

Evaluating IP Routing Schemes with Metric Optimization

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Outline

- Traffic Engineering in IP Networks
- Genetic Algorithms
- Results
 - Failure-free and worst case failures
 - Workaround for an ECMP problem
- Conclusion

TE in IP Networks

- OSPF/IS-IS compute shortest paths based on link weights
- Optimize link weights so that
 - congestion is avoided
 - delay bounds are met
 - ...
- Fortz, Thorup, "Traffic Engineering by Optimizing OSPF Weights"

Objective Function

- **Fixed:**
 - network topology
 - link capacities
 - traffic matrix
- **Given:**
 - link weights (metric)
- **Return:**
 - maximum link load in the network
- **Minimize:**
 - maximum link load

Objective Function

- **Fixed:**
 - network topology
 - link capacities
 - traffic matrix
 - **Given:**
 - link weights (metric)
 - **Return:**
 - maximum link load in the network
 - **Minimize:**
 - maximum link load
- „Environment“
- „Genotype“
- „Fitness“
- „Selective Pressure“

Genetic Algorithms

- Fixed sized population of chromosomes
- Start with random population
 - evaluate each chromosome with objective function
 - select parents according to their fitness
 - crossover: generate children from parents
 - random and directed mutation
- Until #generations reached
- return best chromosome

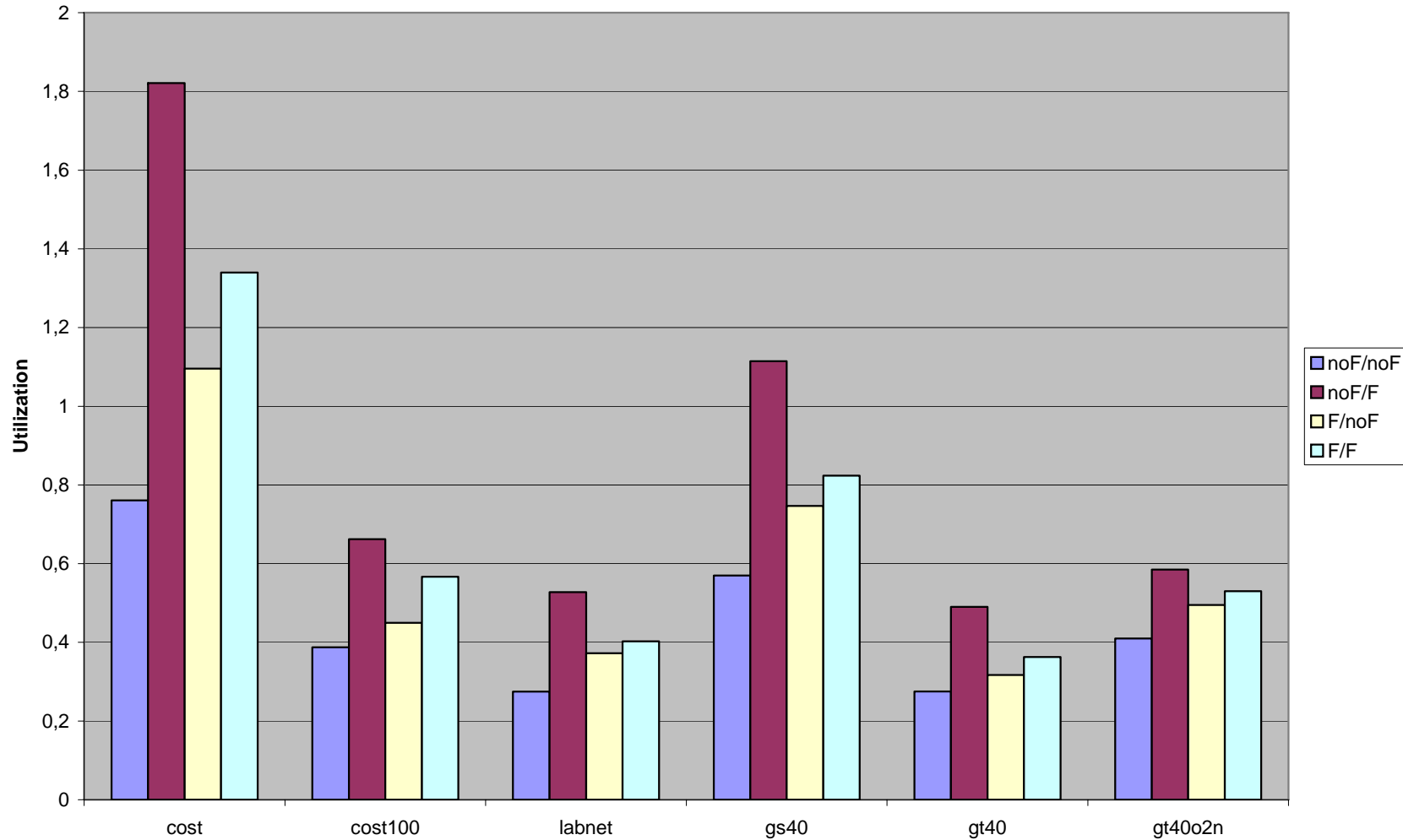
Genetic Algorithms (contd)

- GA randomly selects
 - parents
 - crossover points
 - mutation location and value.
- GA is itself a random variable.
 - Repeat your runs!
- It's not exactly like in biology
 - No speciation, no extinction, no gender, all chromosomes haploid, ...

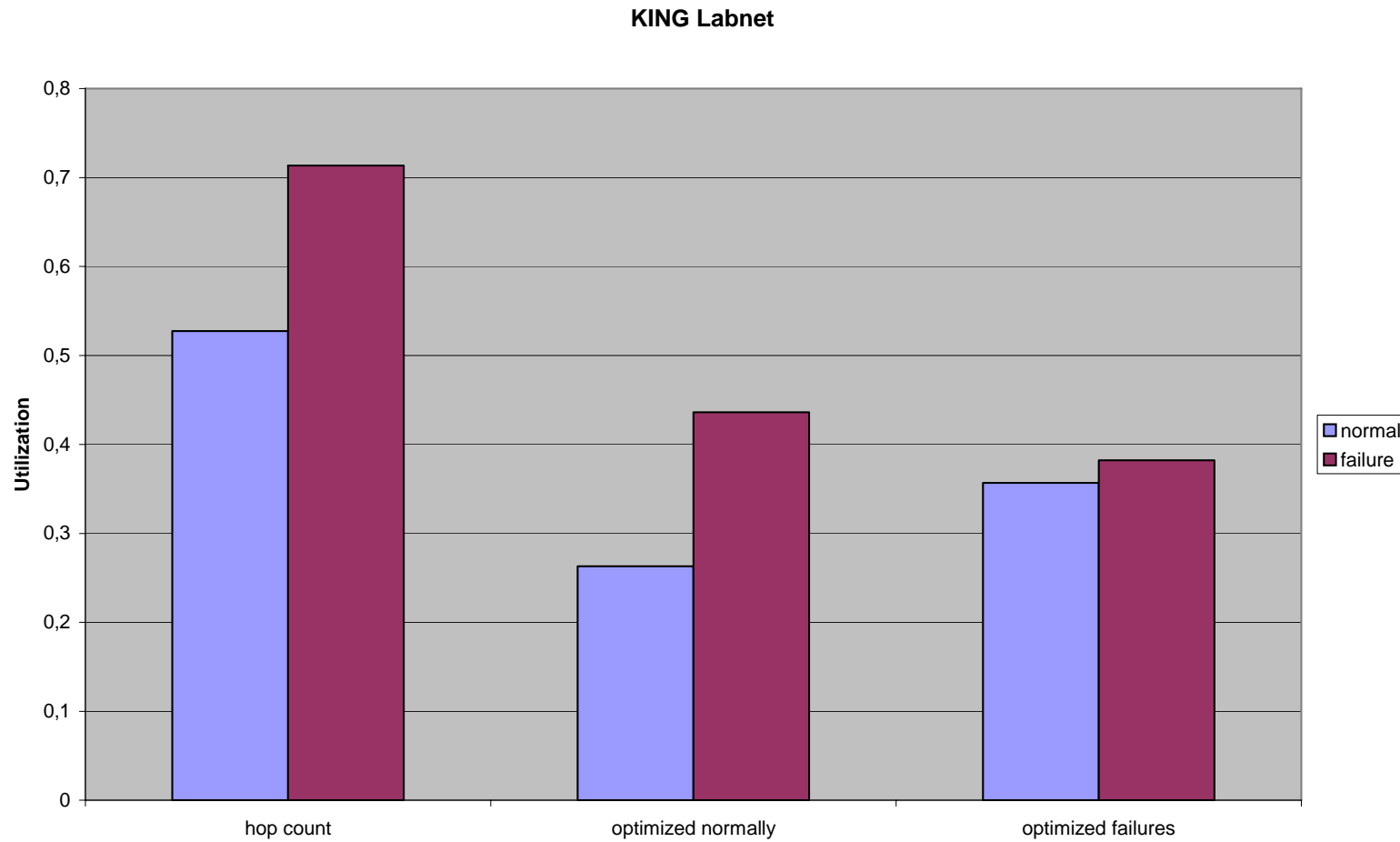
Improvements

- Directed Mutation
 - Increment weight of most loaded link
- Evaluation Cache
 - Store evaluated chromosomes in a cache
 - Cache hit ratio about 50%
- Enhanced Objective Function
 - Worst case failure (incremental SPF)
 - Avoid ECMP multi-split points

Results with and w/o Failures

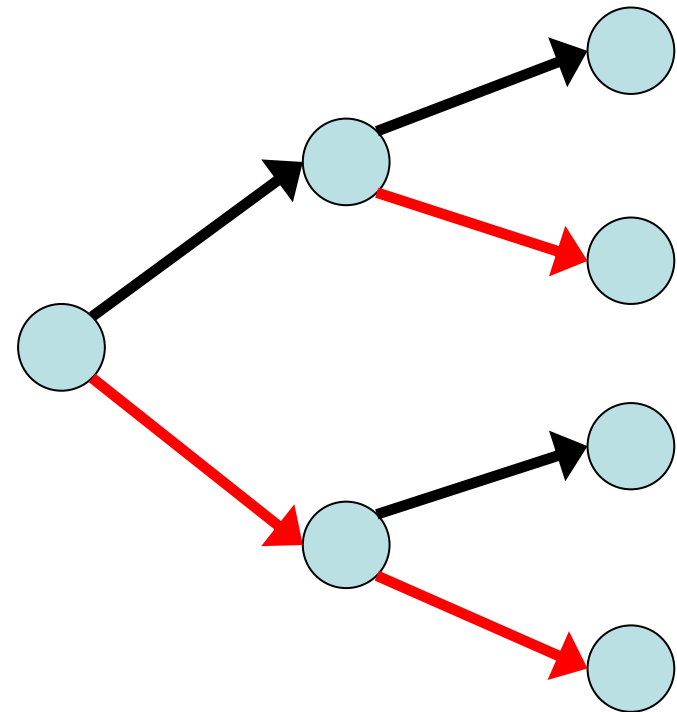


Results for the KING Labnet

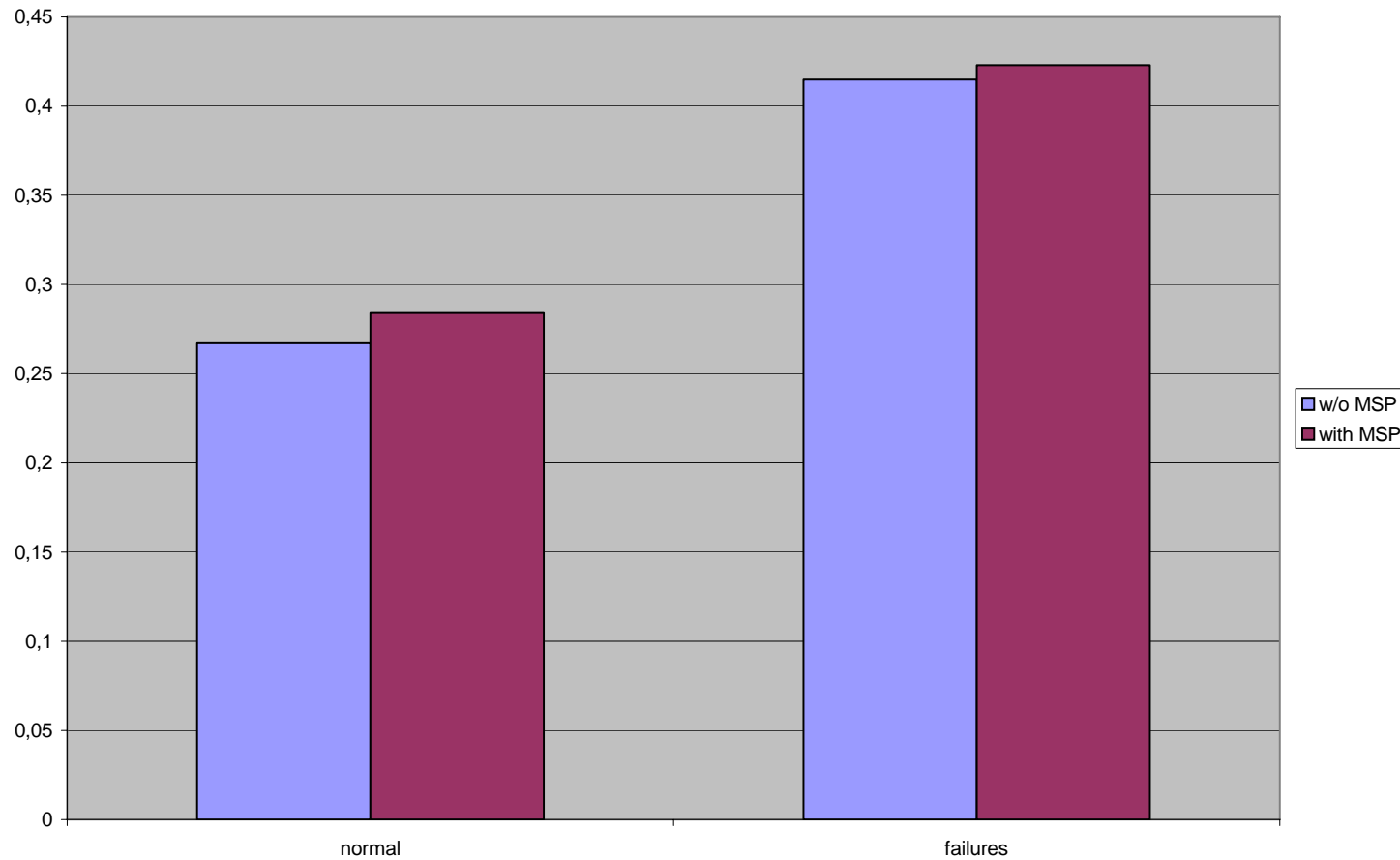


Problem with ECMP Hashing

- Problem:
 - If all Routers use the same ECMP hash function, packets of a given microflow travel either along paths solely black or solely red!
- Workaround:
 - Split flows at most once.
- Approach:
 - Selective pressure on #splitpoints



Results for the KING Labnet



Conclusion

- Metric optimization can drastically reduce max. link load in cases with or without failures.
- Optimizing for failures increases MLL for normal case slightly.
- Optimization even enables to work around bugs.

Thank You!

QUESTIONS ?