Derivation of Fault Tolerance Measures of Self-Stabilizing Algorithms by Simulation

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Motivation

Analytical approach presented in "Reliability and Availability Analysis of Self-Stabilizing Systems" (SSS06)

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  - the method exhibits conservative assumptions only (worst case).
- In this work, we present a simulation framework that delivers average measures in an accurate, timely and extremely scalable fashion.

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  - highly reliable (nine nines, χ^2-test)
  - distributed (to cope with CPU demanding algorithms)
  - platform independent (even heterogeneous Windows/Linux clusters)
- support for large scale models (about 1,000 nodes per GB RAM; analytic approach limited to seven nodes!)

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  - Leader Election
  - Mutual Exclusion
- easy to extend

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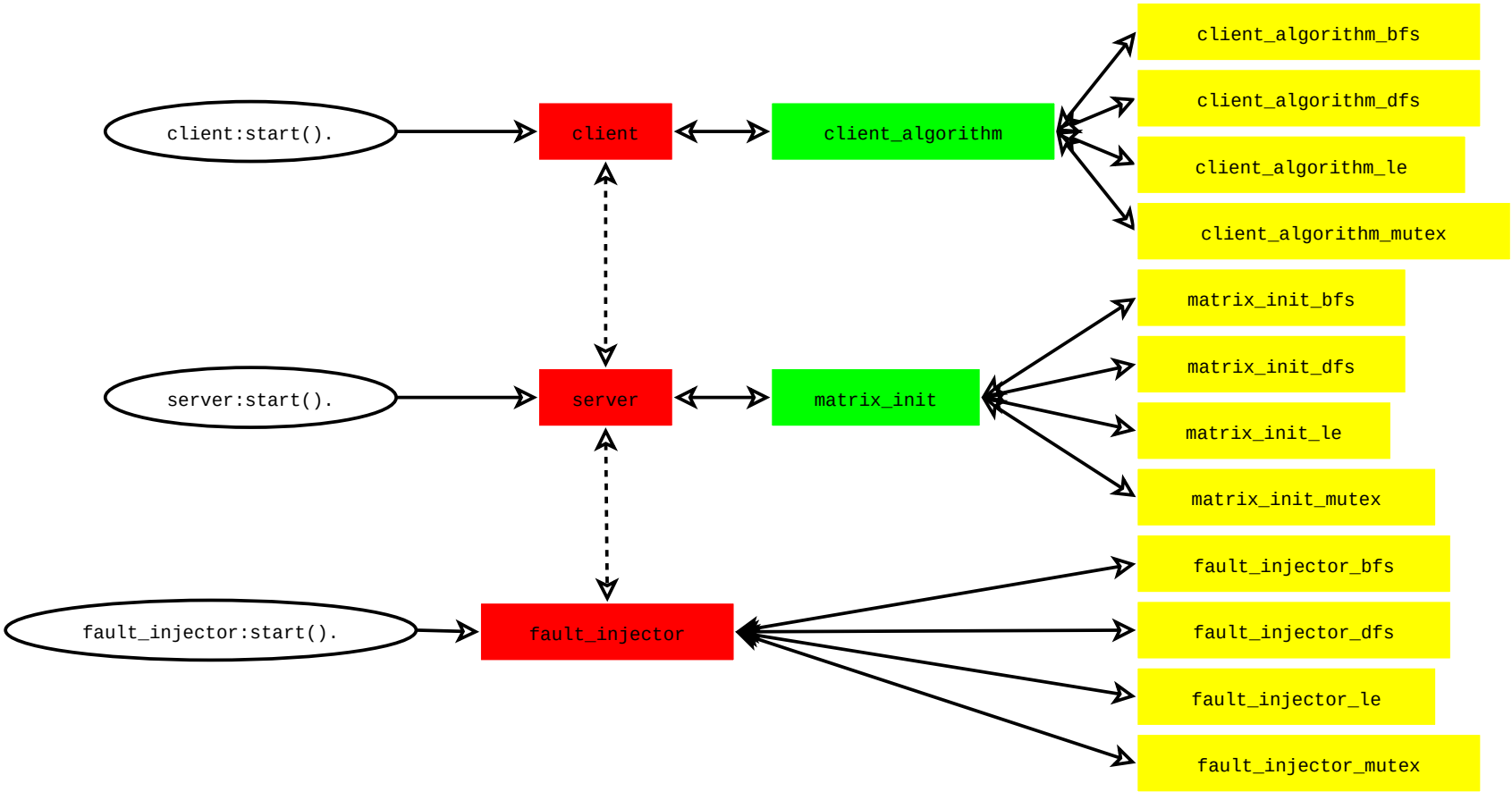
- external fault injection and monitoring facilities
- event logging (if needed)
- choice of schedulers (three provided)
- uses *discrete time Markov chains* as system model

Simulation Framework 4/5

```
7> server:start().
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%                                                                     %%%%%
%%%%%                               SiSSDA                                %%%%%
%%%%%                                                                     %%%%%
%%%%%                               v "1.0"                               %%%%%
%%%%%                                                                     %%%%%
%%%%%                                                                     %%%%%
%%%%%                  Welcome to the Simulator for                       %%%%%
%%%%%              Self-Stabilizing Distributed Algorithms                %%%%%
%%%%%                                                                     %%%%%
%%%%%                               SERVER                                %%%%%
%%%%%                                                                     %%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%% INITIALIZATION-PHASE 1: CHOOSE ALGORITHM                            %%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
true
%%%%% The following algorithms are available:                             %%%%%
%%%%%    [1]bfs
%%%%%    [2]dfs
%%%%%    [3]le
%%%%%    [4]mutex
%%%%% Please enter the appropriate number [n.]>
```

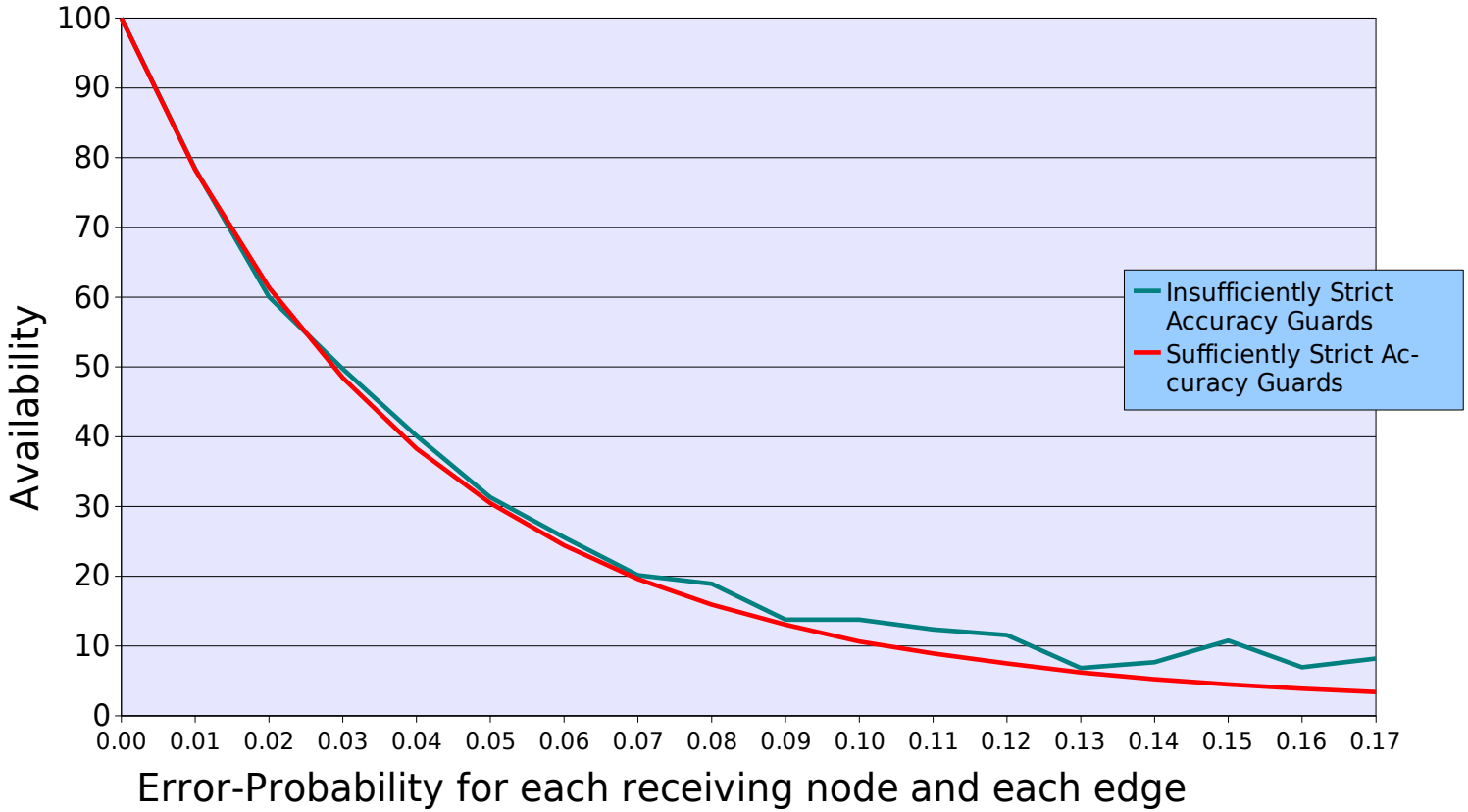
Simulation Framework 5/5



Accuracy 1/2

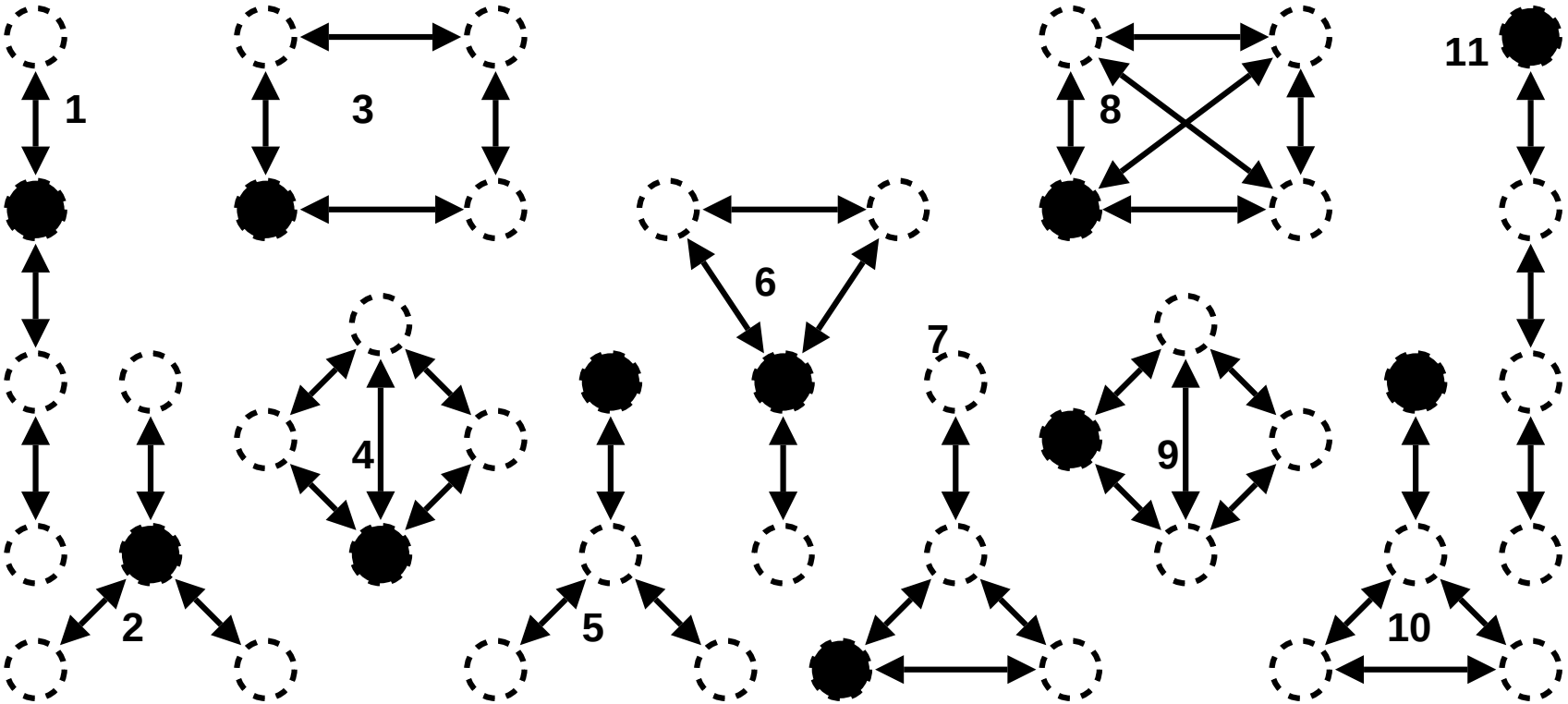
This figure exemplifies availability for first $20,000$ steps of an eight-processor system. The desired accuracy is reached if maximum the deviation within last n steps is lower than a certain barrier. The Results presented in the following feature about $1,000,000$ steps per system node.

Accuracy 2/2



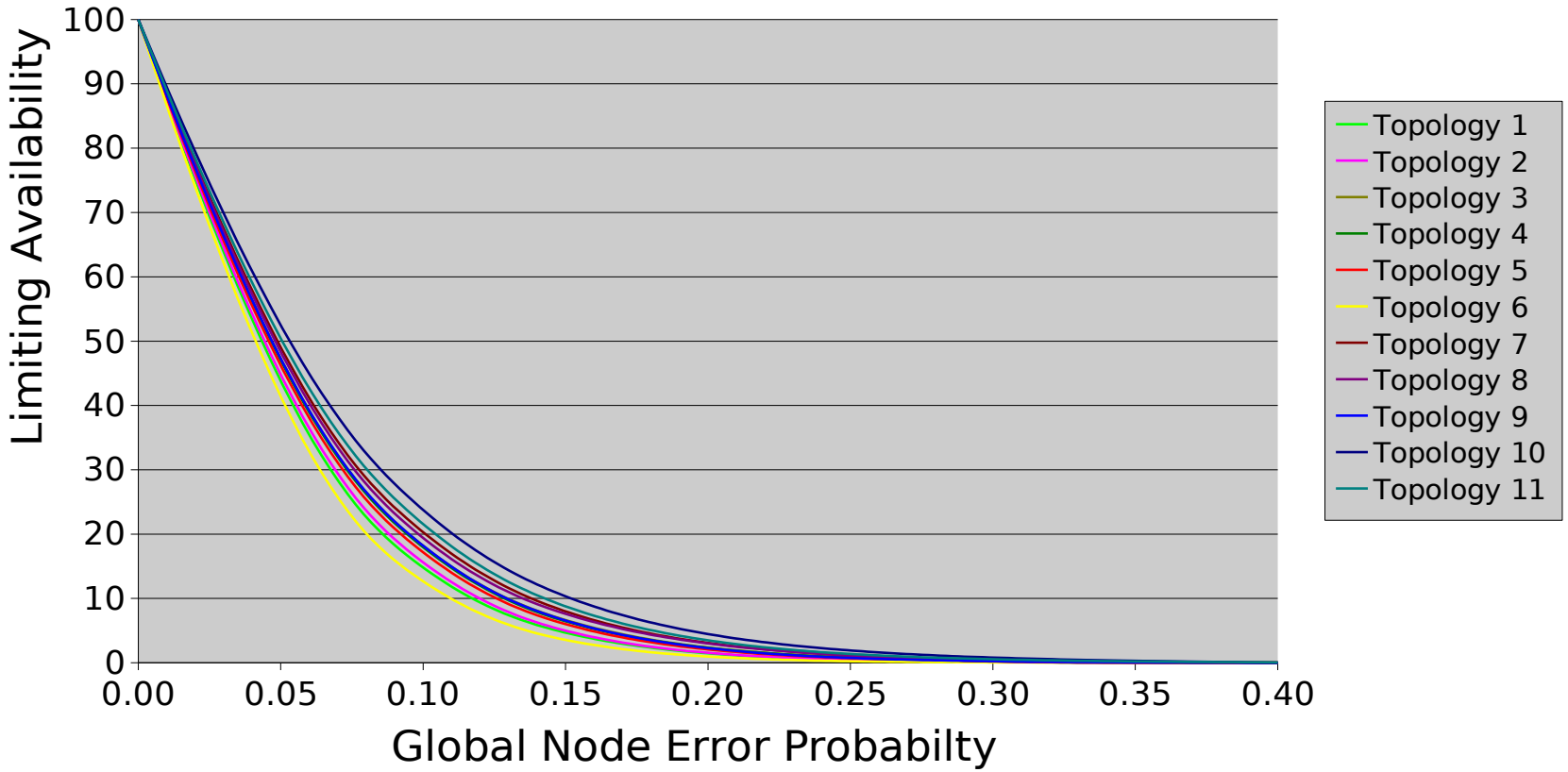
Strictness of accuracy guards is crucial for reliability of results!

Test Case: All Possible 4-node Graphs

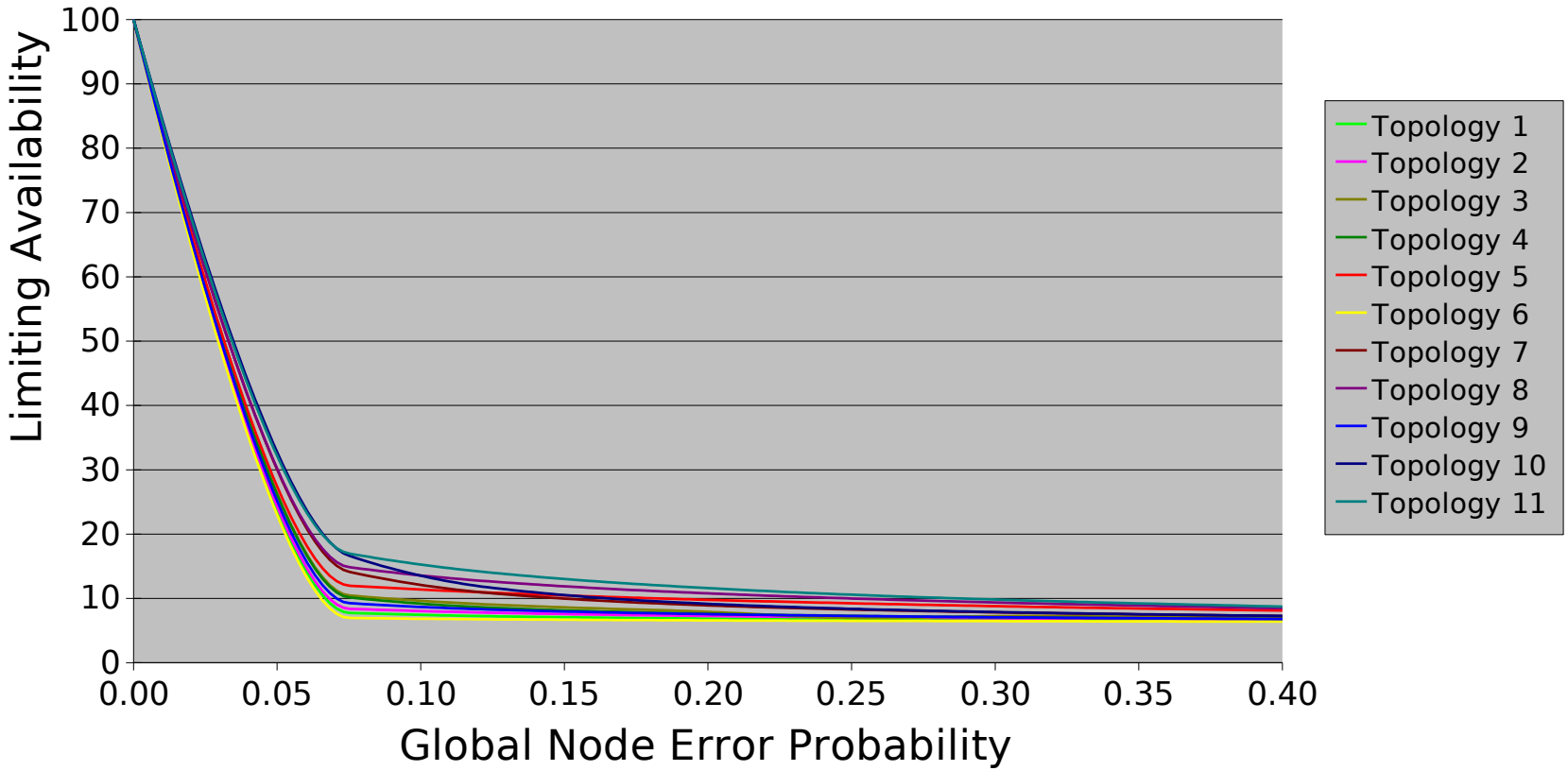


We chose *depth first search* (DFS) and *breadth first search* (BFS) algorithms for comparison with the analytic approach, executed on all possible 4-node graphs.

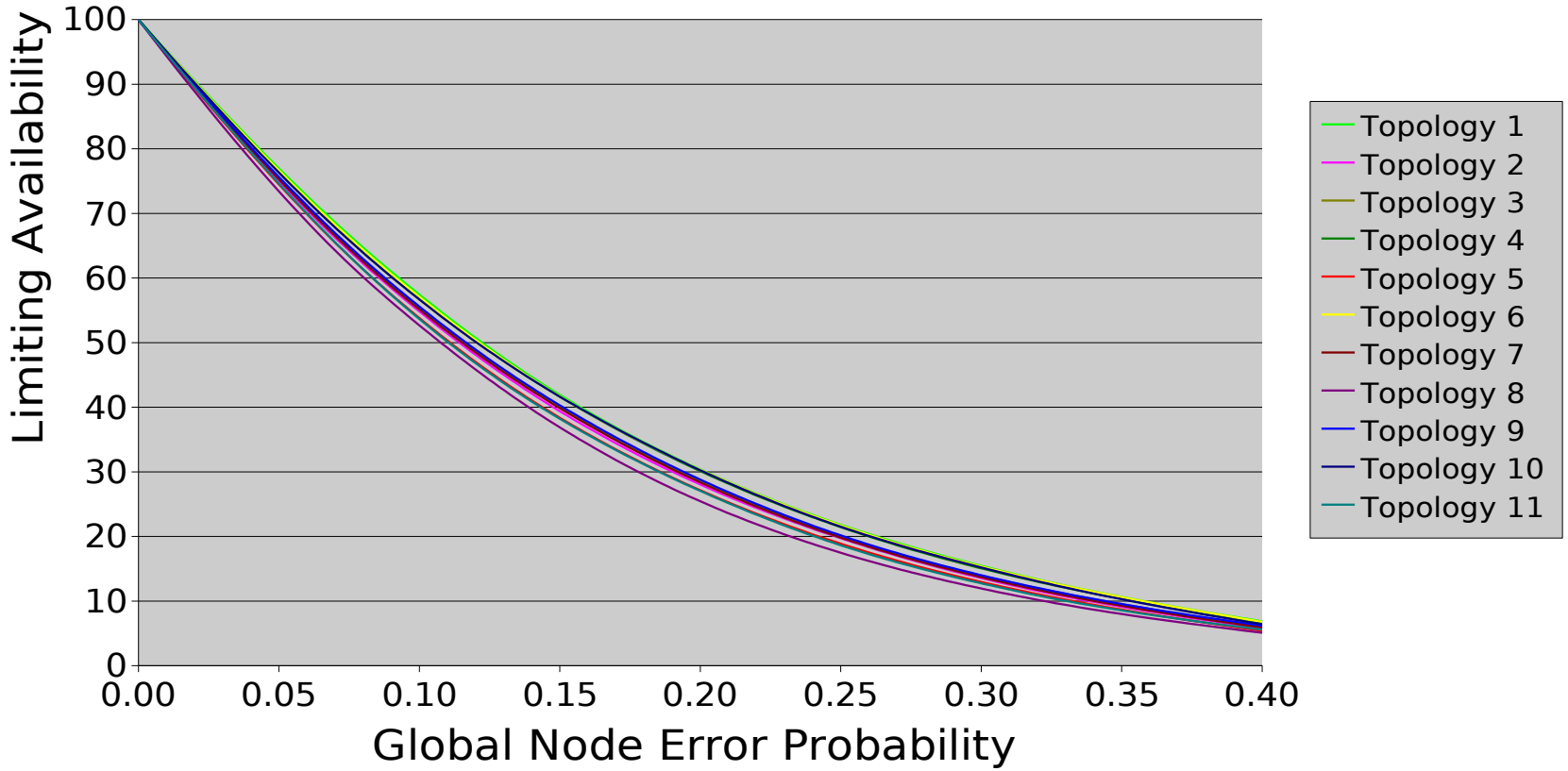
Breadth First Search - Simulation



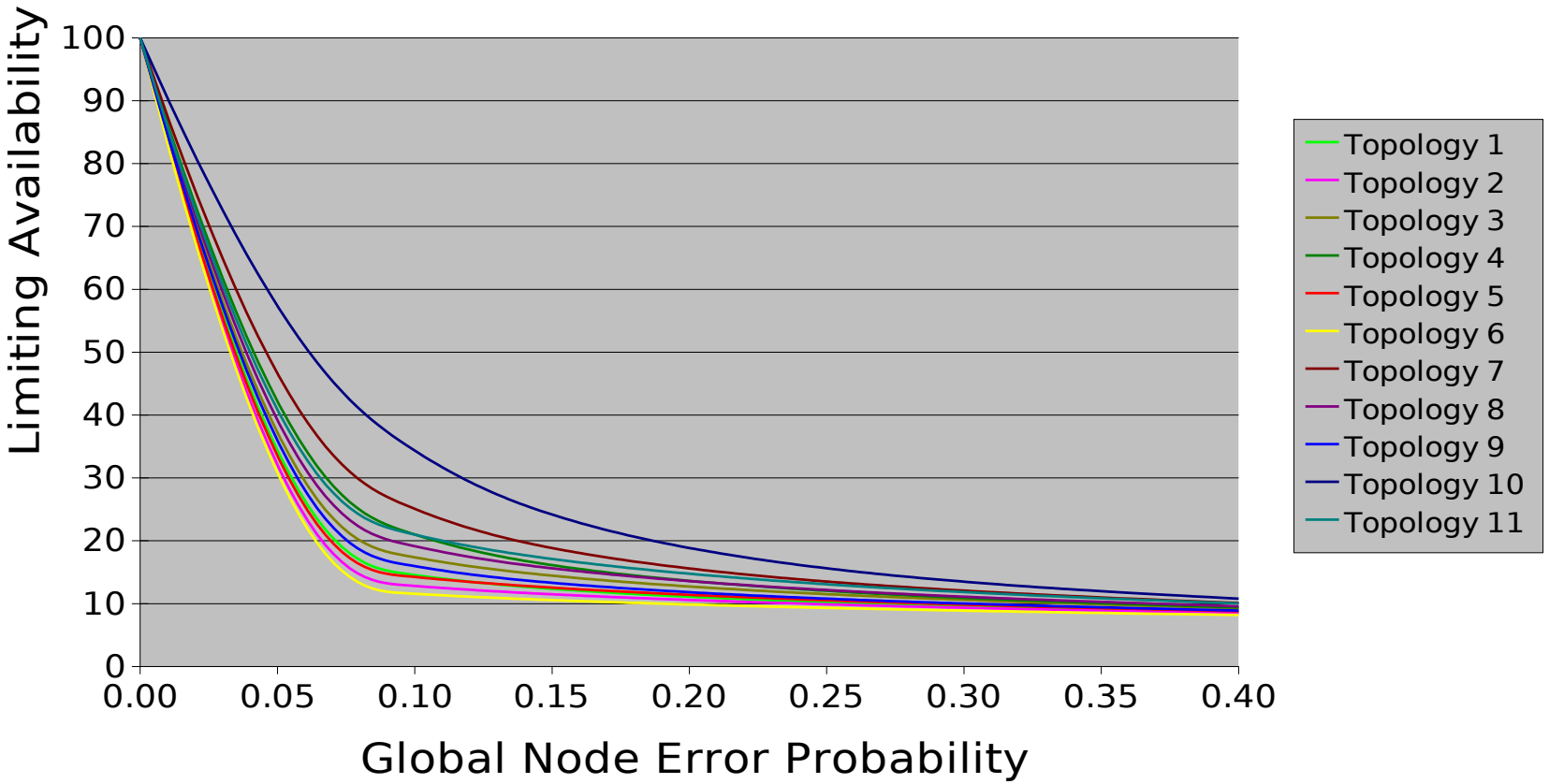
Breadth First Search - Analysis



Depth First Search - Simulation



Depth First Search - Analysis



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- reason: analytic method is insufficient
- method: simulation of self-stabilizing distributed algorithms
- features: modular design, scalability, performance, reliability of results


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