
Figure 36: RMSE for $a12$ event logs with different decision skewness and noise levels with CFc as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The number on the secondary Y-axis is the avg. trace fitness cost over the log by the baseline(BL).



(a) Skewness of decisions level 0

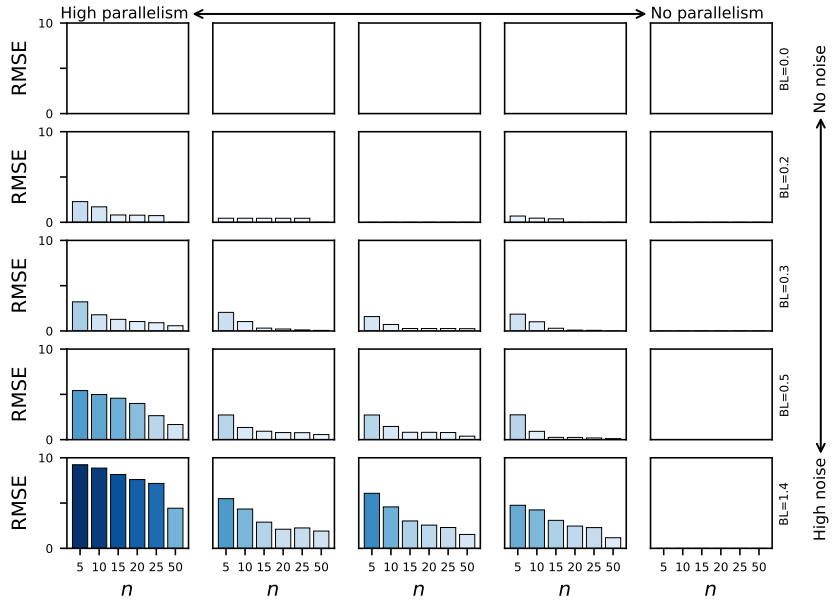


(b) Skewness of decisions level 1

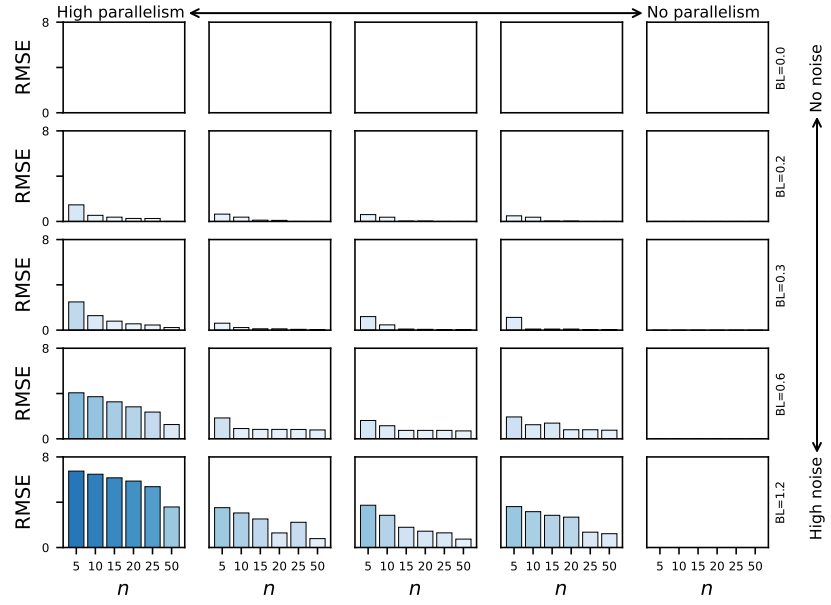


(c) Skewness of decisions level 2

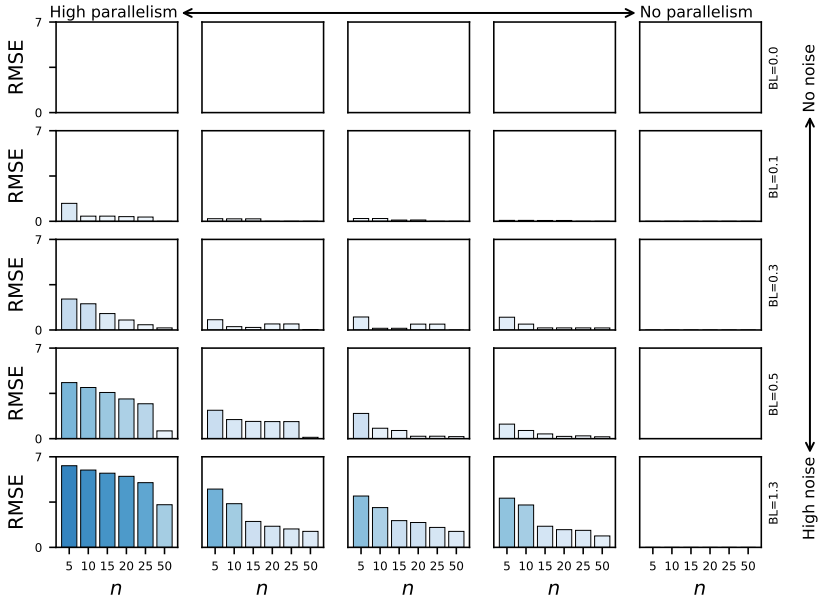
Figure 37: RMSE for $a22$ event logs with different decision skewness and noise levels with CFc as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The number on the secondary Y-axis is the avg. trace fitness cost over the log by the baseline(BL).



(a) Skewness of decisions level 0

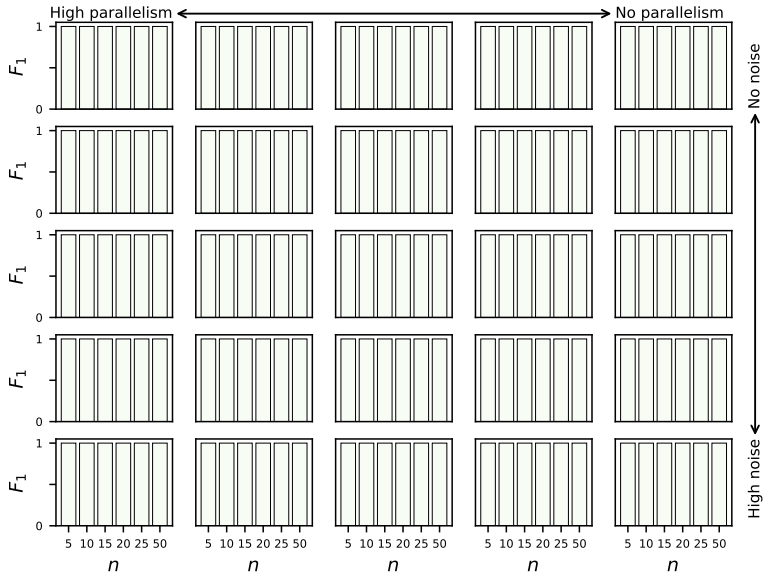


(b) Skewness of decisions level 1

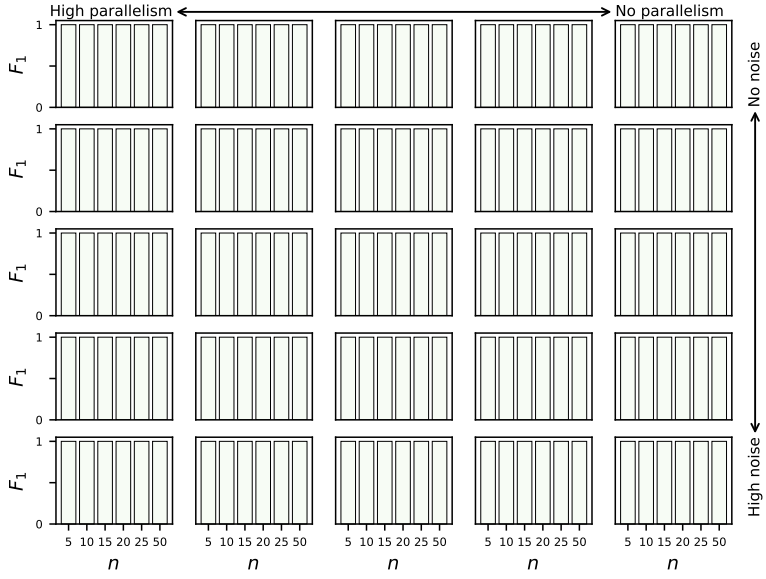


(c) Skewness of decisions level 2

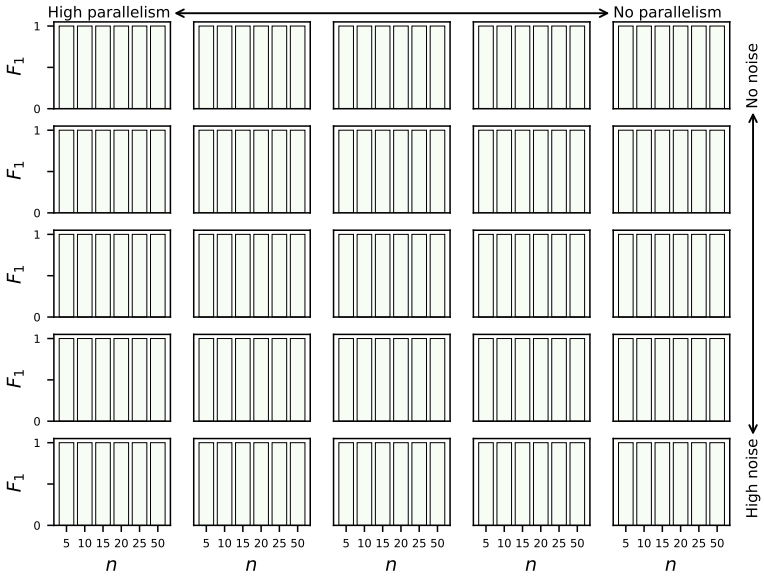
Figure 38: RMSE for $a32$ event logs with different decision skewness and noise levels with CFc as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The number on the secondary Y-axis is the avg. trace fitness cost over the log by the baseline(BL).



(a) Skewness of decisions level 0

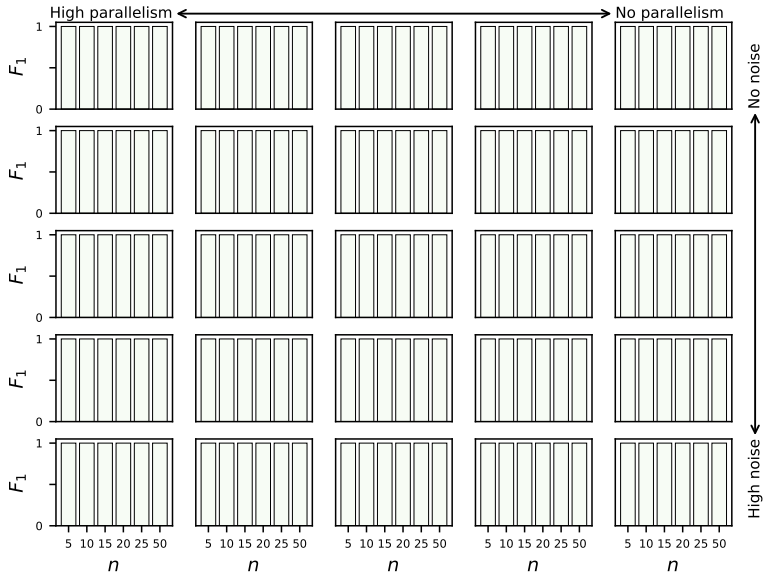


(b) Skewness of decisions level 1

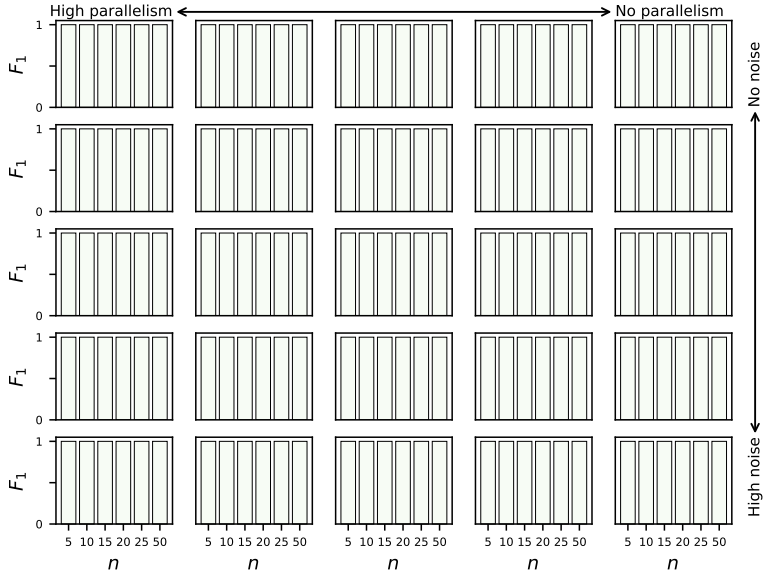


(c) Skewness of decisions level 2

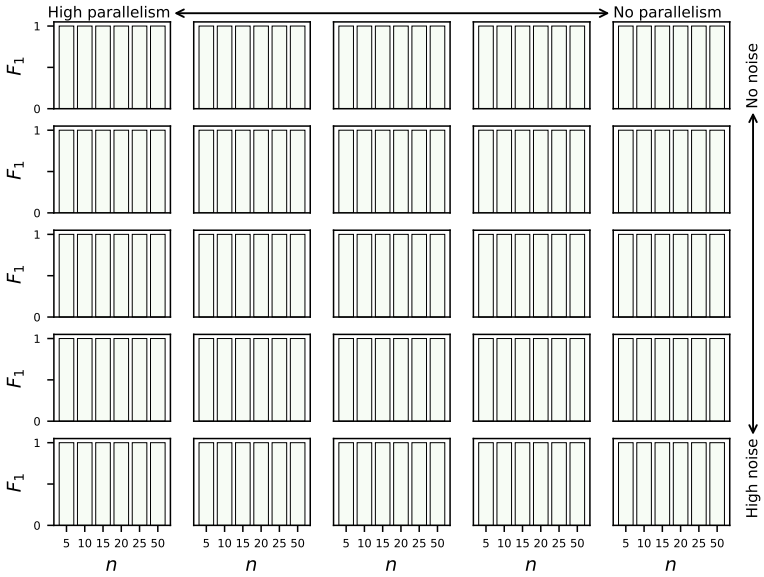
Figure 39: F_1 for $a12$ event logs with different decision skewness and noise levels with CFc as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values.



(a) Skewness of decisions level 0

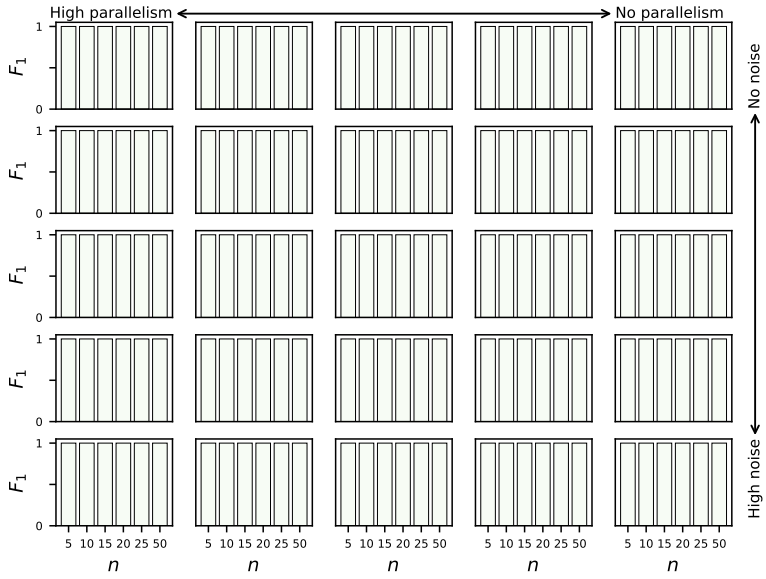


(b) Skewness of decisions level 1

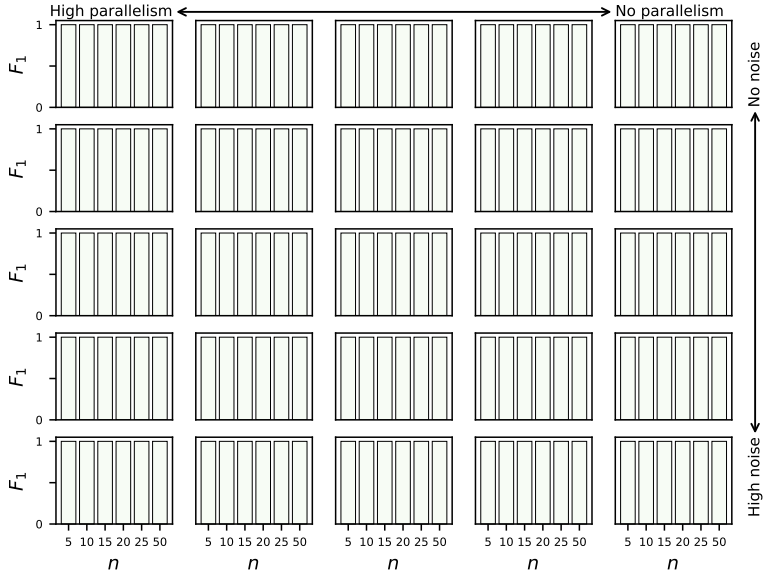


(c) Skewness of decisions level 2

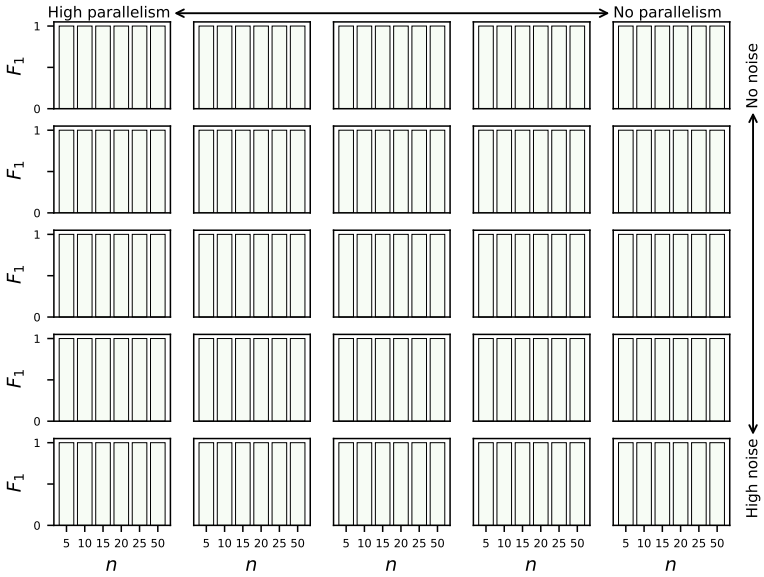
Figure 40: F_1 for $a22$ event logs with different decision skewness and noise levels with CFc as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values.



(a) Skewness of decisions level 0



(b) Skewness of decisions level 1



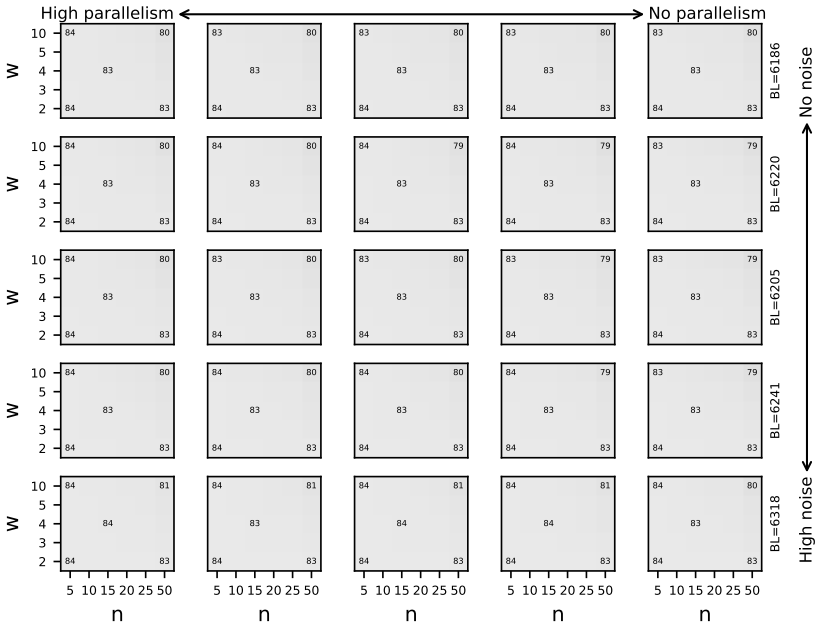
(c) Skewness of decisions level 2

Figure 41: F_1 for $a32$ event logs with different decision skewness and noise levels with CFc as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values.

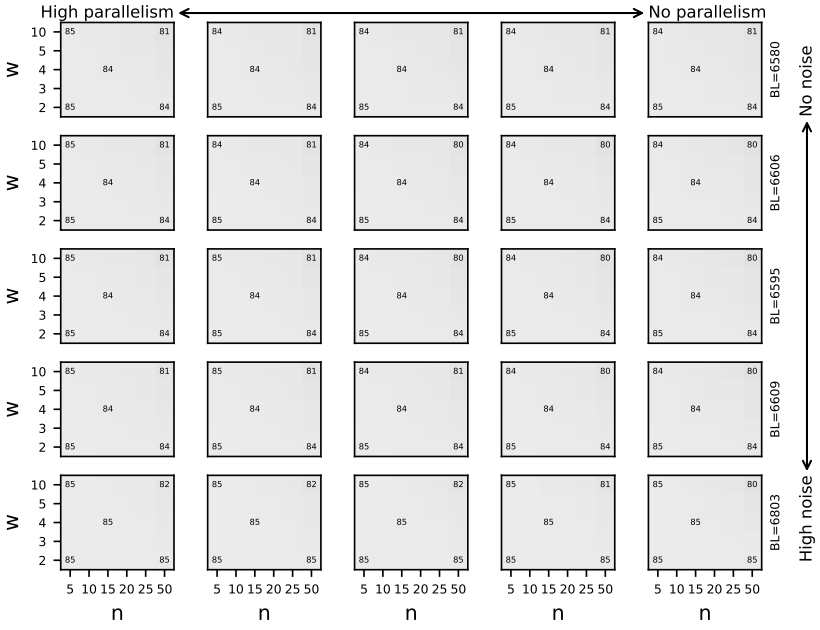
Appendix 6

.1 Bounding Both Cases and States with Carry-forward Marking and Cost($CFcs$).

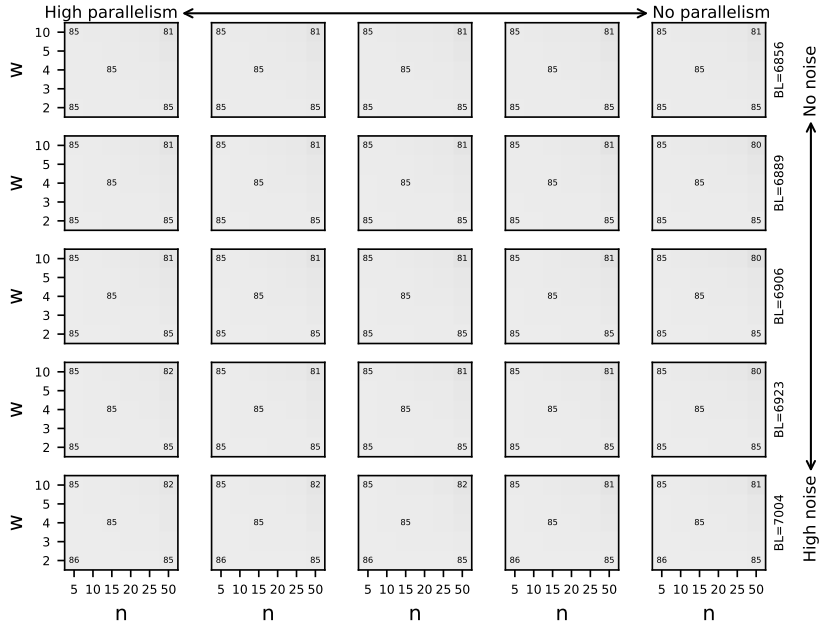
In this section, we provide the complete set of results for the experiments with $a12$, $a22$, and $a32$ synthetic events logs for the $CFcs$ stateful approach.



(a) Skewness of decisions level 0

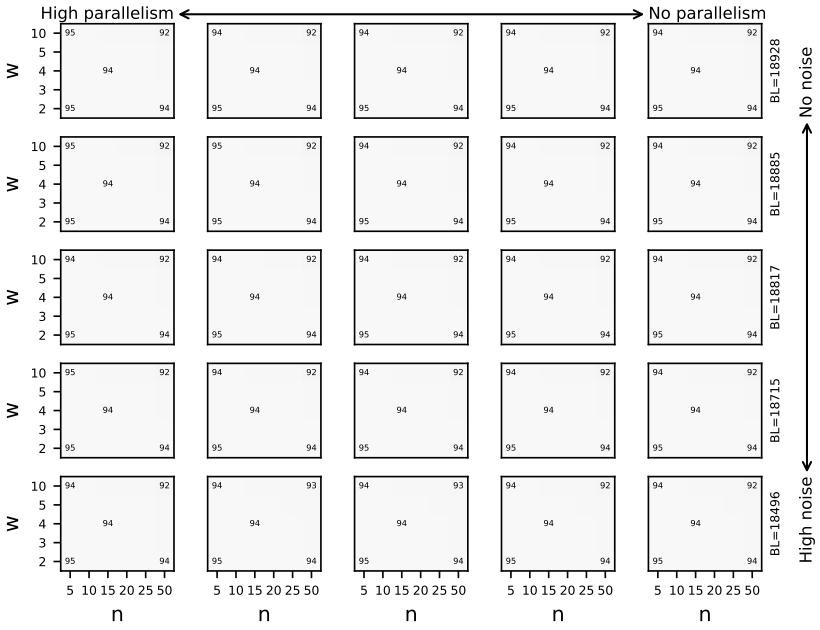


(b) Skewness of decisions level 1

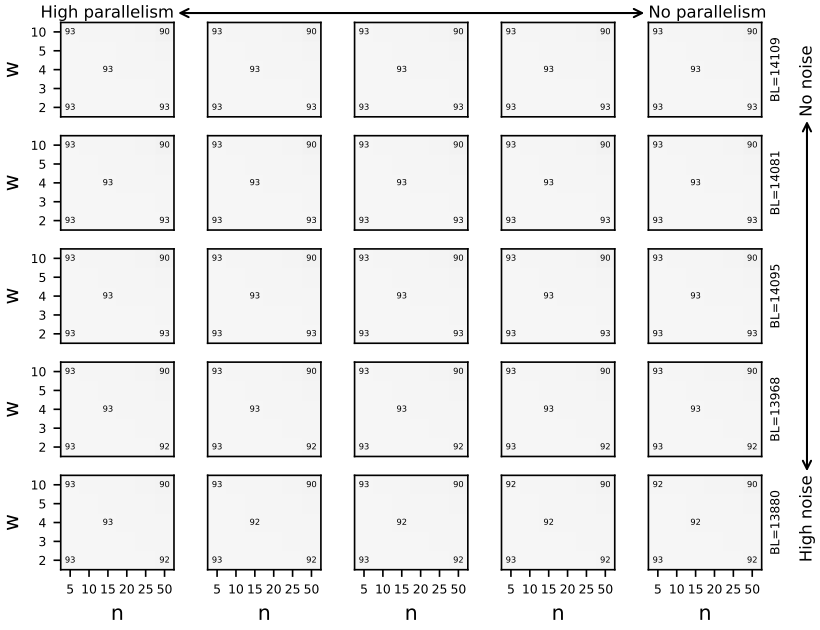


(c) Skewness of decisions level 2

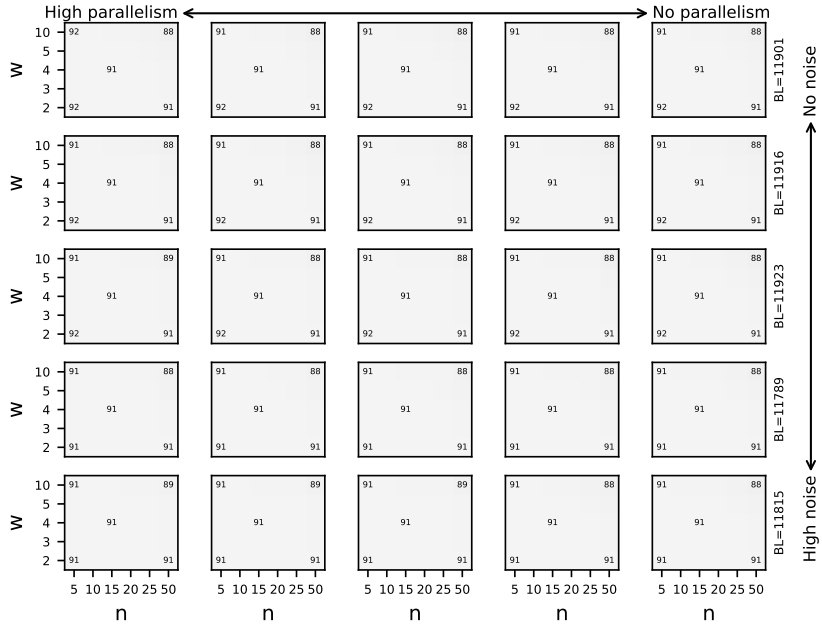
Figure 42: Percentage reduction in memory footprint w.r.t. the baseline (BL) for $a12$ event logs with different skewness of decisions and noise levels with $CFcs$ as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The value w on the X-axis is the maximum number of states allowed to be retained in D_C. The number on the secondary Y-axis is the maximum states consumed by the baseline (BL).



(a) Skewness of decisions level 0

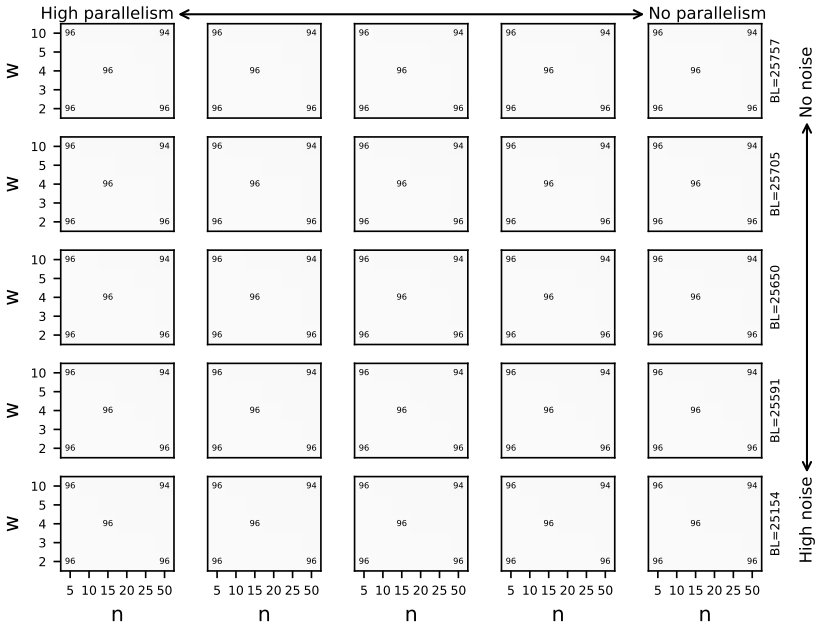


(b) Skewness of decisions level 1

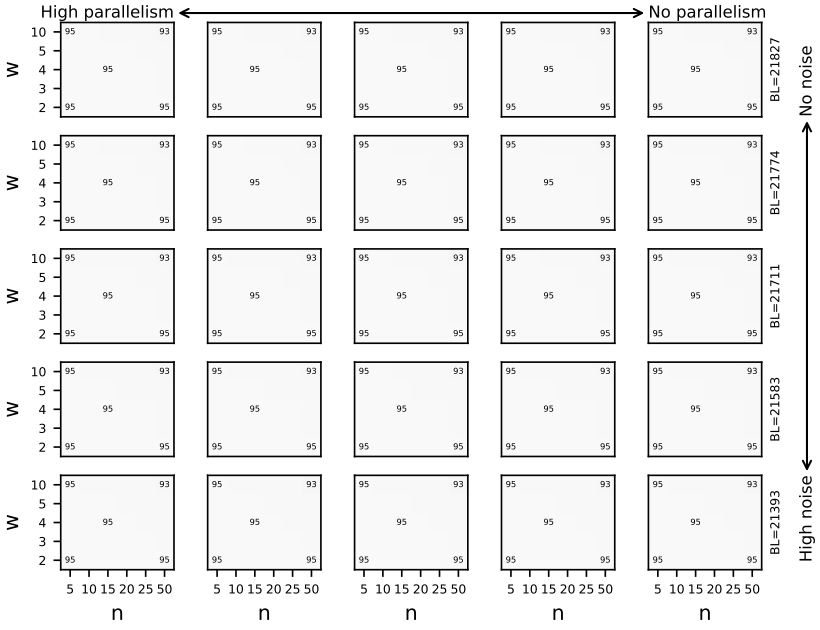


(c) Skewness of decisions level 2

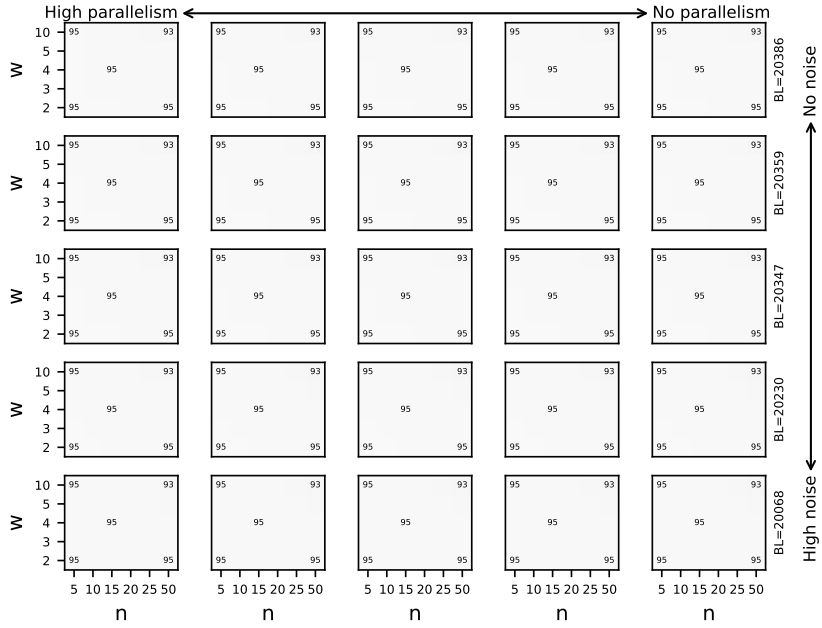
Figure 43: Percentage reduction in memory footprint w.r.t. the baseline (BL) for $a22$ event logs with different skewness of decisions and noise levels with $CFcs$ as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The value w on the X-axis is the maximum number of states allowed to be retained in D_C. The number on the secondary Y-axis is the maximum states consumed by the baseline (BL).



(a) Skewness of decisions level 0

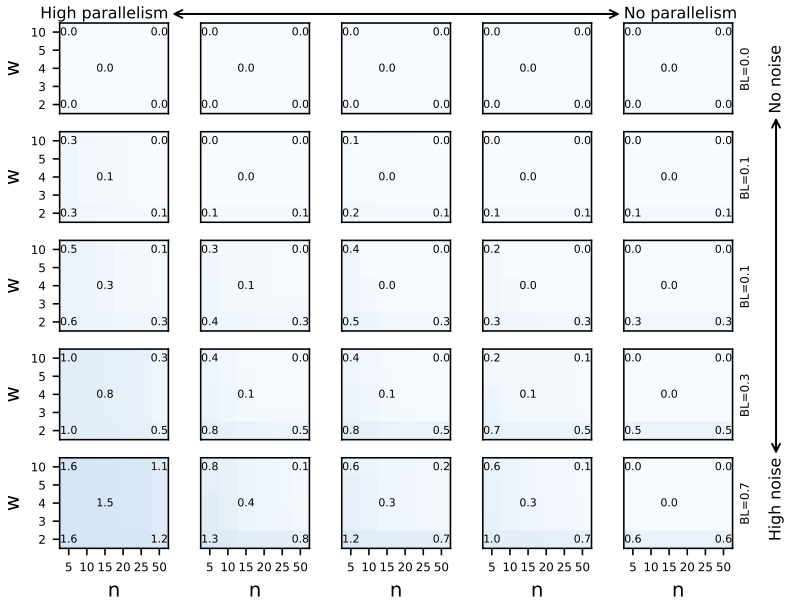


(b) Skewness of decisions level 1

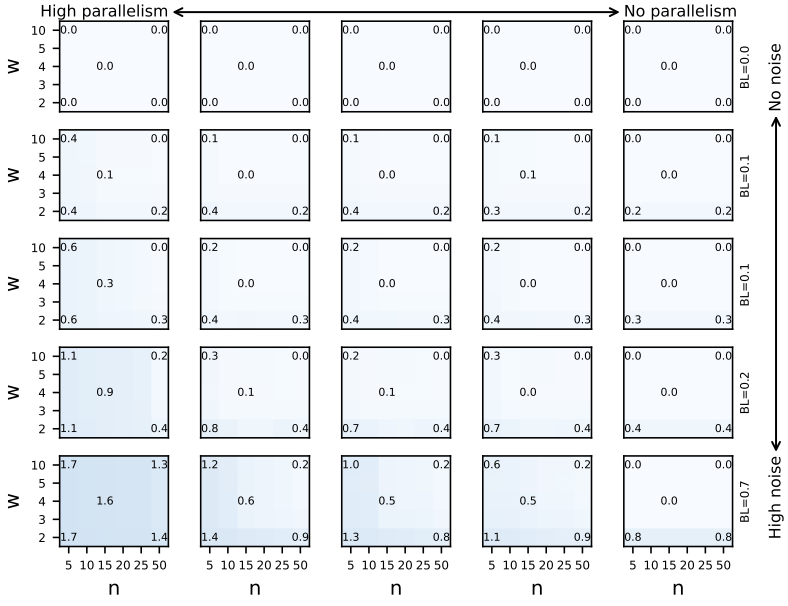


(c) Skewness of decisions level 2

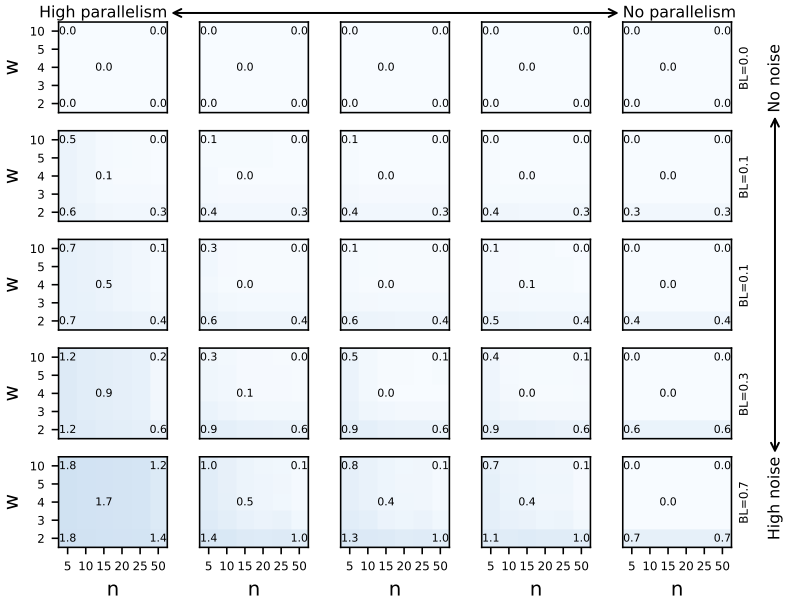
Figure 44: Percentage reduction in memory footprint w.r.t. the baseline (BL) for $a32$ event logs with different skewness of decisions and noise levels with $CFcs$ as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The value w on the X-axis is the maximum number of states allowed to be retained in D_C. The number on the secondary Y-axis is the maximum states consumed by the baseline (BL).



(a) Skewness of decisions level 0

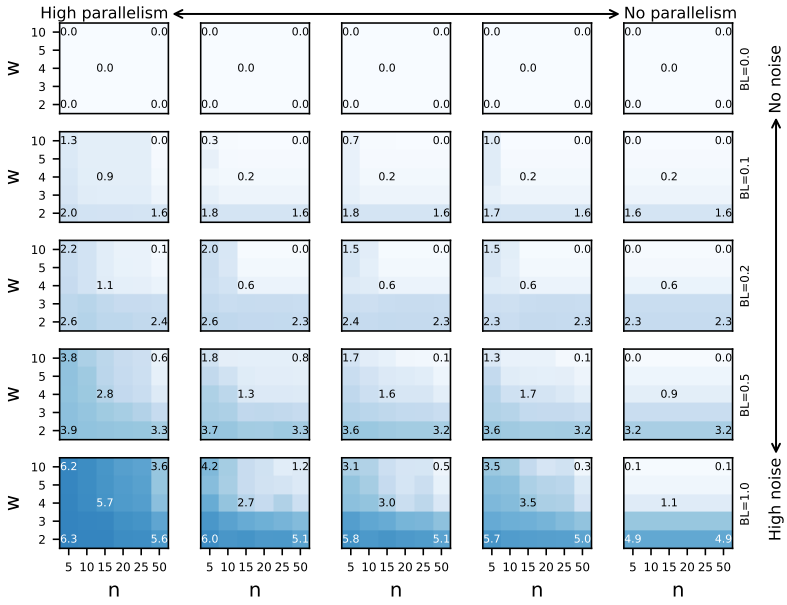


(b) Skewness of decisions level 1

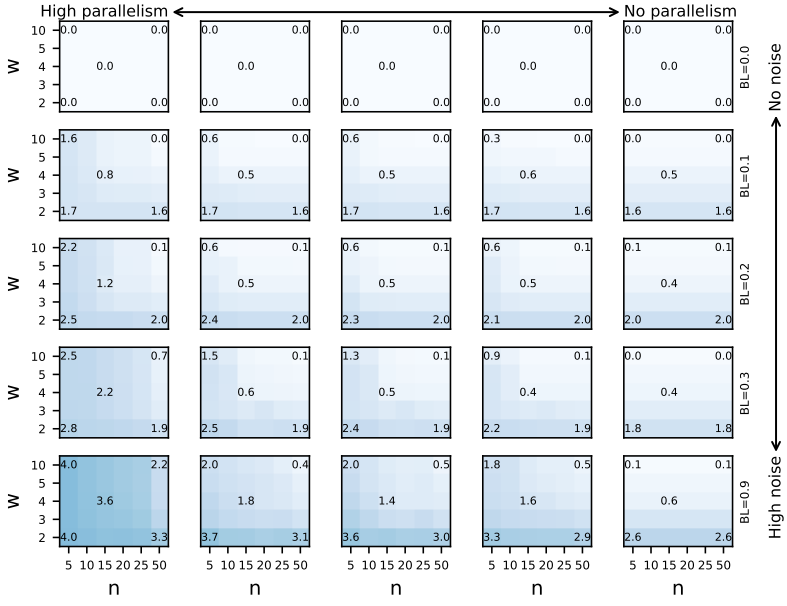


(c) Skewness of decisions level 2

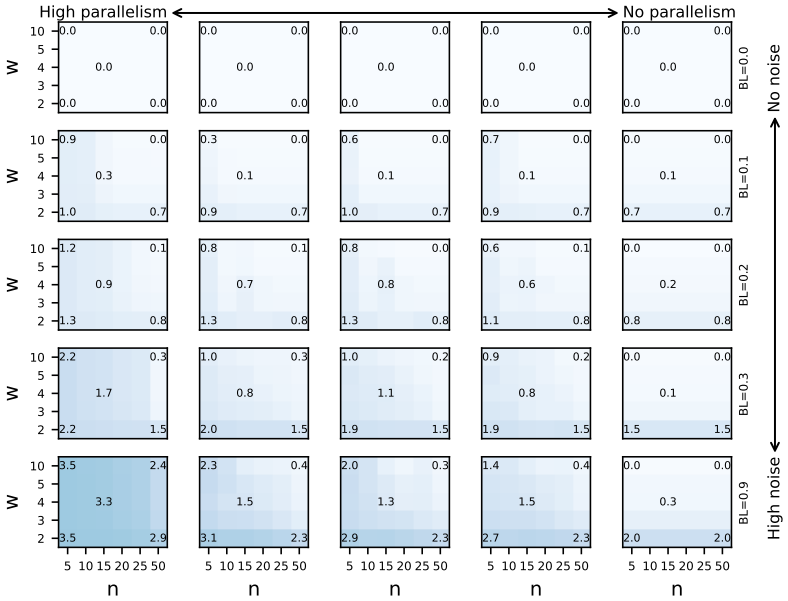
Figure 45: RMSE for $a12$ event logs with different decision skewness and noise levels with $CFcs$ as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The number on the secondary Y-axis is the avg. trace fitness cost over the log by the baseline(BL).



(a) Skewness of decisions level 0

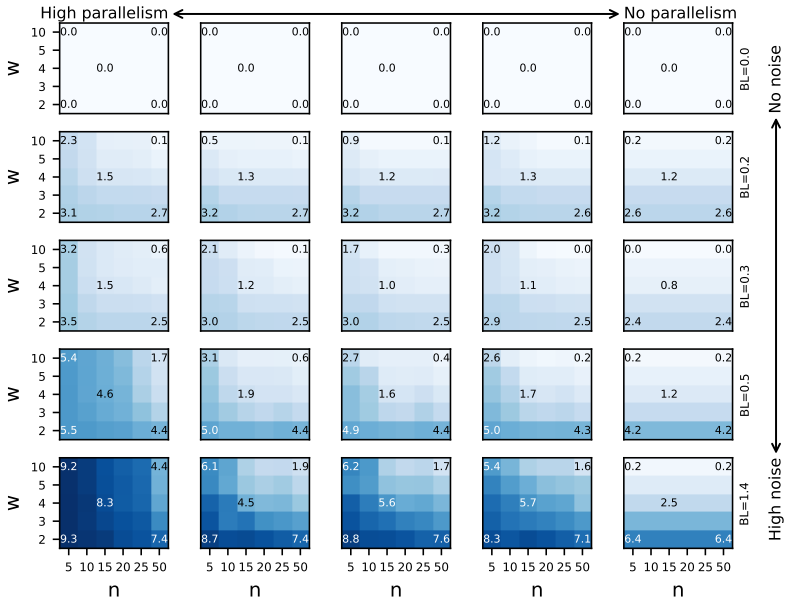


(b) Skewness of decisions level 1

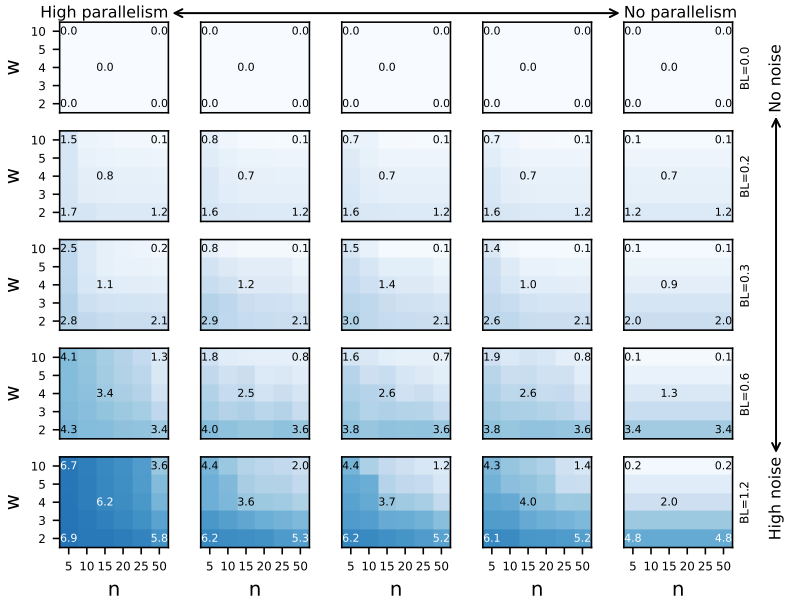


(c) Skewness of decisions level 2

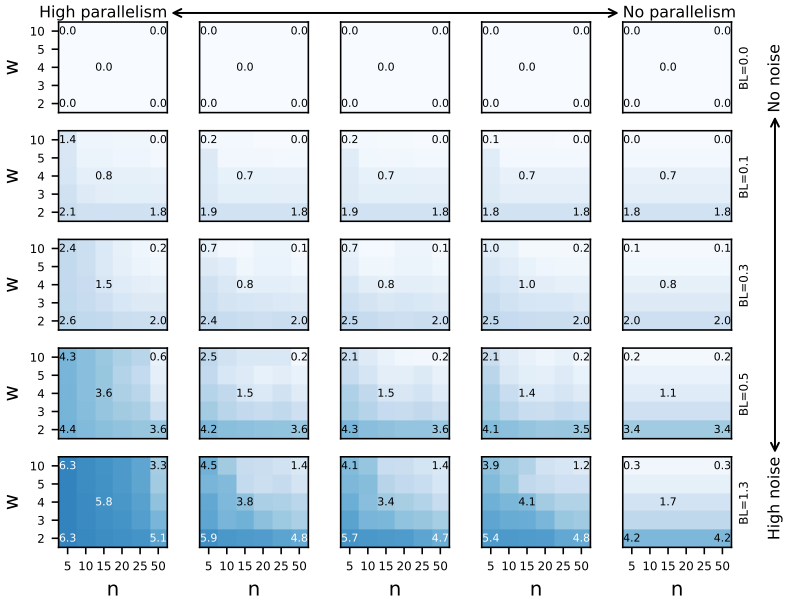
Figure 46: RMSE for $a22$ event logs with different decision skewness and noise levels with $CFcs$ as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The number on the secondary Y-axis is the avg. trace fitness cost over the log by the baseline(BL).



(a) Skewness of decisions level 0

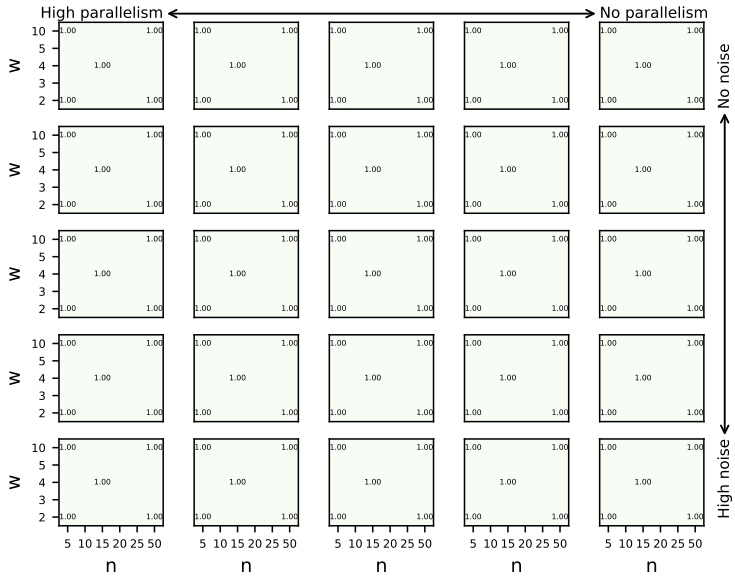


(b) Skewness of decisions level 1

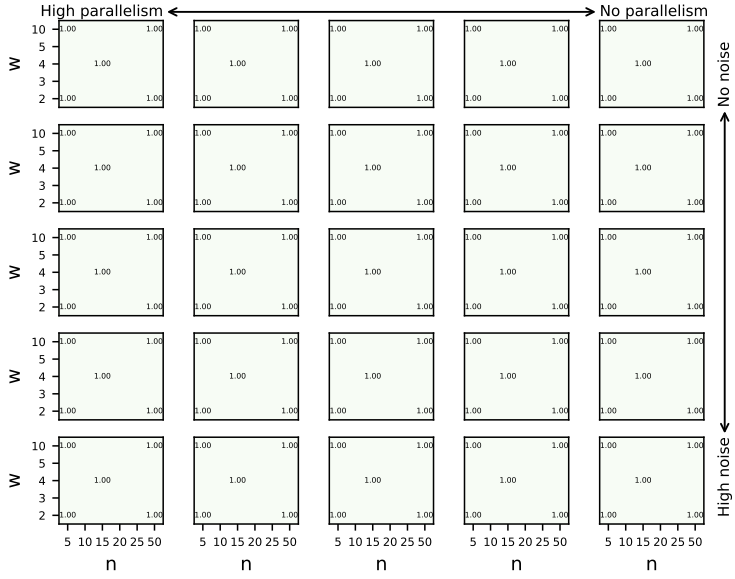


(c) Skewness of decisions level 2

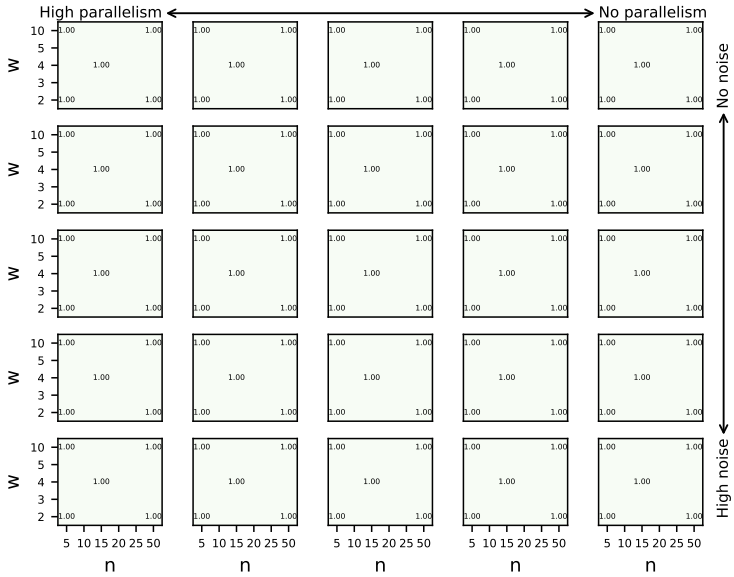
Figure 47: RMSE for $a32$ event logs with different decision skewness and noise levels with $CFcs$ as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values. The number on the secondary Y-axis is the avg. trace fitness cost over the log by the baseline(BL).



(a) Skewness of decisions level 0

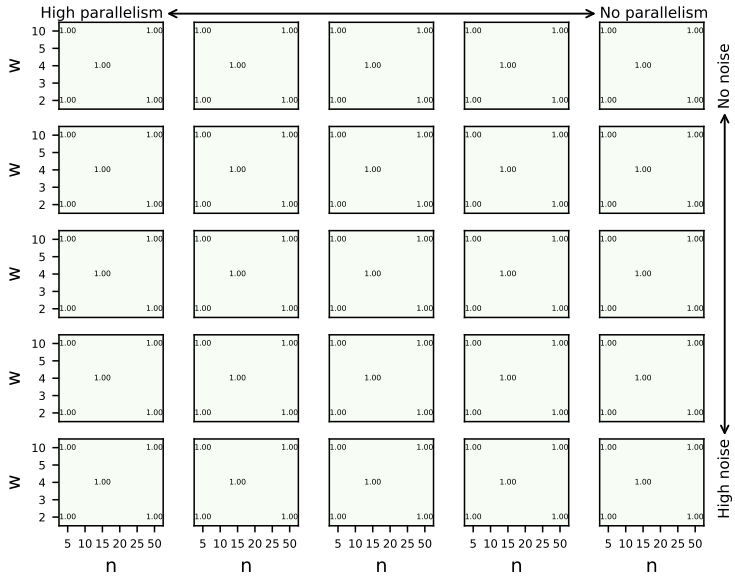


(b) Skewness of decisions level 1

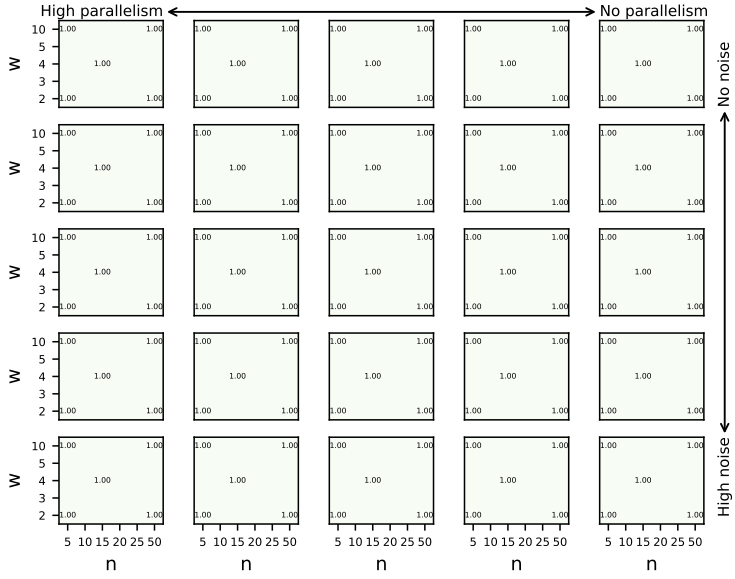


(c) Skewness of decisions level 2

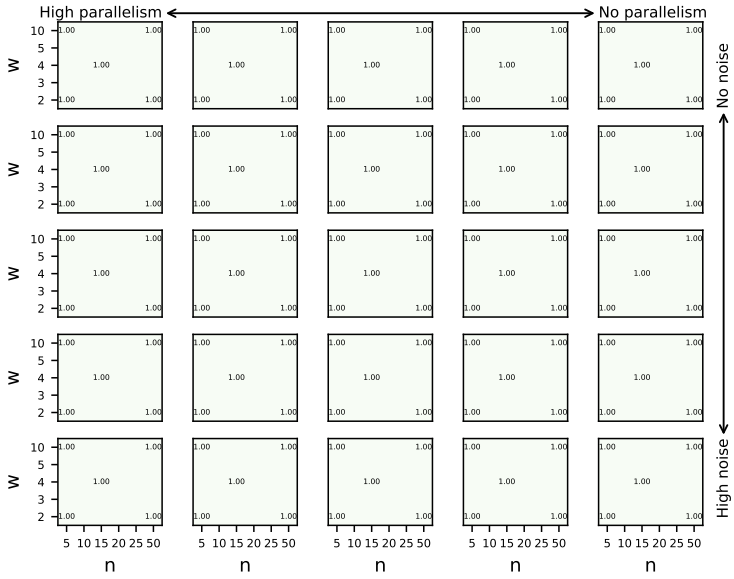
Figure 48: F_1 for $a12$ event logs with different decision skewness and noise levels with $CFcs$ as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values.



(a) Skewness of decisions level 0

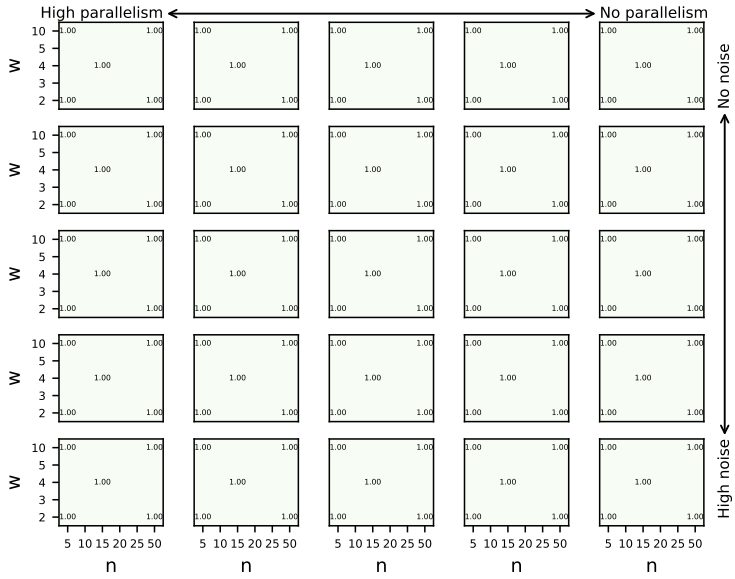


(b) Skewness of decisions level 1

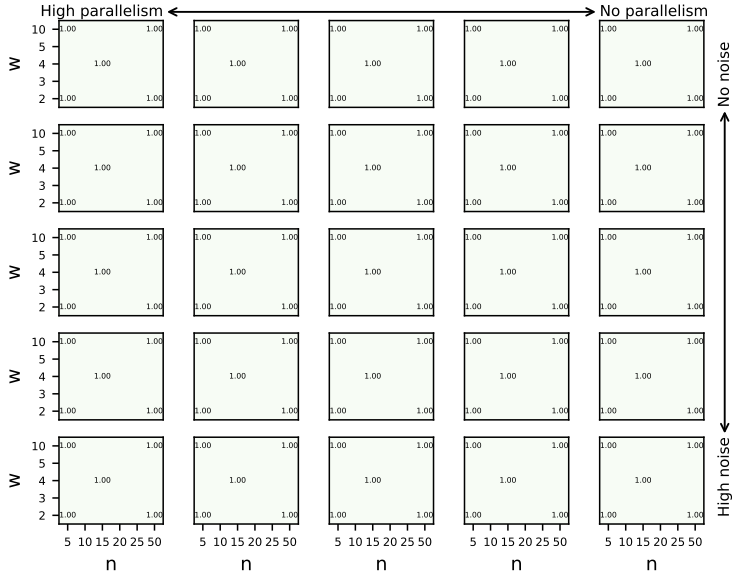


(c) Skewness of decisions level 2

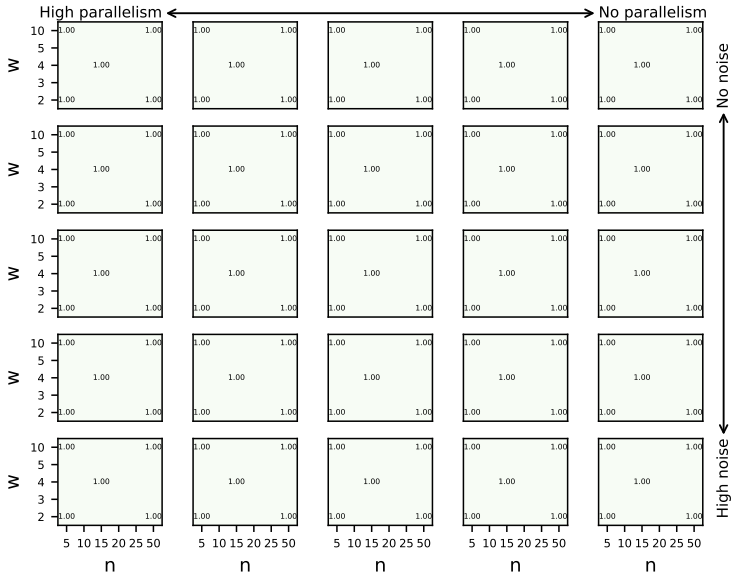
Figure 49: F_1 for $a22$ event logs with different decision skewness and noise levels with $CFcs$ as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values.



(a) Skewness of decisions level 0



(b) Skewness of decisions level 1



(c) Skewness of decisions level 2

Figure 50: F_1 for $a32$ event logs with different decision skewness and noise levels with $CFcs$ as a heatmap. A dark color represents the worst value of the respective metric, while brighter colors encapsulate its best values.