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## Massive MIMO Optimization with Compatible Sets

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# Massive MIMO Optimization With Compatible Sets

## Technical Report

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March 26, 2019

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explanation of the meaning of each parameter and the method for conducting the experiments.

The following results are contained in this report. For Experiment 1, the column generation iteration number vs. the dual objective for maximum ratio combining with optimal and static power control, as well as for zero forcing with fair, optimal, and static power control. Experiments 2 and 3 were omitted from the paper, and so full results for these experiments are provided here. For Experiments 4 and 5, results are given here for scenarios 2–6.

## References

[1] E. Fitzgerald, M. Pióro, and F. Tufvesson, “Massive MIMO optimization with compatible sets,” *IEEE Transactions on Wireless Communications*, 2019, in press, available at <https://arxiv.org/abs/1903.08260>.

## 1 Introduction

In this report we provide results for those experiments and scenarios whose results were omitted from our paper [1]. In Tables 2–1, we provide a reference of the experimental parameters used, however, readers are referred to the paper for a full

Experiment	Near distance	Far distance	Other parameters
1	50 m	200 m	
2	200 m	400 m	
3	50 m	100 m	
4	50 m	100 m	$\mu$ : 1, 5...50; step 5, $K$ : 20
5	50 m	100 m	$K$ : 4...40, step 4
6	50 m	500 m	$K$ : 40 total: 8 near, 32 far

Table 1: Experiment configurations.

Parameter	Value
$\hat{\rho}$	10 dB
$\tilde{\rho}$	10 dB
$M$	100
$\mu$	1.0
$S$	1
$P$	12
$\alpha$	3.7
$R$	200 m
$K$	40

Table 2: Parameters used for experiments

Scenario 1		
Group	Uplink demand $\hat{h}$	Downlink demand $\check{h}$
Near	10	10
Far	2	2
Scenario 2		
Group	Uplink demand $\hat{h}$	Downlink demand $\check{h}$
Near	2	2
Far	10	10
Scenario 3		
Group	Uplink demand $\hat{h}$	Downlink demand $\check{h}$
Near	2	10
Far	10	2
Scenario 4		
Group	Uplink demand $\hat{h}$	Downlink demand $\check{h}$
Near	10	2
Far	2	10
Scenario 5		
Group	Uplink demand $\hat{h}$	Downlink demand $\check{h}$
Near	10	2
Far	10	2
Scenario 6		
Group	Uplink demand $\hat{h}$	Downlink demand $\check{h}$
Near	2	10
Far	2	10

Table 3: Scenarios for experiments

## 2 Experiment 1

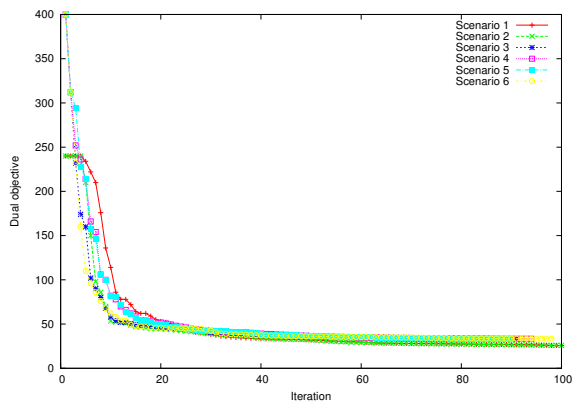


Figure 1: Iteration number vs. dual objective for MRC with optimal power control

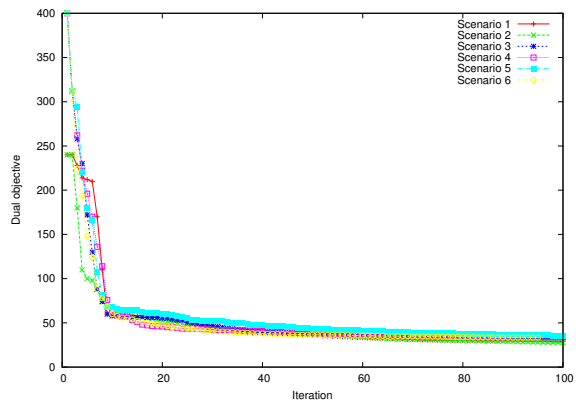


Figure 3: Iteration number vs. dual objective for MRC with downlink power control

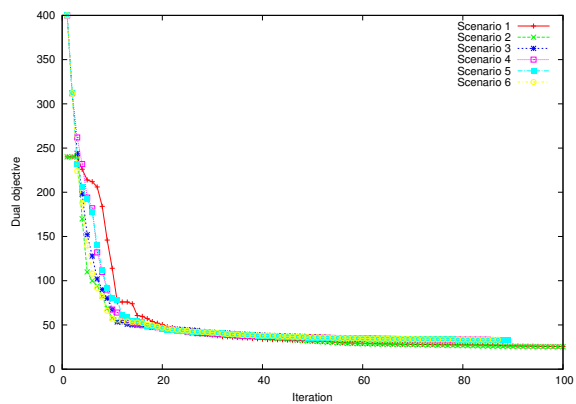


Figure 4: Iteration number vs. dual objective for ZF with fair power control

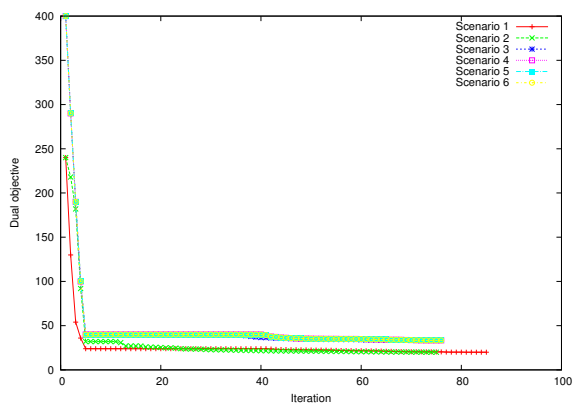


Figure 2: Iteration number vs. dual objective for MRC with static power control

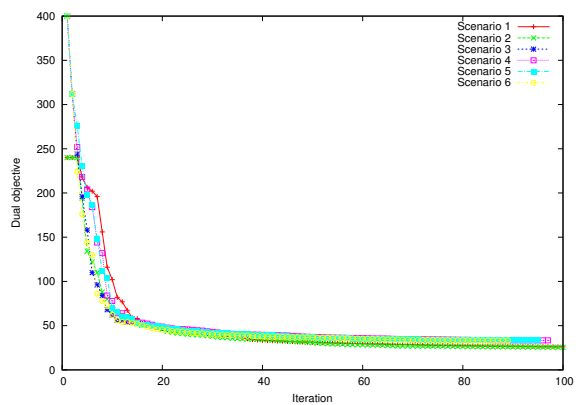


Figure 5: Iteration number vs. dual objective for ZF with optimal power control

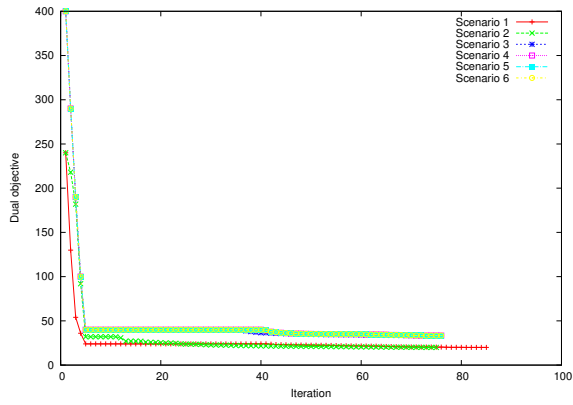


Figure 6: Iteration number vs. dual objective for ZF with static power control

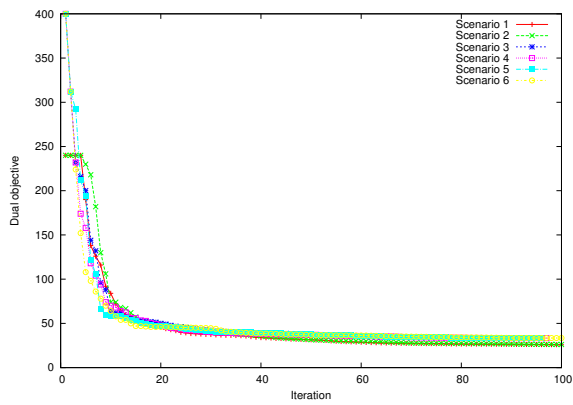


Figure 7: Iteration number vs. dual objective for ZF with downlink power control

### 3 Experiment 2

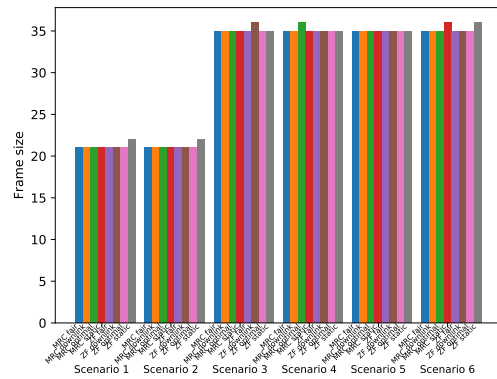


Figure 8: Frame size

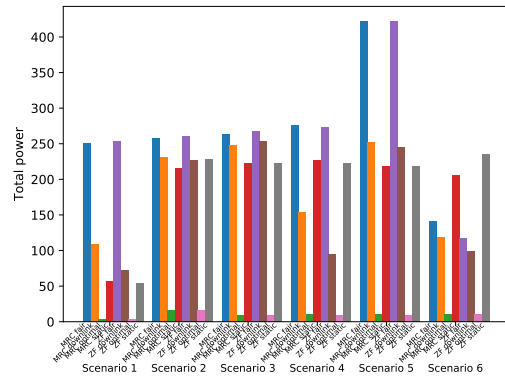


Figure 9: Total power

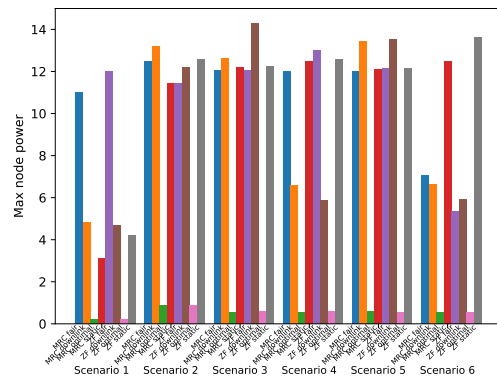


Figure 10: Max node power

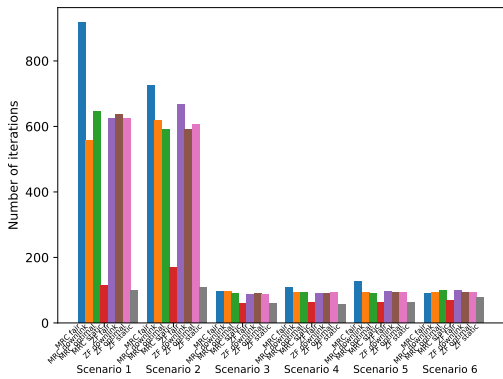


Figure 11: Number of pricing problem iterations

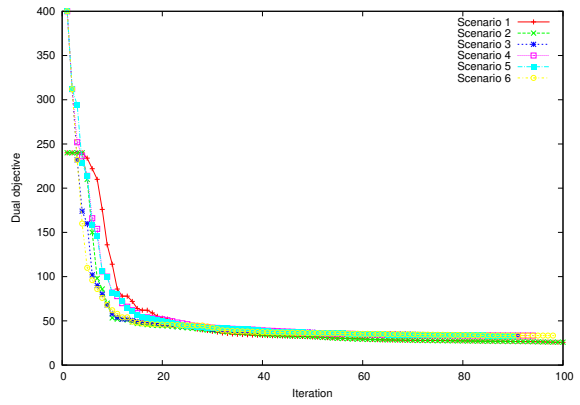


Figure 14: Iteration number vs. dual objective for MRC with optimal power control

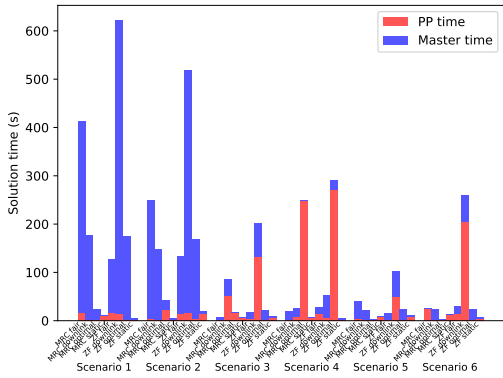


Figure 12: Solution time

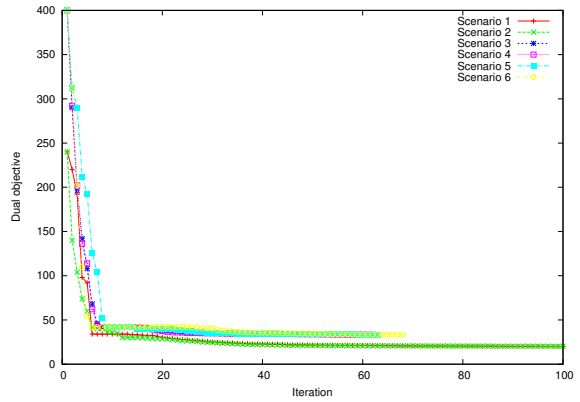


Figure 15: Iteration number vs. dual objective for MRC with static power control

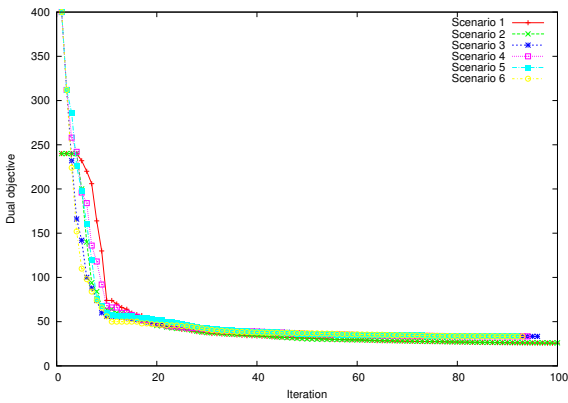


Figure 13: Iteration number vs. dual objective for MRC with fair power control

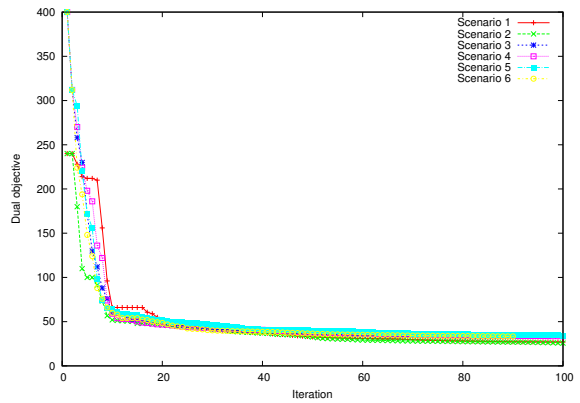


Figure 16: Iteration number vs. dual objective for MRC with downlink power control

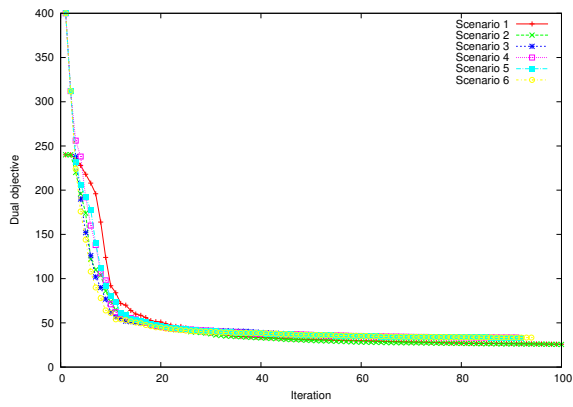


Figure 17: Iteration number vs. dual objective for ZF with fair power control

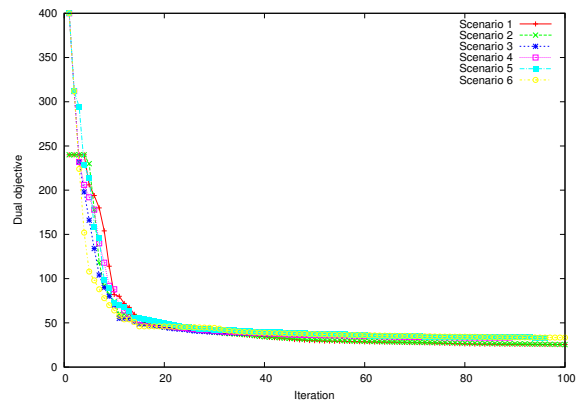


Figure 20: Iteration number vs. dual objective for ZF with downlink power control

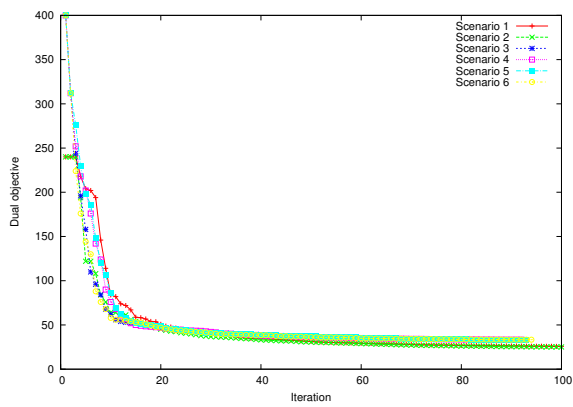


Figure 18: Iteration number vs. dual objective for ZF with optimal power control

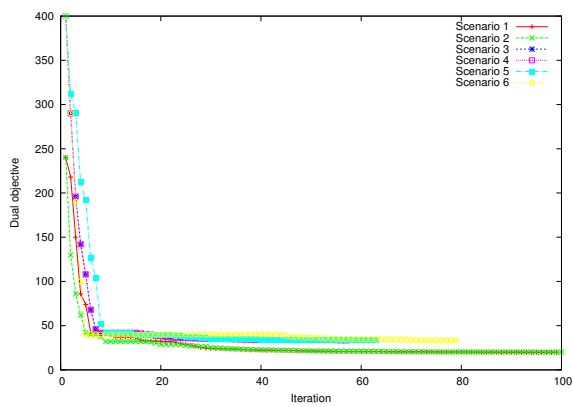


Figure 19: Iteration number vs. dual objective for ZF with static power control

## 4 Experiment 3

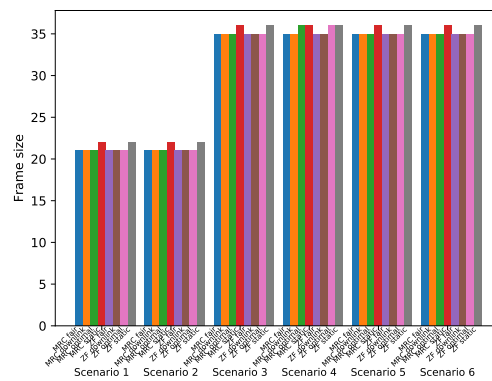


Figure 21: Frame size

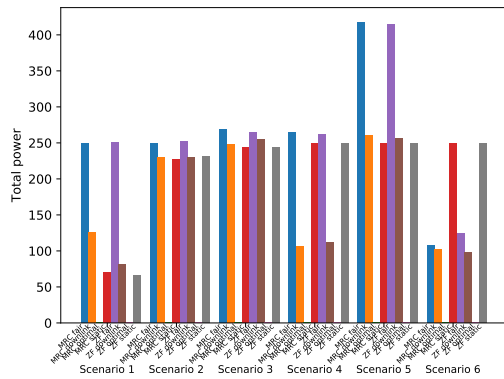


Figure 22: Total power

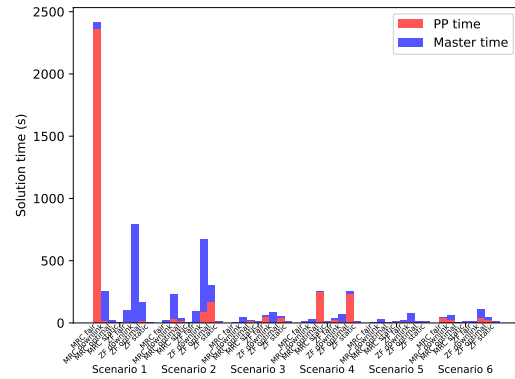


Figure 25: Solution time

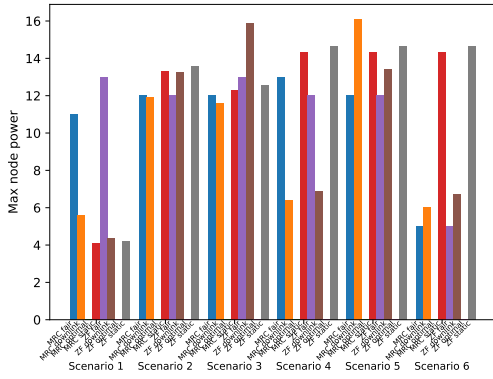


Figure 23: Max node power

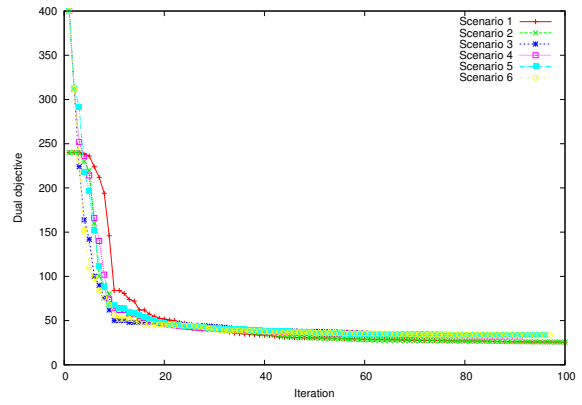


Figure 26: Iteration number vs. dual objective for MRC with fair power control

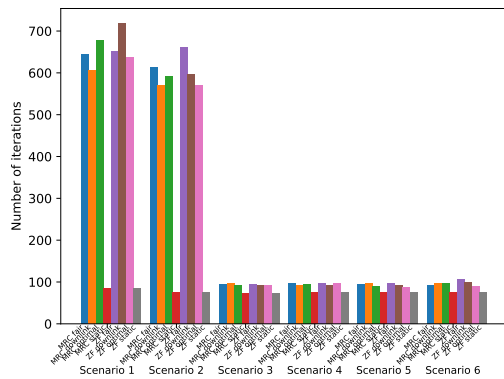


Figure 24: Number of pricing problem iterations

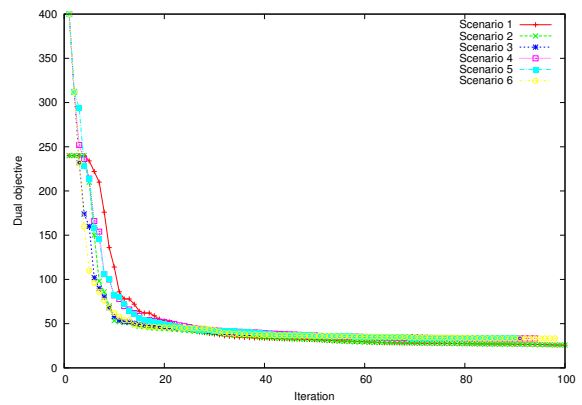


Figure 27: Iteration number vs. dual objective for MRC with optimal power control



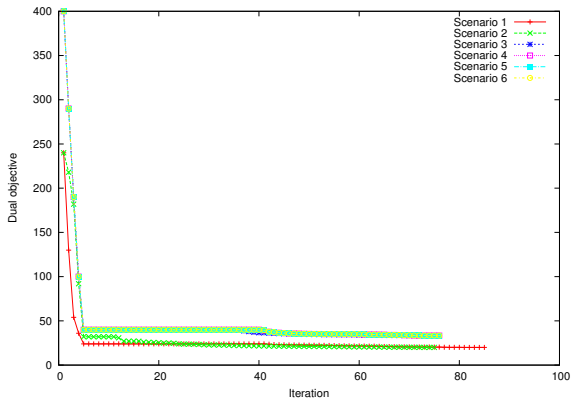


Figure 28: Iteration number vs. dual objective for MRC with static power control

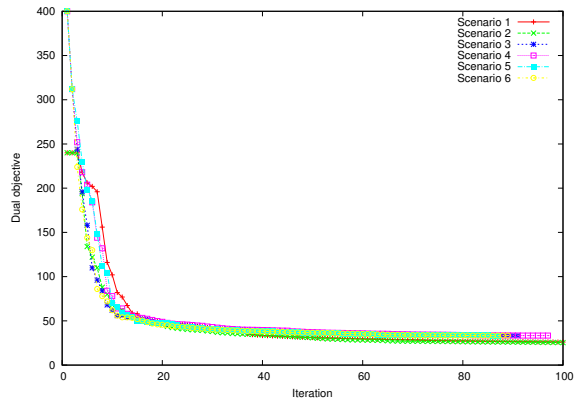


Figure 31: Iteration number vs. dual objective for ZF with optimal power control

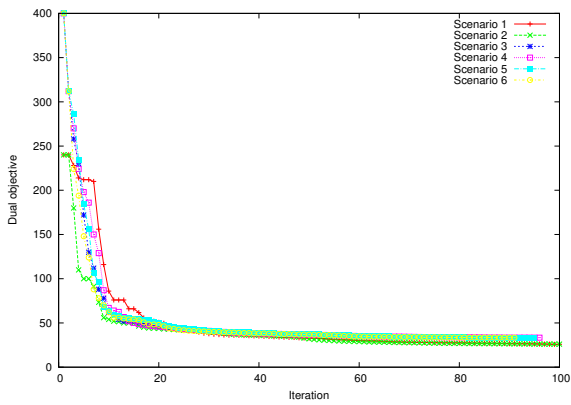


Figure 29: Iteration number vs. dual objective for MRC with downlink power control

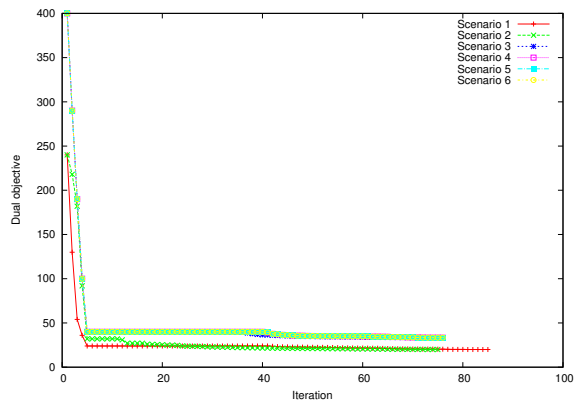


Figure 32: Iteration number vs. dual objective for ZF with static power control

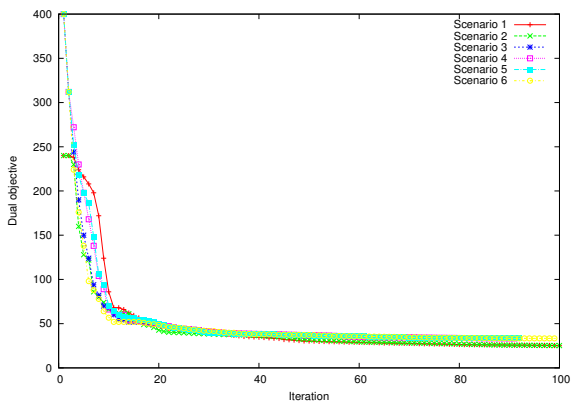


Figure 30: Iteration number vs. dual objective for ZF with fair power control

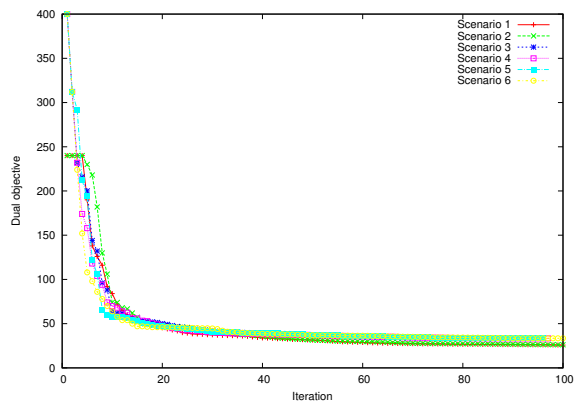


Figure 33: Iteration number vs. dual objective for ZF with downlink power control

## 5 Experiment 4

### 5.1 Scenario 2

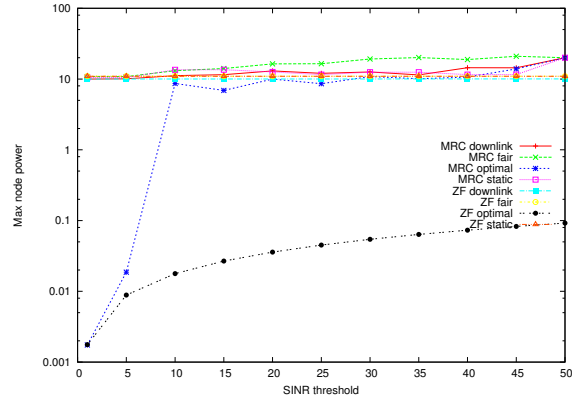


Figure 36: Max node power

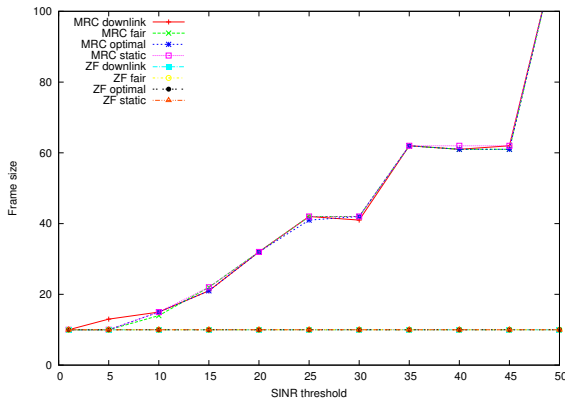


Figure 34: Frame size

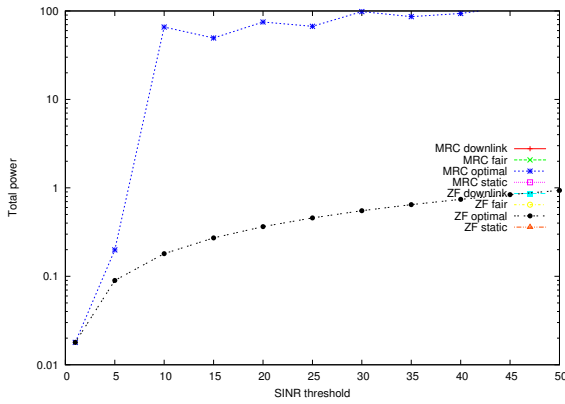


Figure 35: Total power

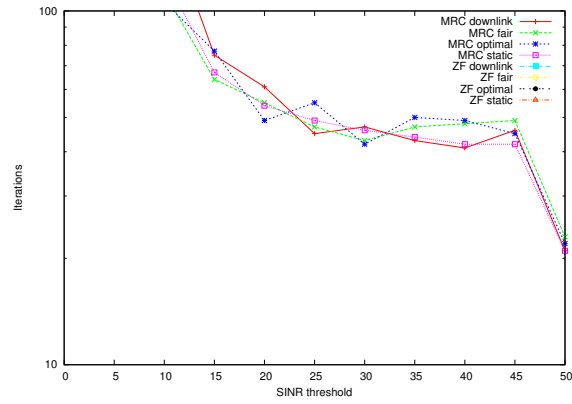


Figure 37: Number of pricing problem iterations

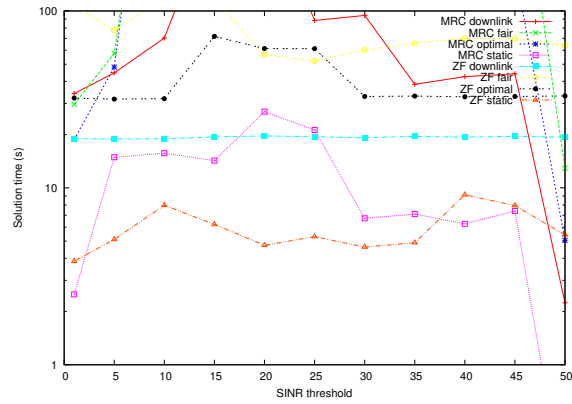


Figure 38: Total solution time

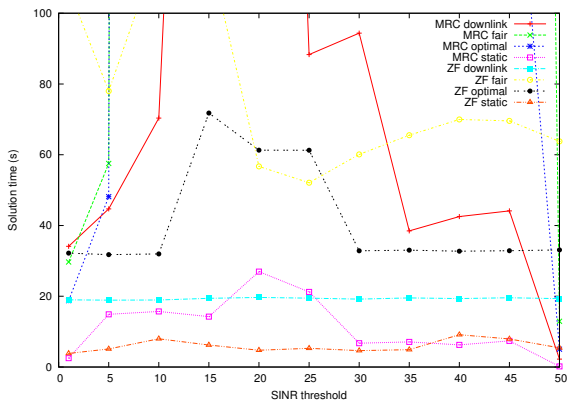


Figure 39: Total solution time, enlarged view

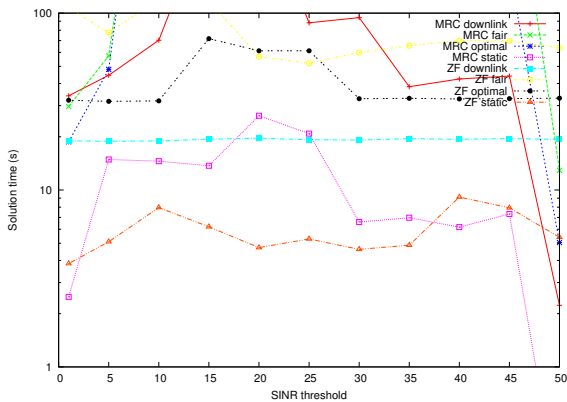


Figure 40: Solution time for pricing problem

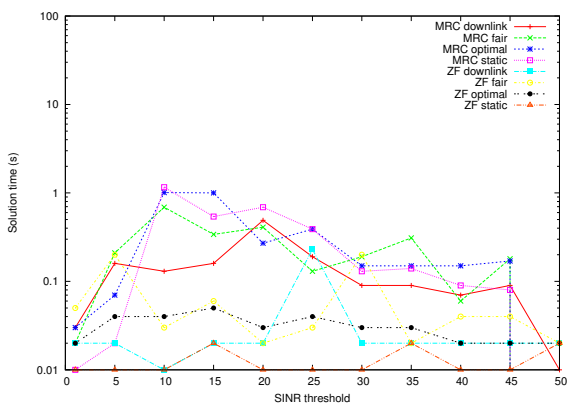


Figure 41: Solution time for master problem

## 5.2 Scenario 3

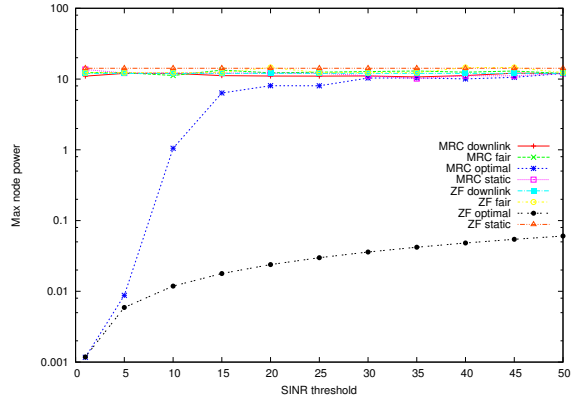


Figure 44: Max node power

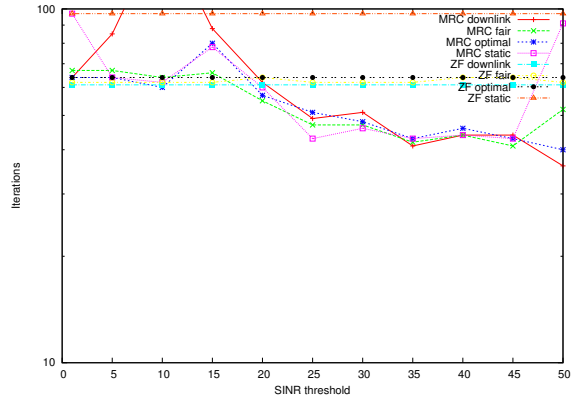


Figure 45: Number of pricing problem iterations

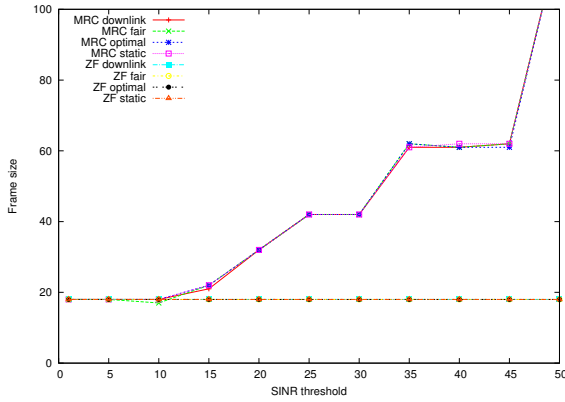


Figure 42: Frame size

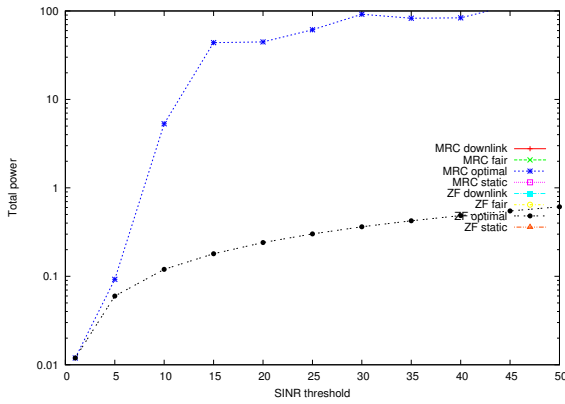


Figure 43: Total power

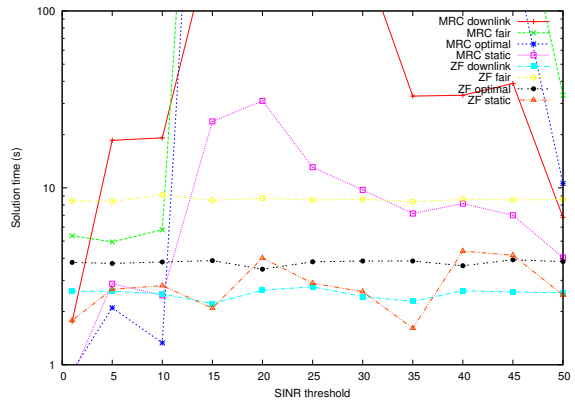


Figure 46: Total solution time

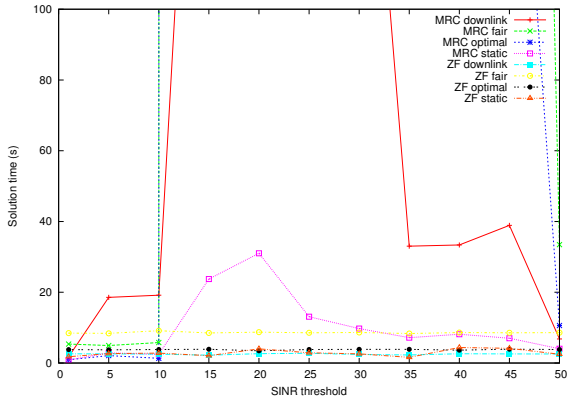


Figure 47: Total solution time, enlarged view

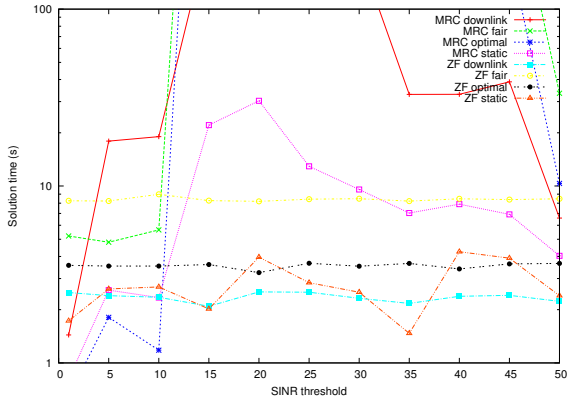


Figure 48: Solution time for pricing problem

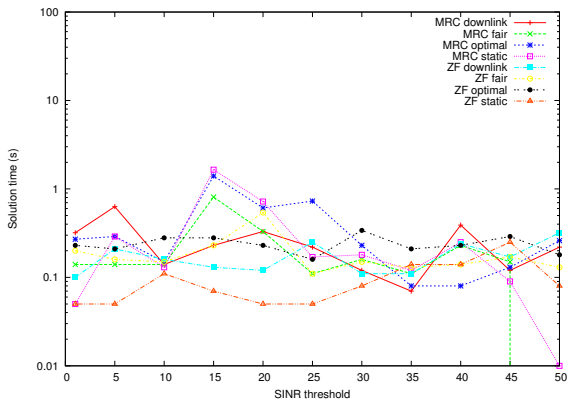


Figure 49: Solution time for master problem

### 5.3 Scenario 4

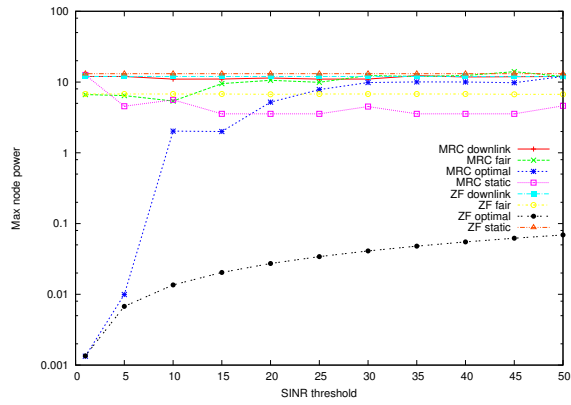


Figure 52: Max node power

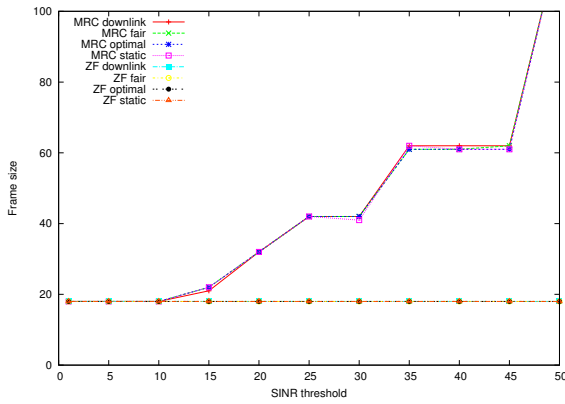


Figure 50: Frame size

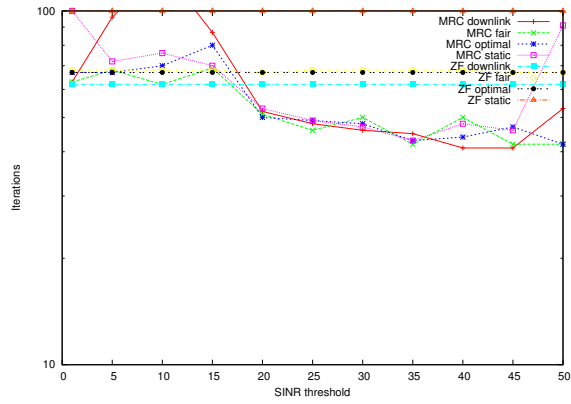


Figure 53: Number of pricing problem iterations

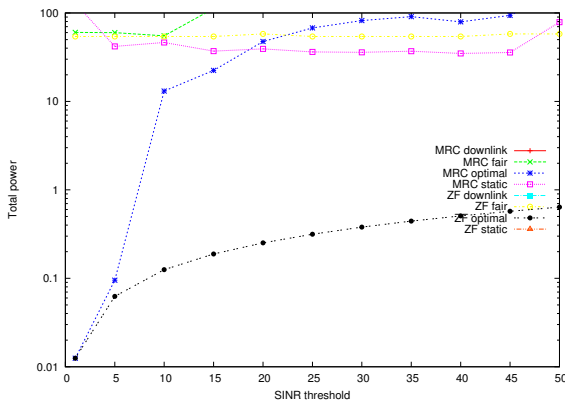


Figure 51: Total power

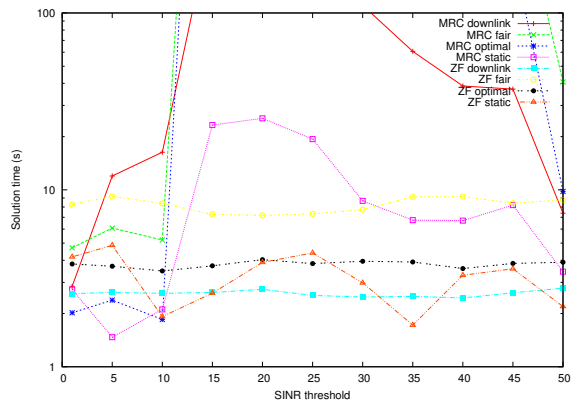


Figure 54: Total solution time

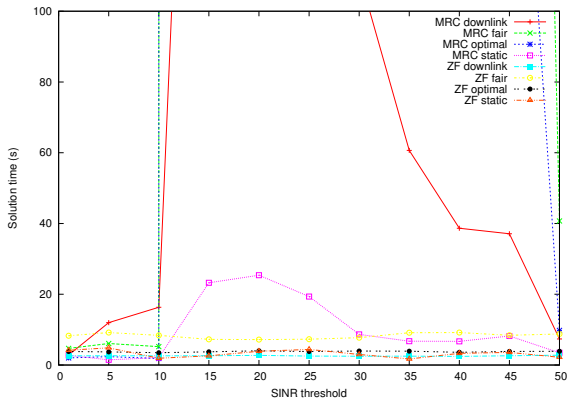


Figure 55: Total solution time, enlarged view

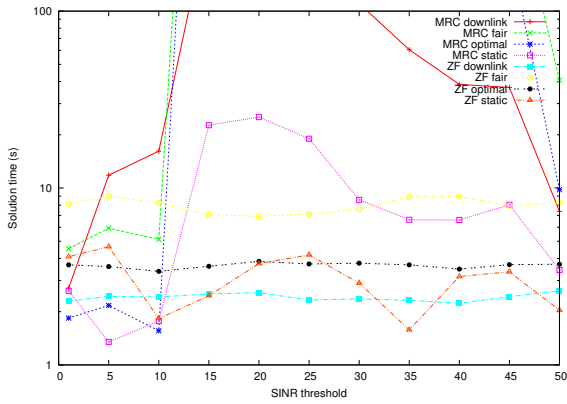


Figure 56: Solution time for pricing problem

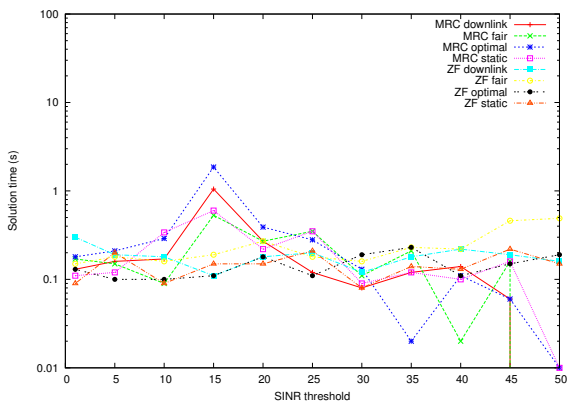


Figure 57: Solution time for master problem

## 5.4 Scenario 5

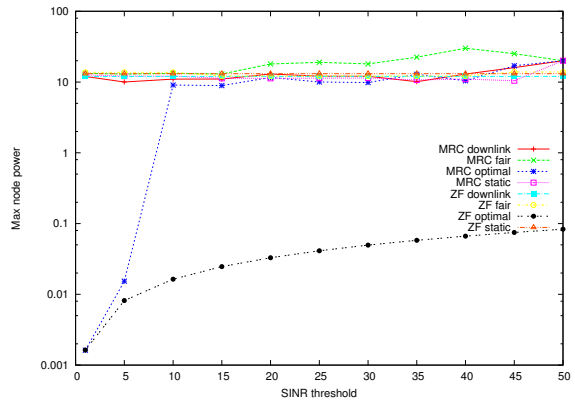


Figure 60: Max node power

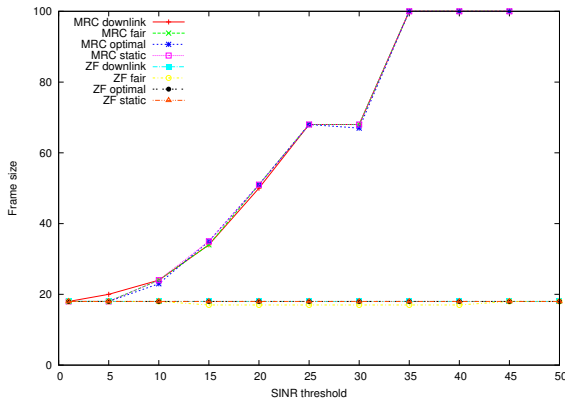


Figure 58: Frame size

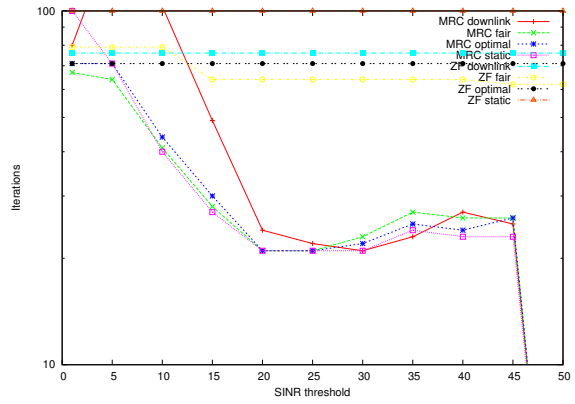


Figure 61: Number of pricing problem iterations

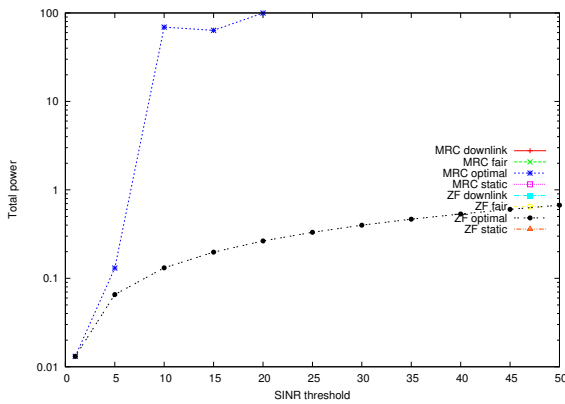


Figure 59: Total power

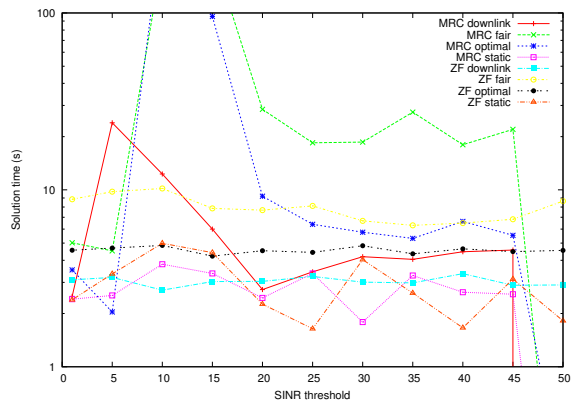


Figure 62: Total solution time



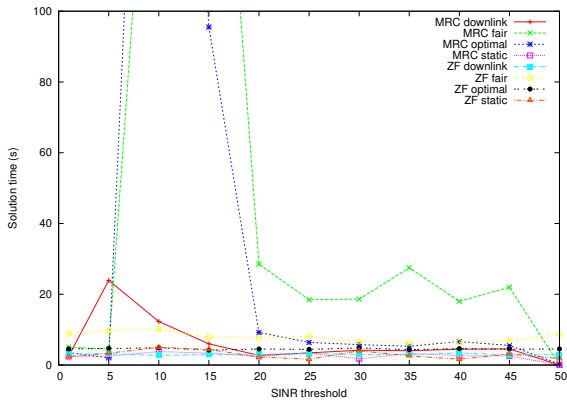


Figure 63: Total solution time, enlarged view

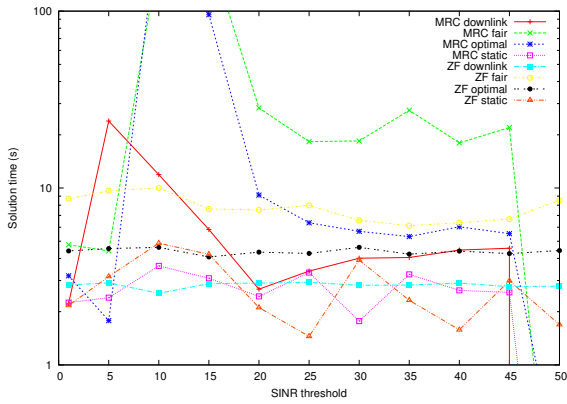


Figure 64: Solution time for pricing problem

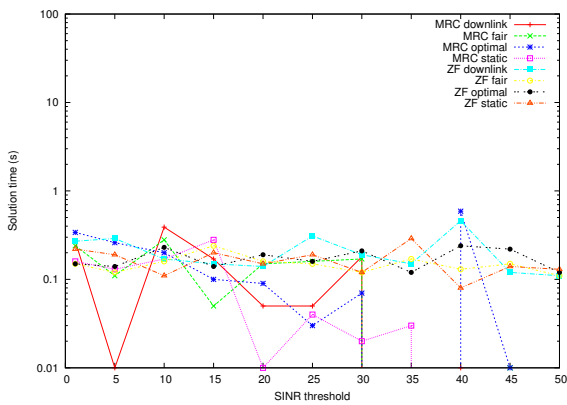


Figure 65: Solution time for master problem

## 5.5 Scenario 6

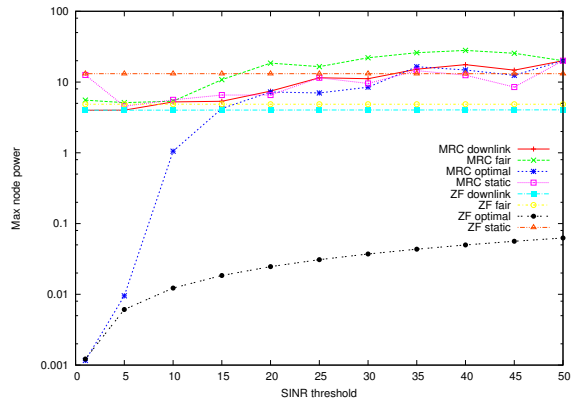


Figure 68: Max node power

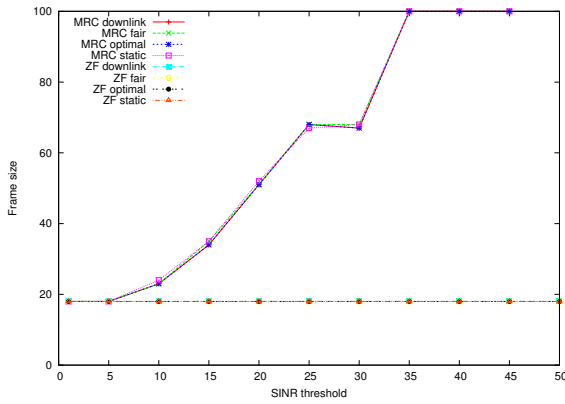


Figure 66: Frame size

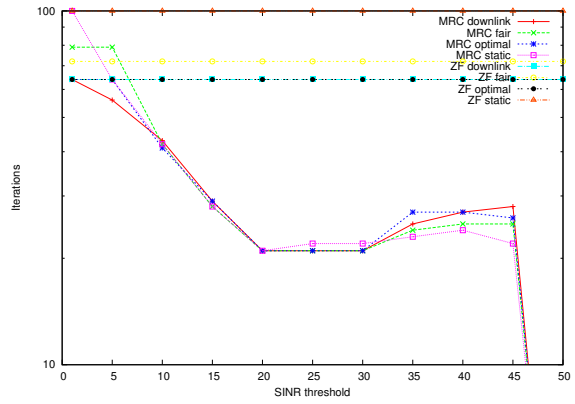


Figure 69: Number of pricing problem iterations

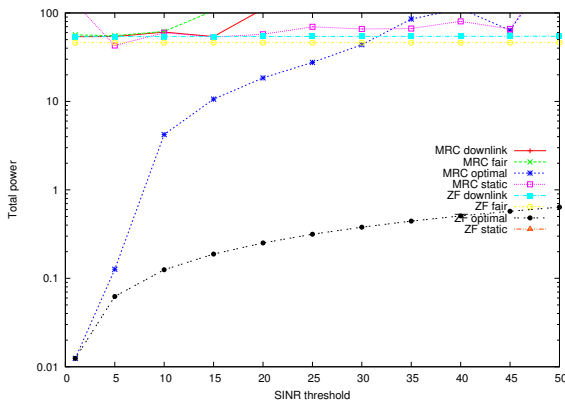


Figure 67: Total power

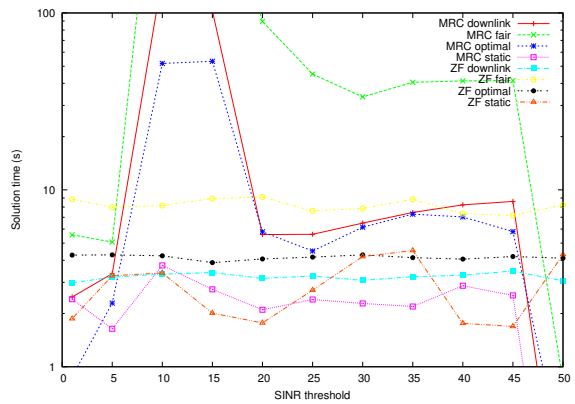


Figure 70: Total solution time

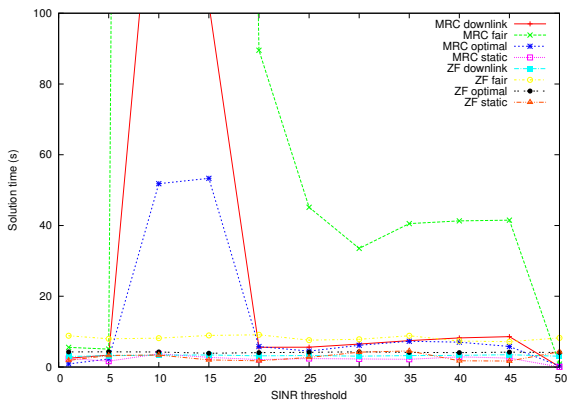


Figure 71: Total solution time, enlarged view

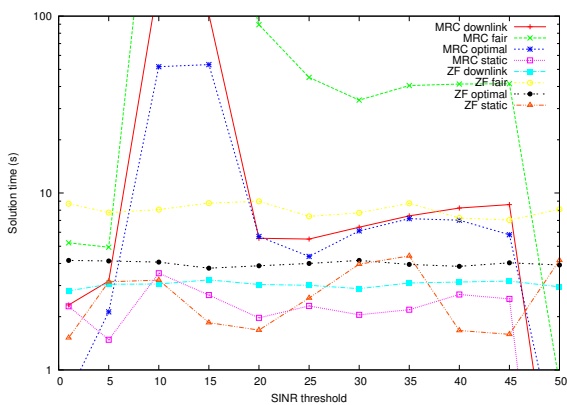


Figure 72: Solution time for pricing problem

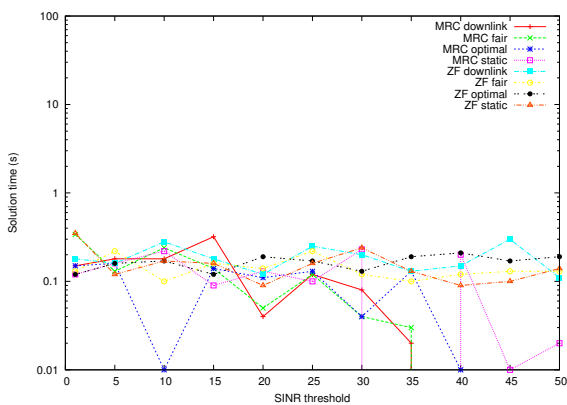


Figure 73: Solution time for master problem

# 6 Experiment 5

## 6.1 Scenario 2

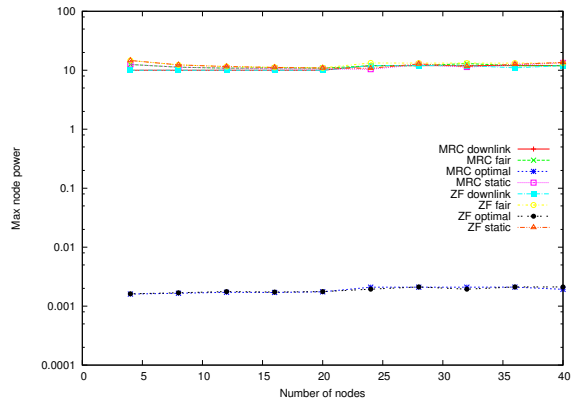


Figure 76: Max node power

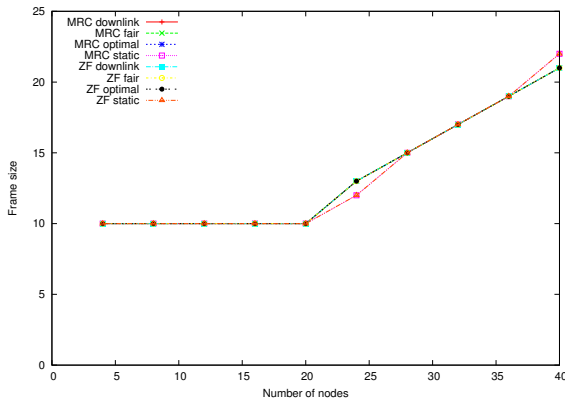


Figure 74: Frame size

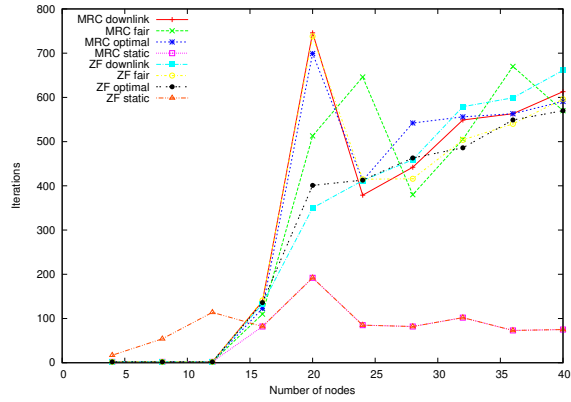


Figure 77: Number of pricing problem iterations

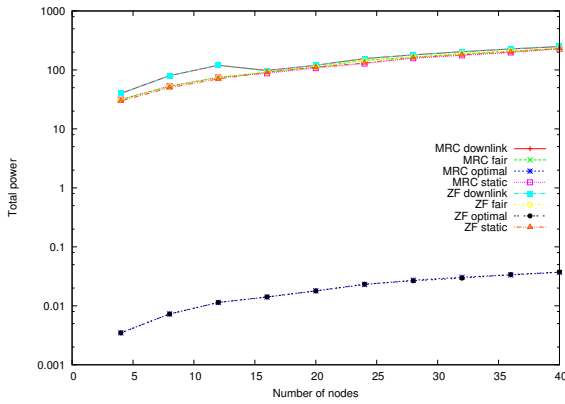


Figure 75: Total power

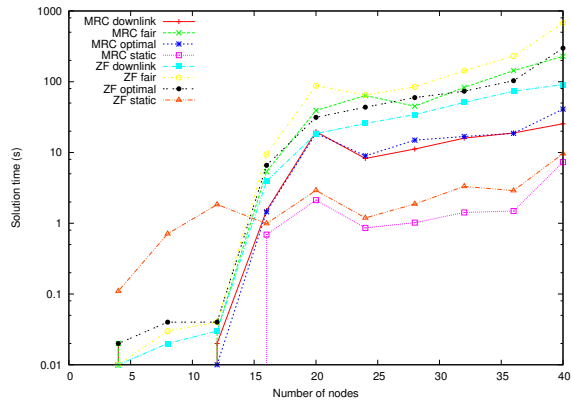


Figure 78: Total solution time

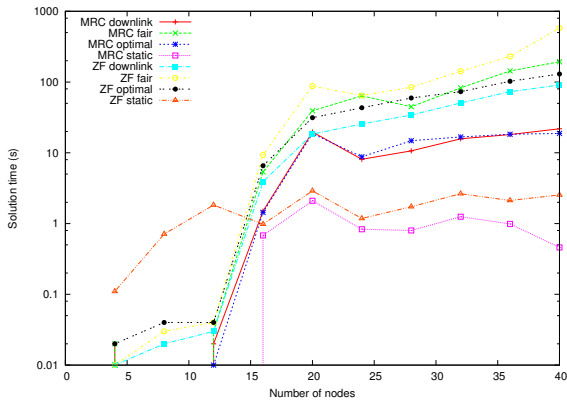


Figure 79: Solution time for pricing problem

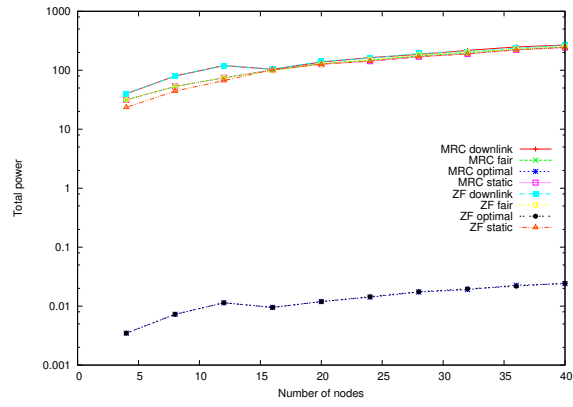


Figure 82: Total power

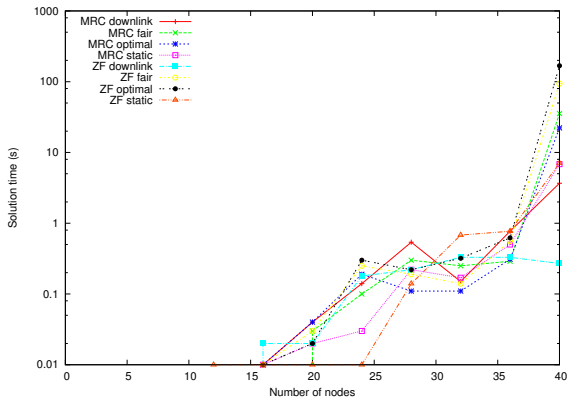


Figure 80: Solution time for master problem

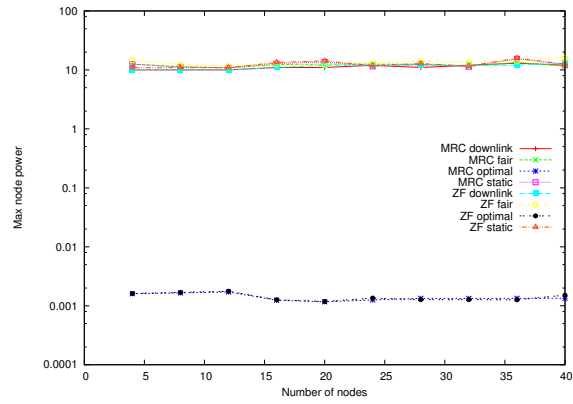


Figure 83: Max node power

## 6.2 Scenario 3

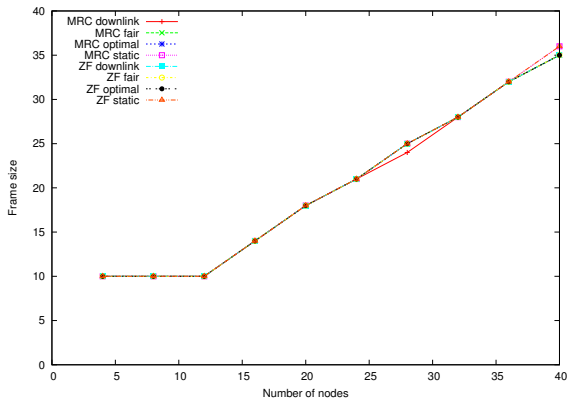


Figure 81: Frame size

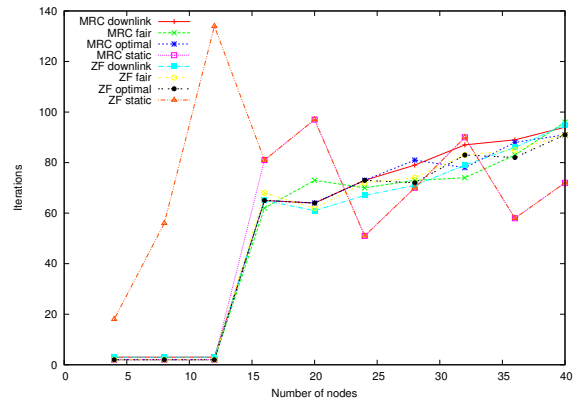


Figure 84: Number of pricing problem iterations

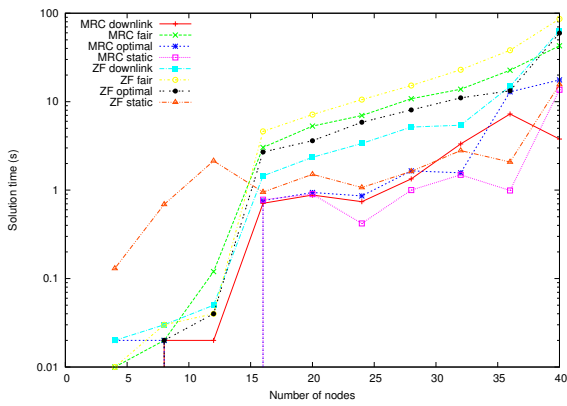


Figure 85: Total solution time

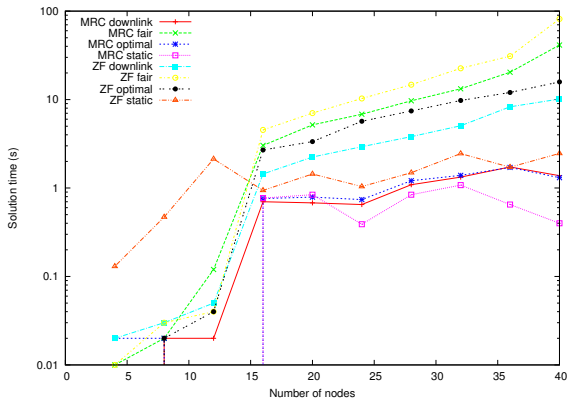


Figure 86: Solution time for pricing problem

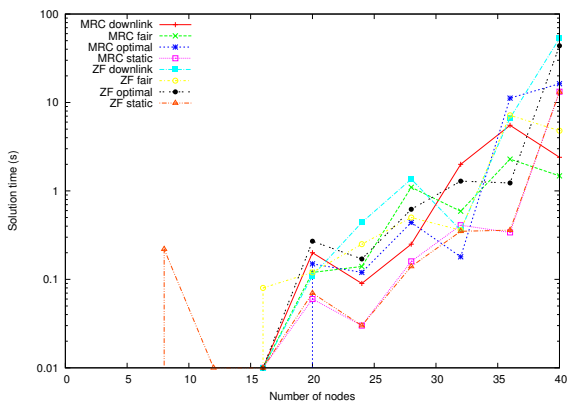


Figure 87: Solution time for master problem

### 6.3 Scenario 4

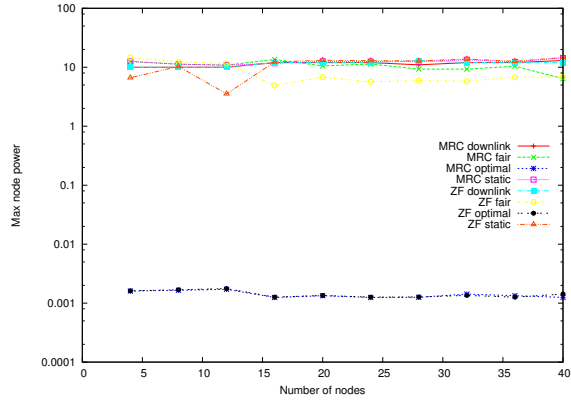


Figure 90: Max node power

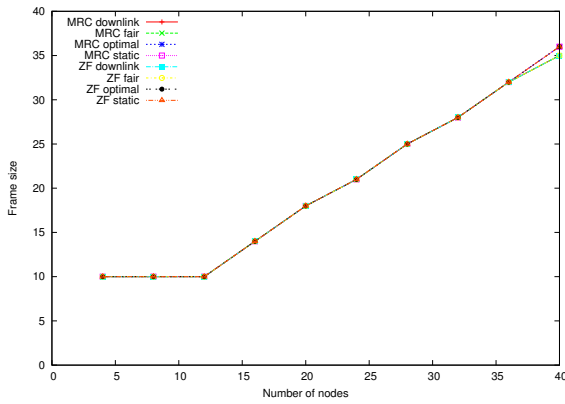


Figure 88: Frame size

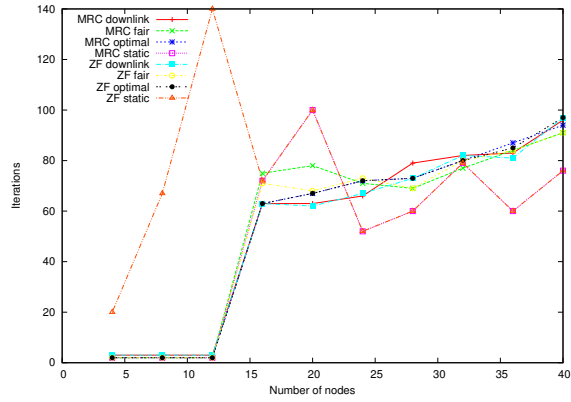


Figure 91: Number of pricing problem iterations

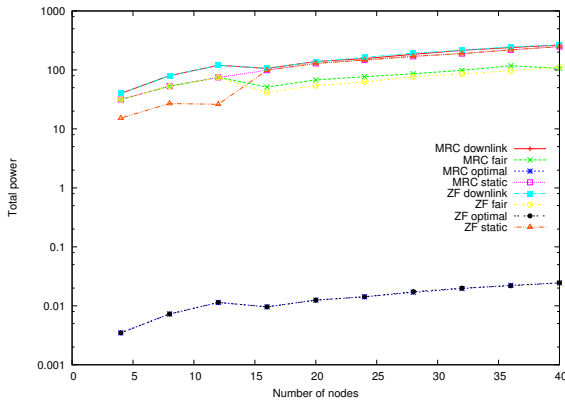


Figure 89: Total power

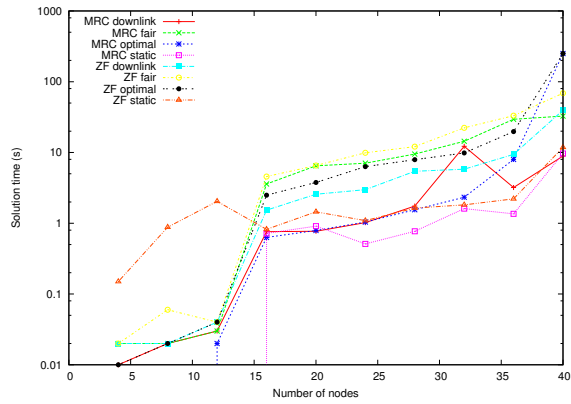


Figure 92: Total solution time

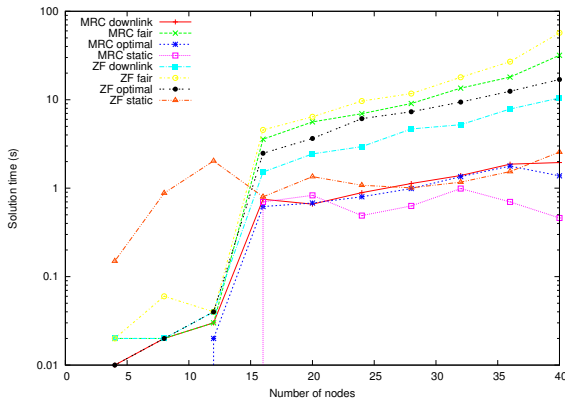


Figure 93: Solution time for pricing problem

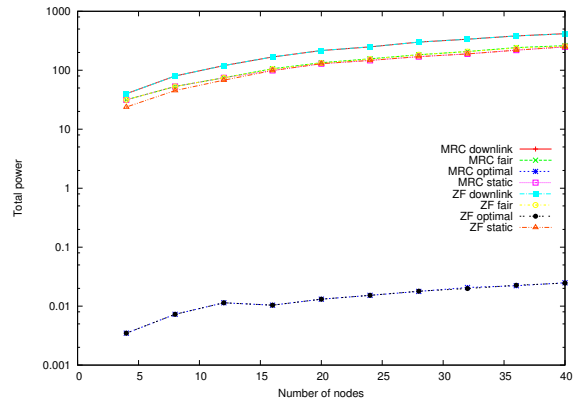


Figure 96: Total power

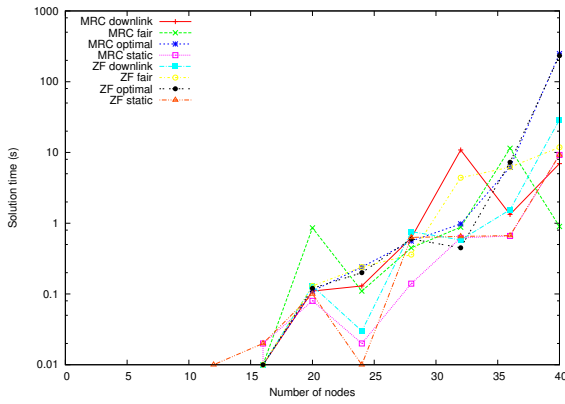


Figure 94: Solution time for master problem

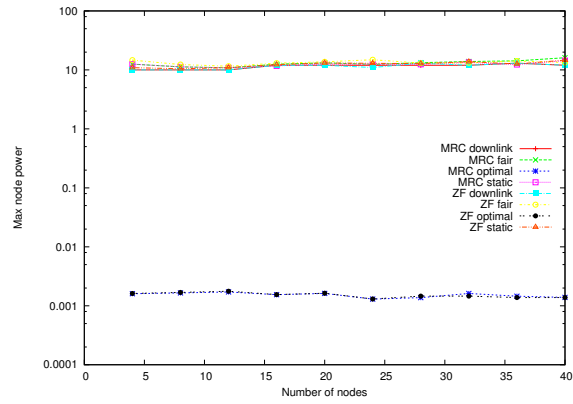


Figure 97: Max node power

## 6.4 Scenario 5

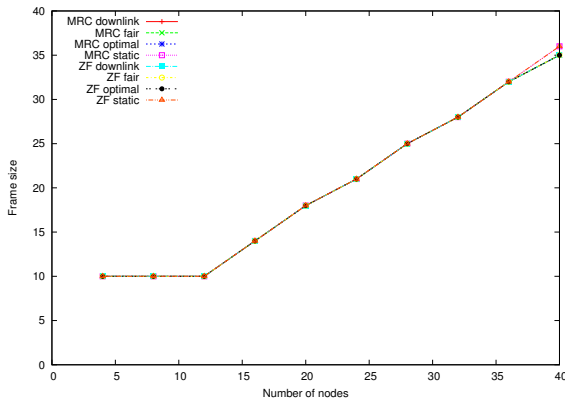


Figure 95: Frame size

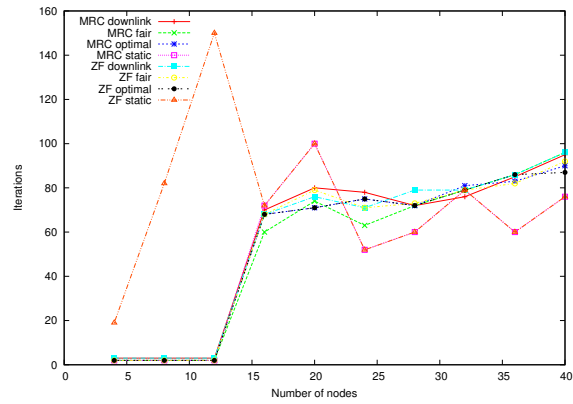


Figure 98: Number of pricing problem iterations



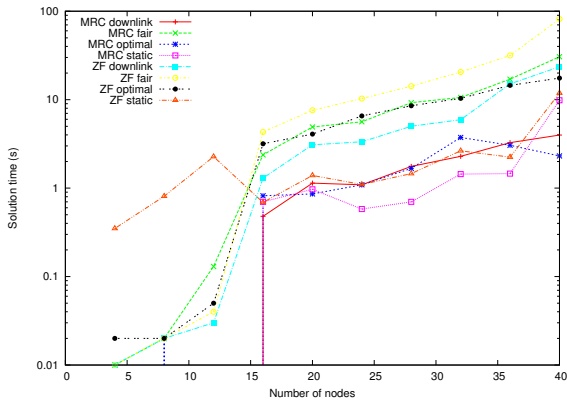


Figure 99: Total solution time

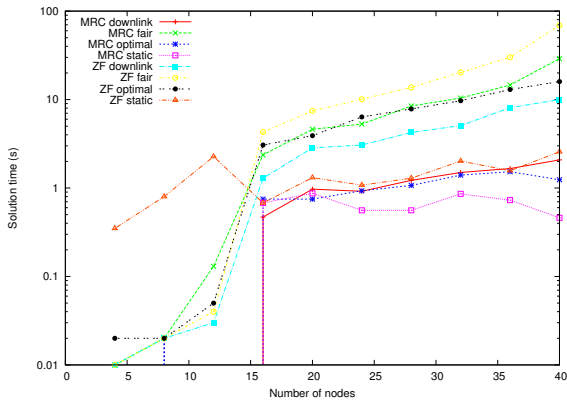


Figure 100: Solution time for pricing problem

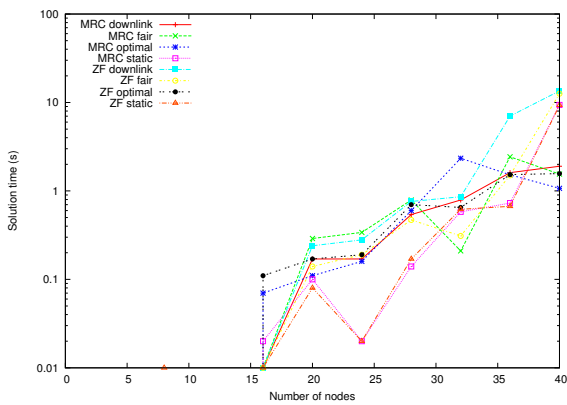


Figure 101: Solution time for master problem

## 6.5 Scenario 6

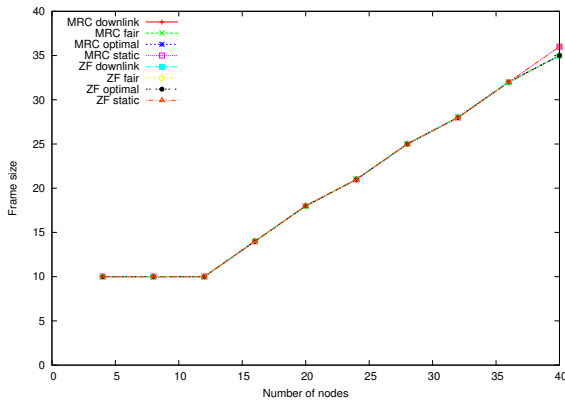


Figure 102: Frame size

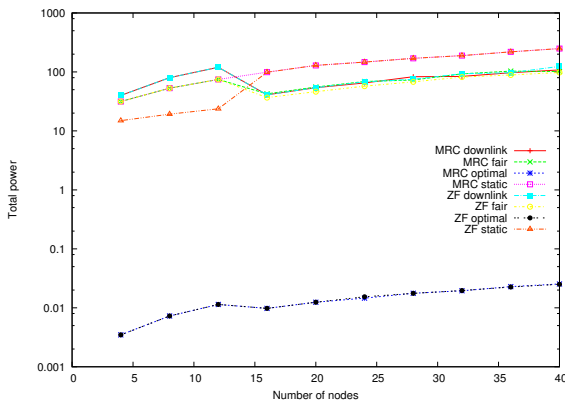


Figure 103: Total power

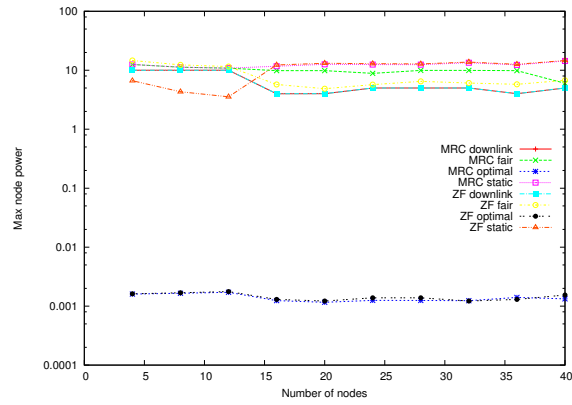


Figure 104: Max node power

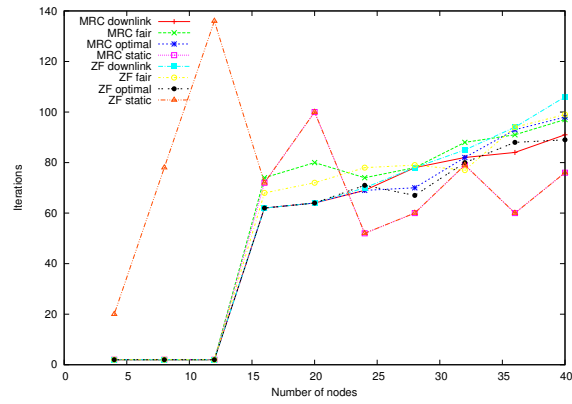


Figure 105: Number of pricing problem iterations

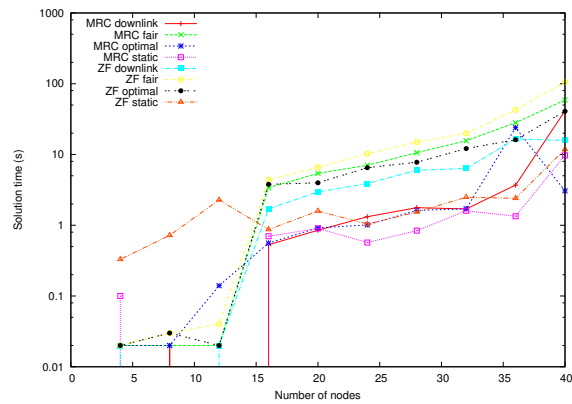


Figure 106: Total solution time

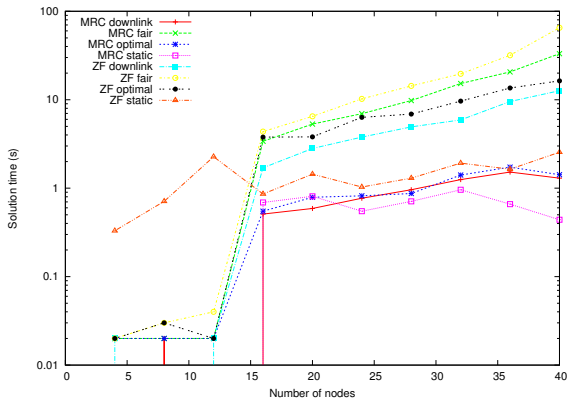


Figure 107: Solution time for pricing problem

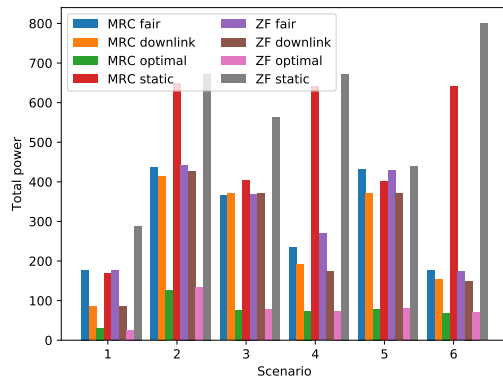


Figure 110: Total power

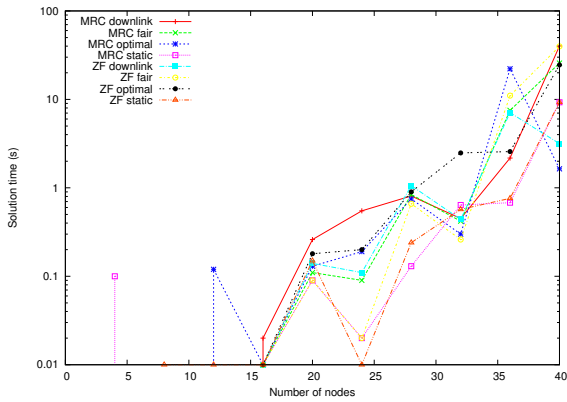


Figure 108: Solution time for master problem

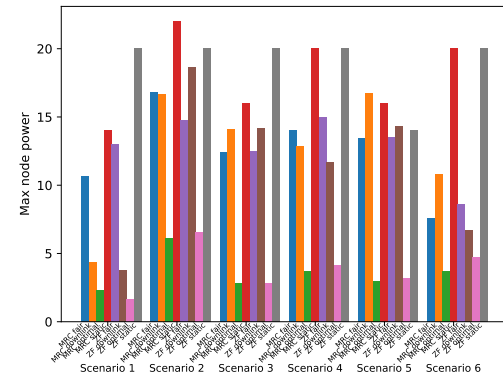


Figure 111: Max node power

## 7 Experiment 6

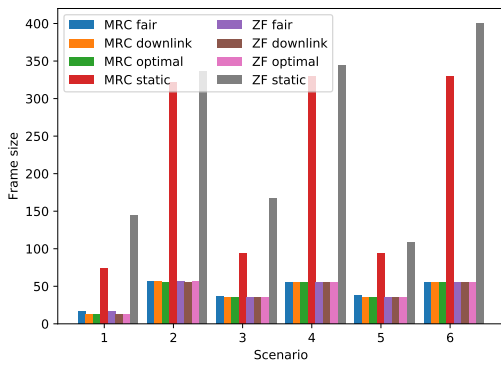


Figure 109: Frame size

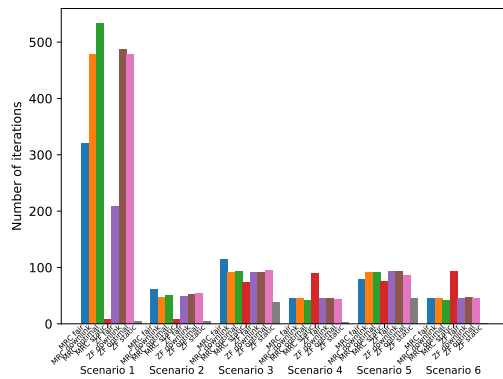


Figure 112: Number of pricing problem iterations

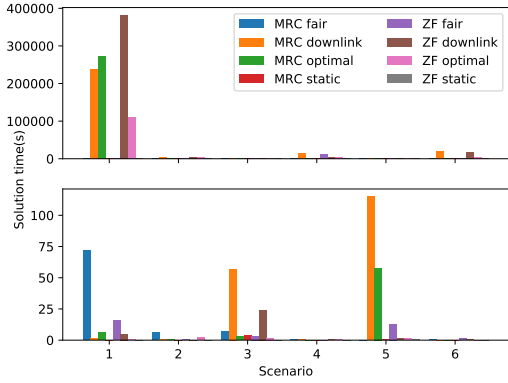


Figure 113: Solution time for the pricing problem (top) and main problem (bottom)

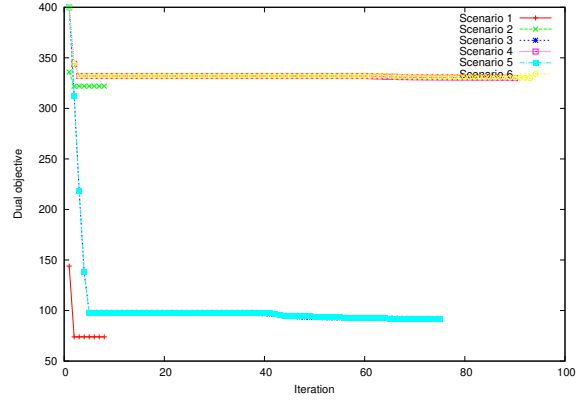


Figure 116: Iteration number vs. dual objective for MRC with static power control

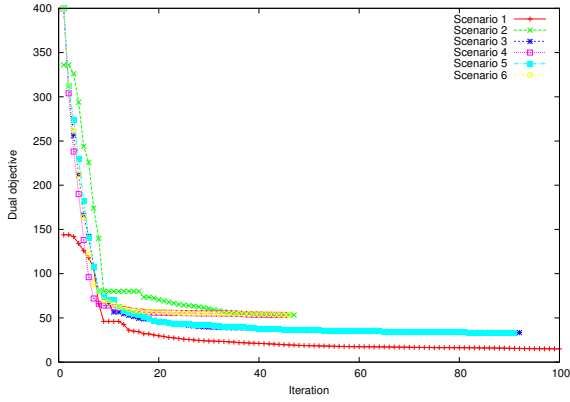


Figure 114: Iteration number vs. dual objective for MRC with fair power control

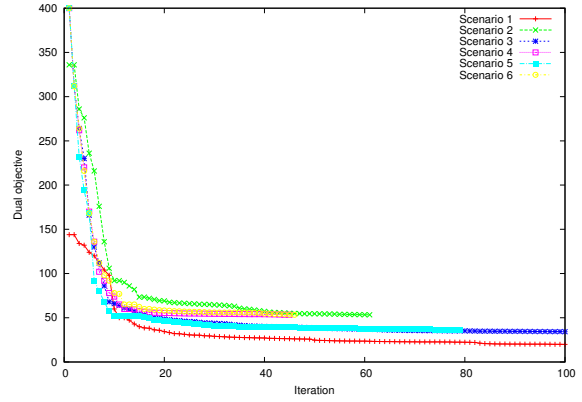


Figure 117: Iteration number vs. dual objective for MRC with downlink power control

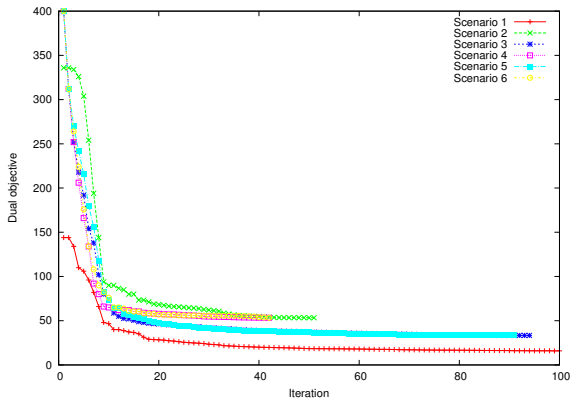


Figure 115: Iteration number vs. dual objective for MRC with optimal power control

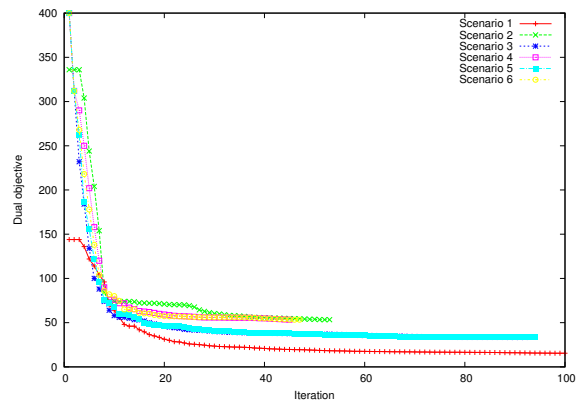


Figure 118: Iteration number vs. dual objective for ZF with fair power control

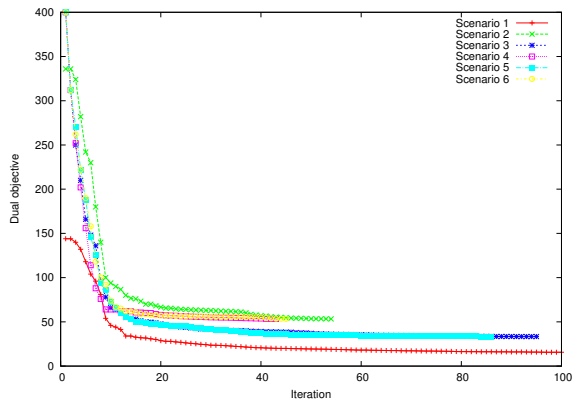


Figure 119: Iteration number vs. dual objective for ZF with optimal power control

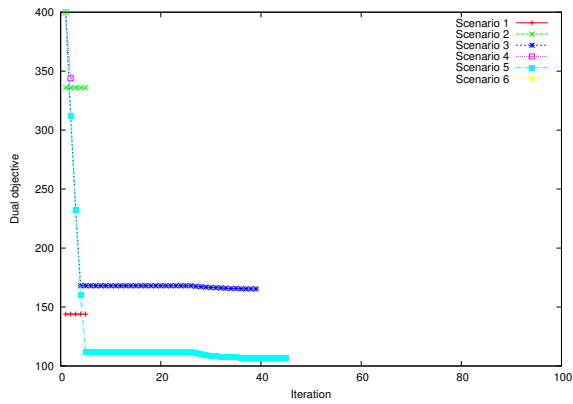


Figure 120: Iteration number vs. dual objective for ZF with static power control

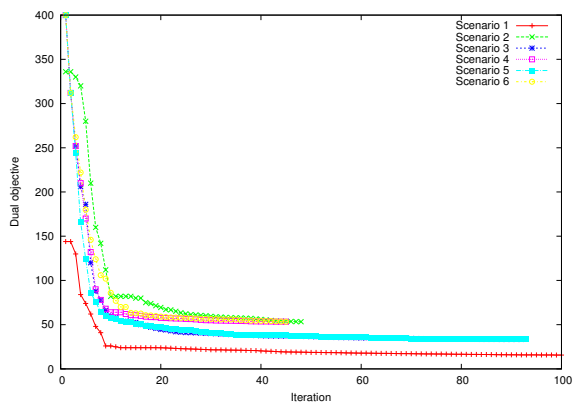


Figure 121: Iteration number vs. dual objective for ZF with downlink power control