UNIVERSITEIT GENT

FACULTY OF ENGINEERING

Tree-Based Sequential Sampling Algorithm for Scalable Macromodeling of High-Speed Systems

Krishnan Chemmangat
krishnan.cmc@intec.ugent.be
www.ibcn.intec.ugent.be
Internet Based Communication Networks and Services (IBCN)
Department of Information Technology (INTEC)
Ghent University - IBBT

Authors: Krishnan Chemmangat, Francesco Ferranti,Tom Dhaene and Luc Knockaert

Outline

- Introduction
- Proposed method
- Numerical example
- Results
- Conclusions

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- **Introduction**
- **Proposed method**
- **Numerical example**
- **Results**
- **Conclusions**

Introduction

Real world system.

Measurements

- Design space exploration
- Design optimization
- Sensitivity analysis...

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Real world system.

Measurements

Modeling

Simulation model.

Simulation data or model

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ROM

Compact macromodel

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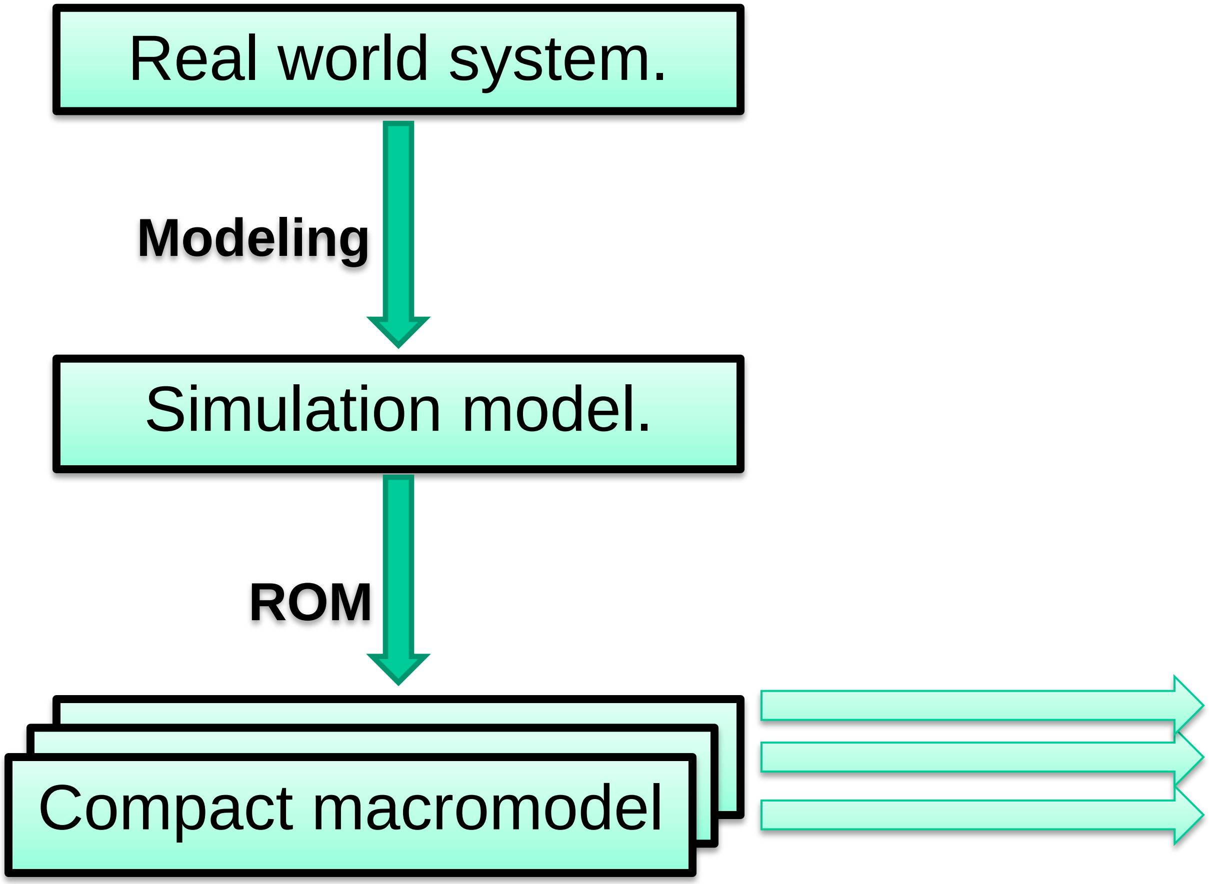
Introduction



- Design space exploration
- Design optimization
- Sensitivity analysis...

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↓ **Modeling**

Simulation model.

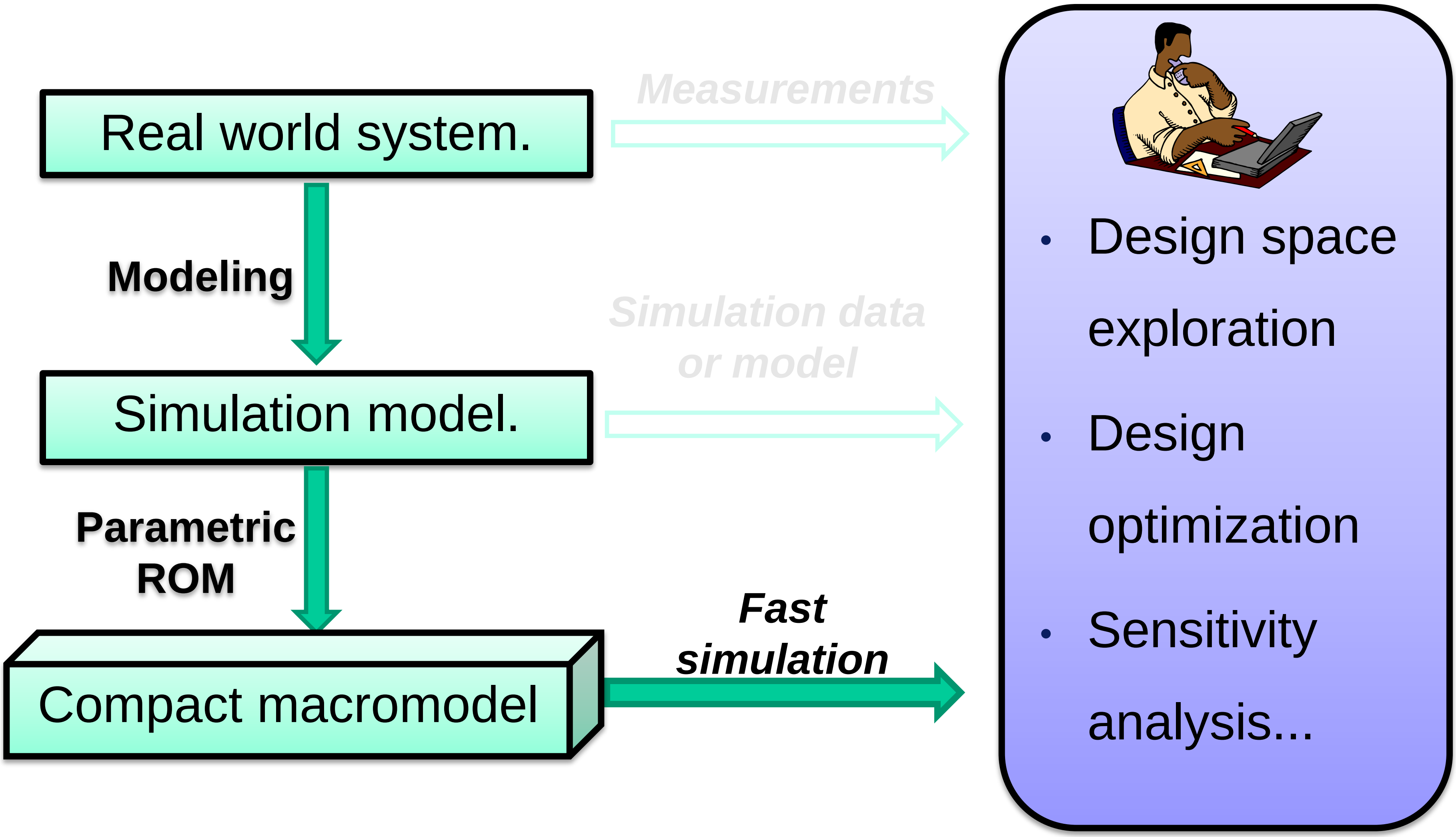
↓ **ROM**

Compact macromodel

→ Efficient

- Design space exploration
- Design optimization
- Sensitivity analysis...

Introduction



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Simulation model.

Simulation data or model

Parametric ROM

Main focus

Compact macromodel

Fast simulation

- Design space exploration
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Parametric ROM

Optimal Samples

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Compact macromodel

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  - Flow Chart
  - Parametric macromodeling
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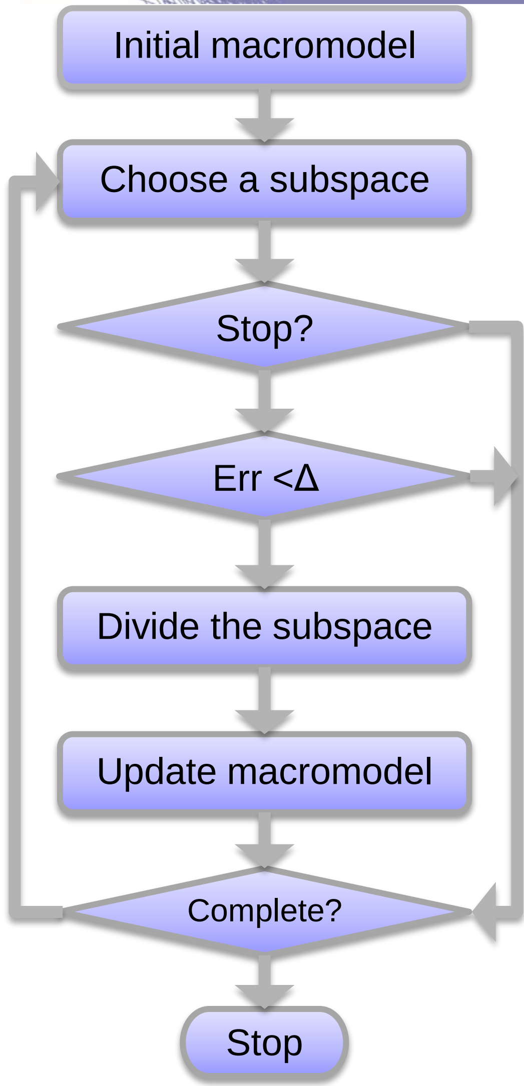
Flow Chart


Initial macromodel
Choose a subspace
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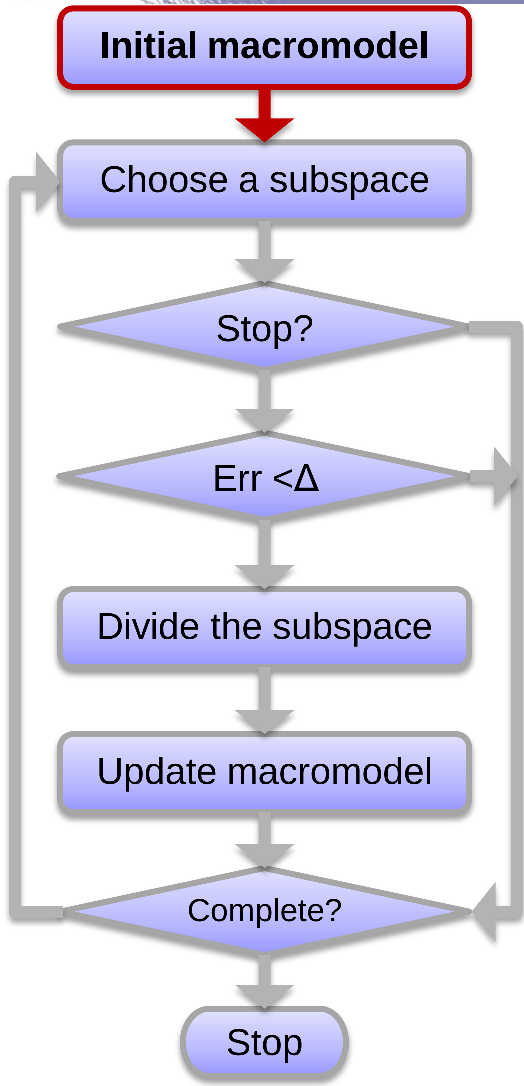

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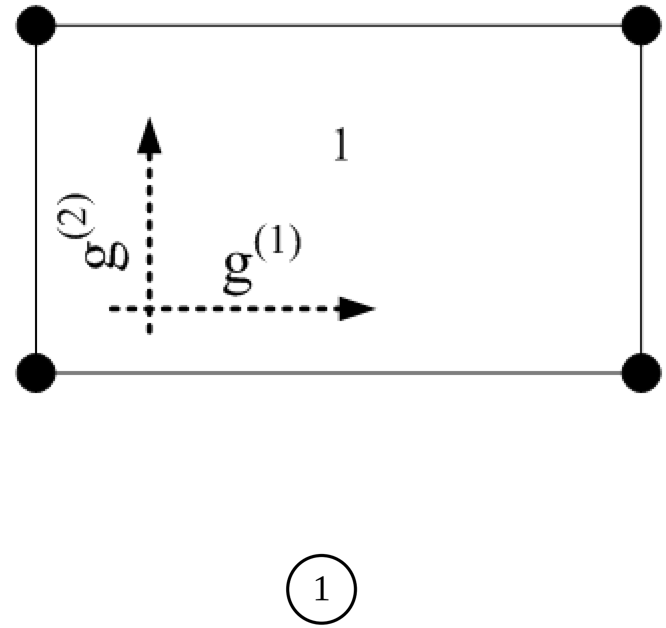
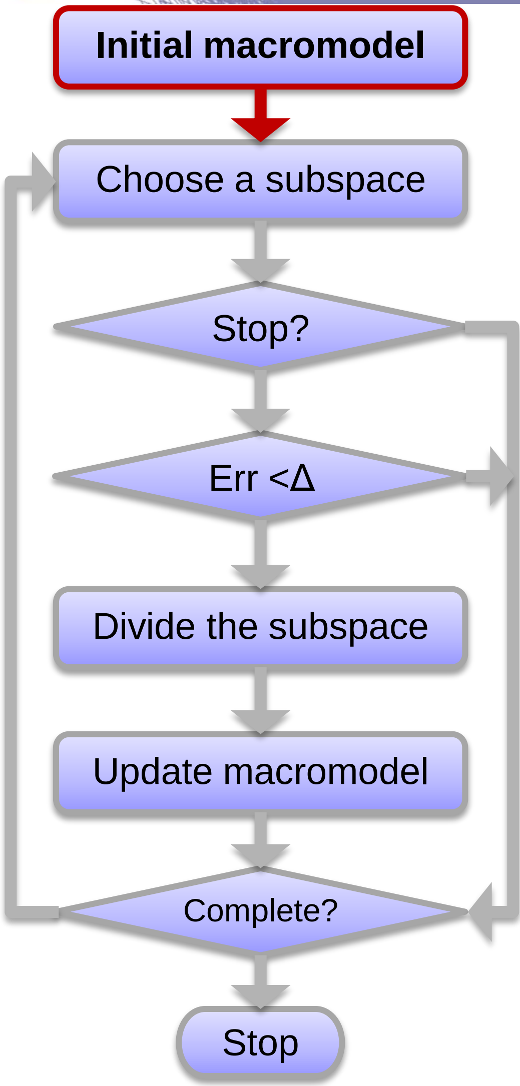


1
$g^{(2)}$
$g^{(1)}$
1

Flow Chart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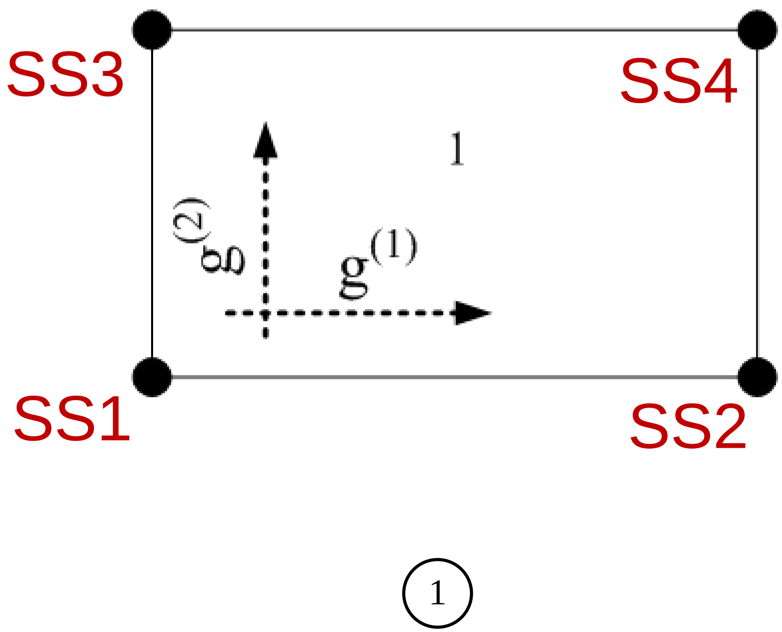
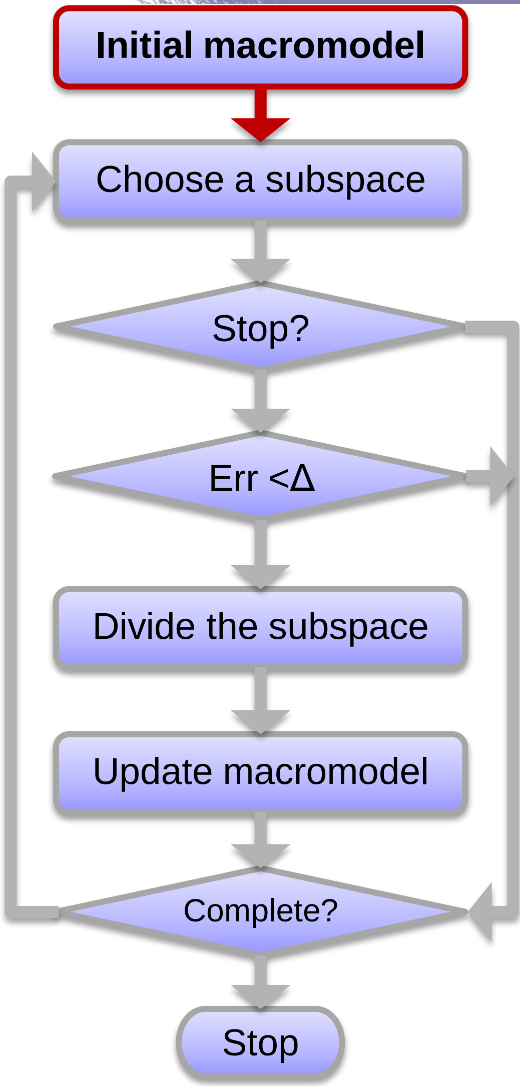

SS3
SS4
1
$g^{(2)}$
$g^{(1)}$
SS1
SS2
1

Flow Chart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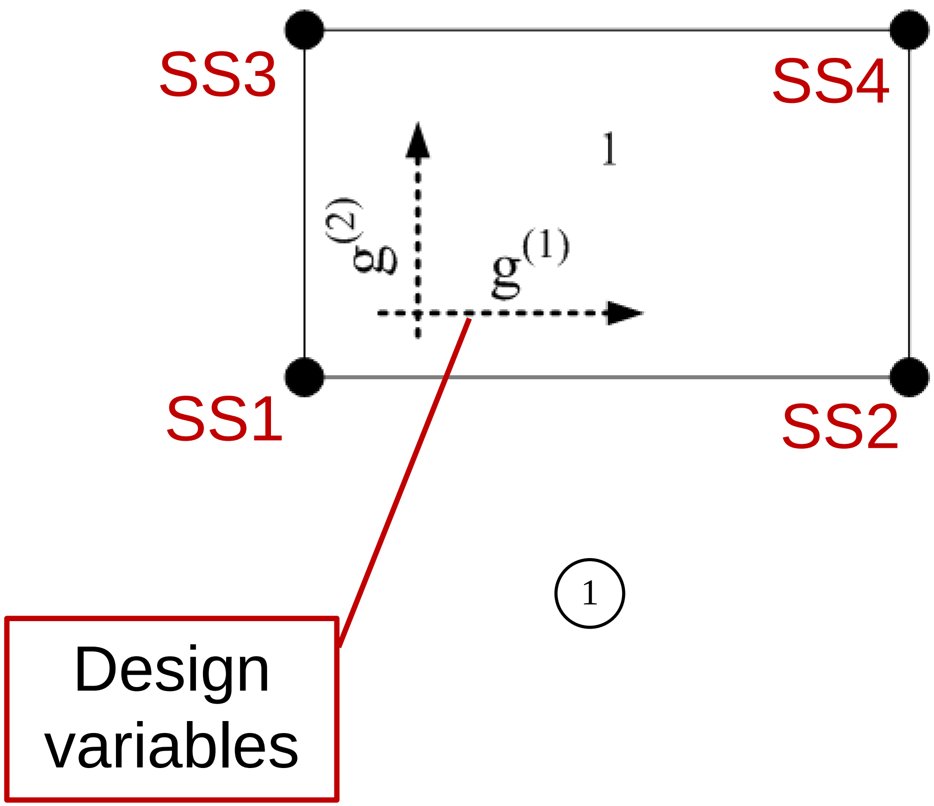
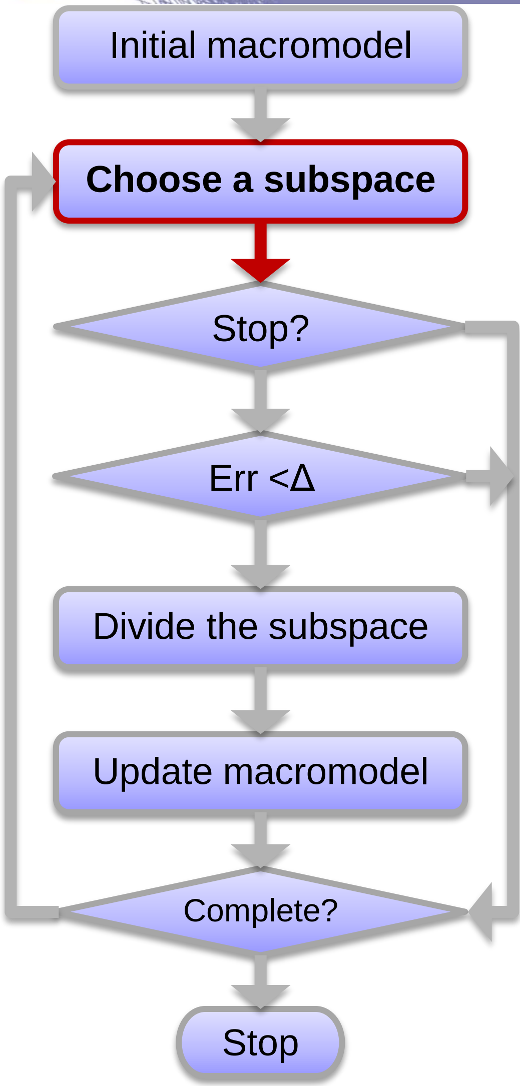

SS3
SS4
SS1
SS2
1
$g^{(2)}$
$g^{(1)}$
1
Design variables

Flow Chart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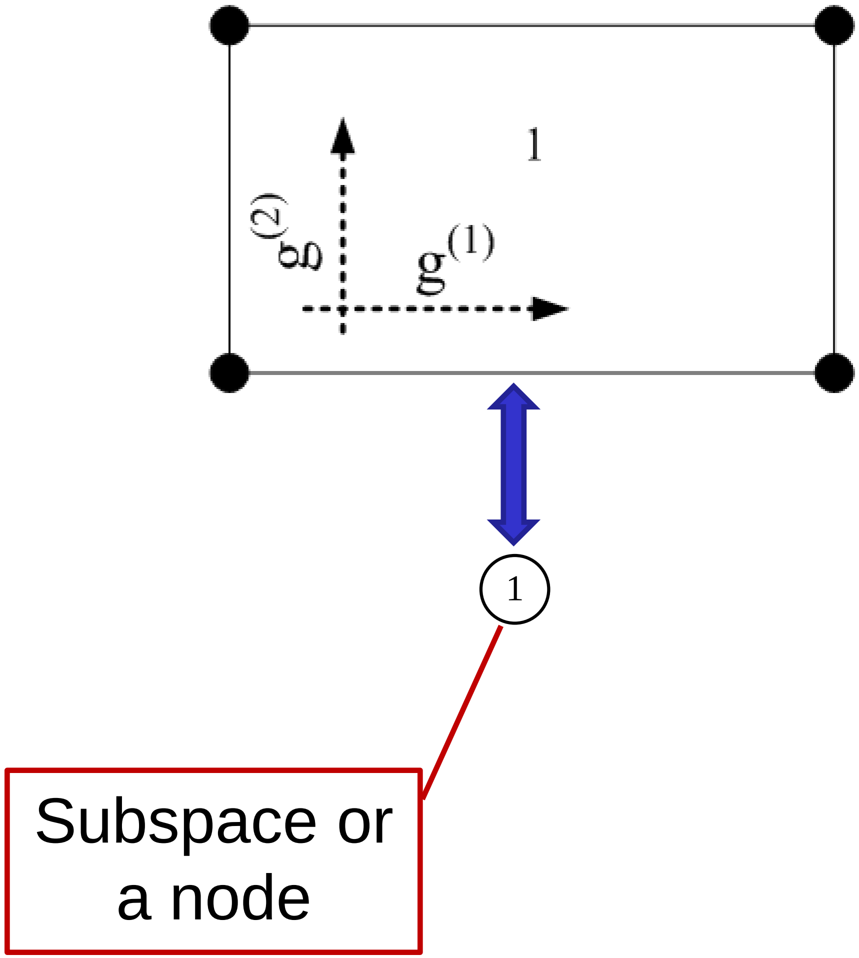
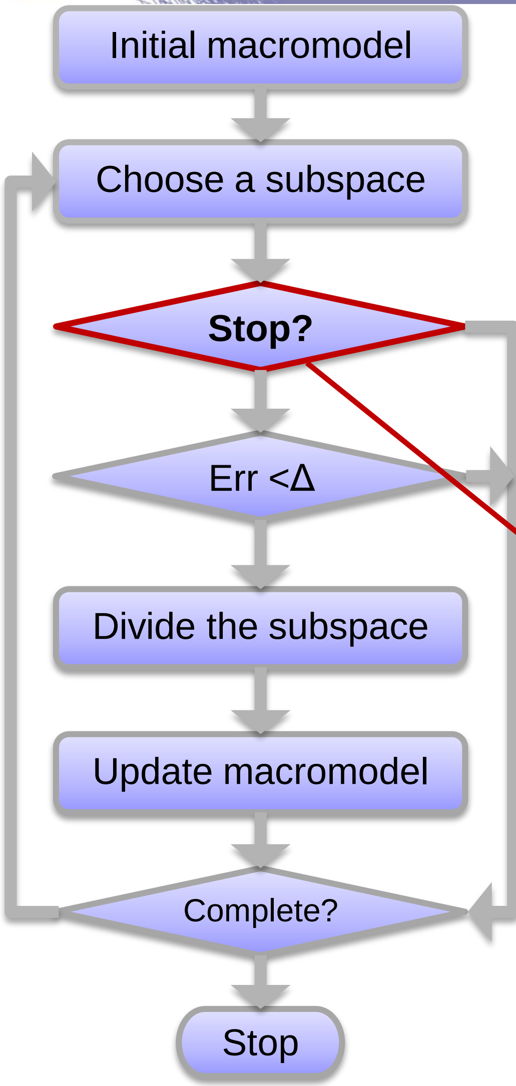
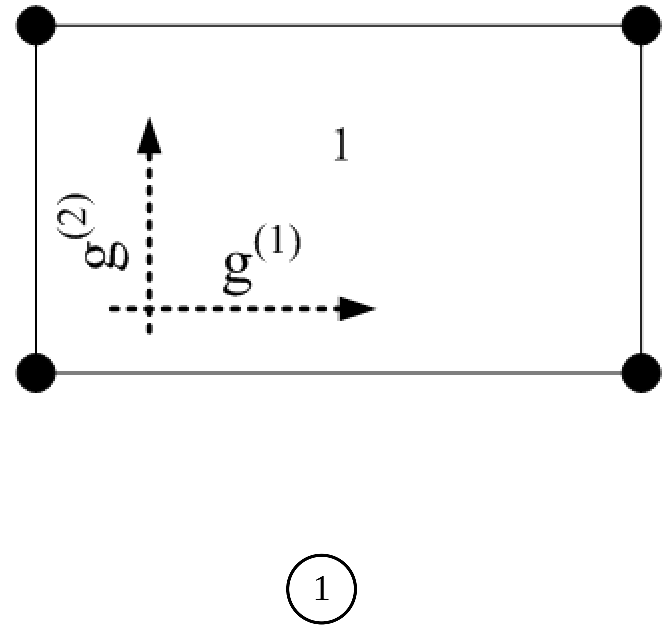

1
$g^{(2)}$
$g^{(1)}$
1
Subspace or a node

Flow Chart

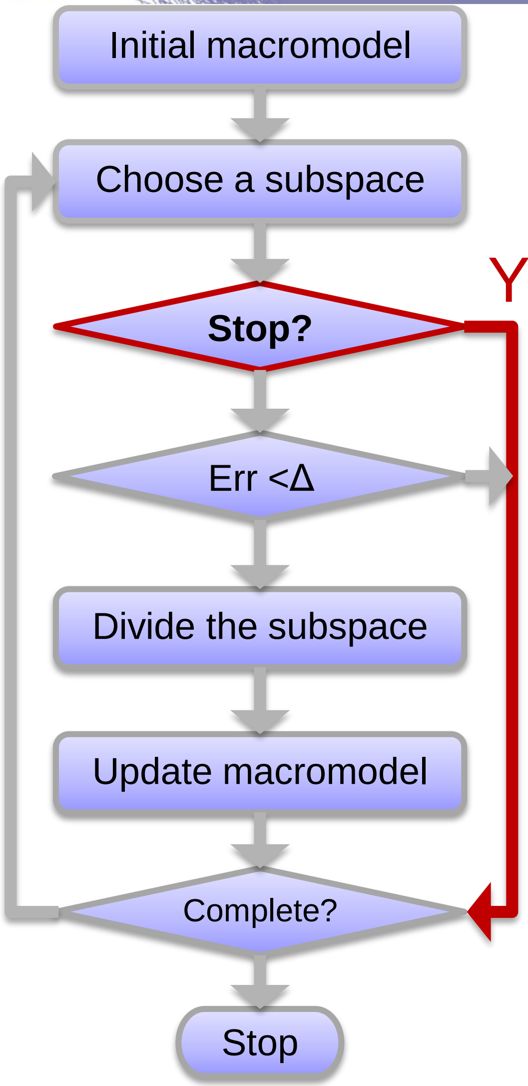




Stopping Criteria

$$\Delta \mathbf{g}/\mathbf{g}$$

Flow Chart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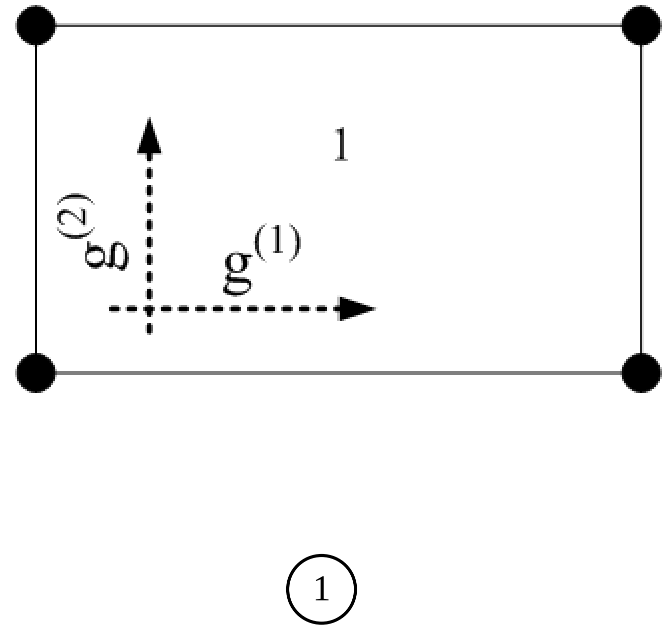
1
$g^{(2)}$
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1

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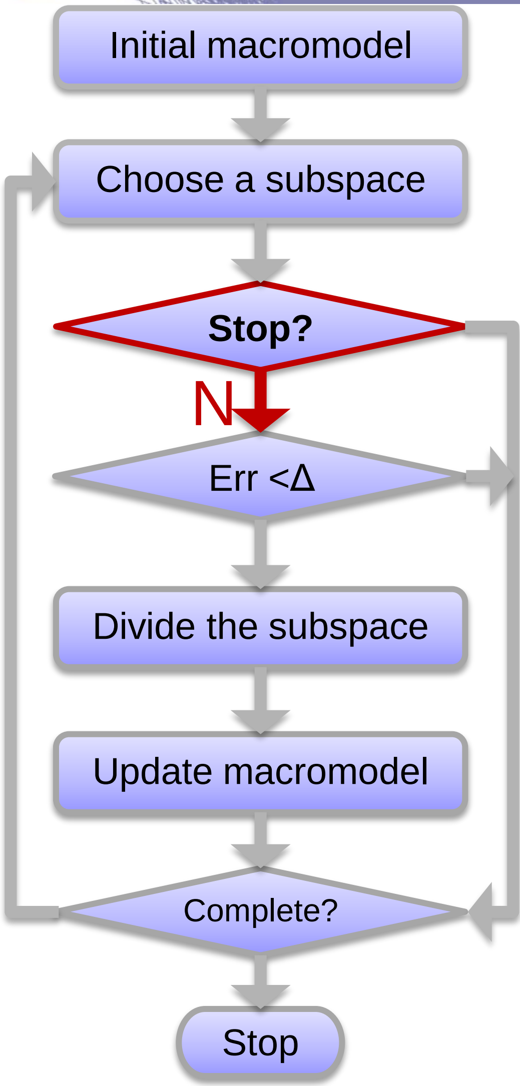
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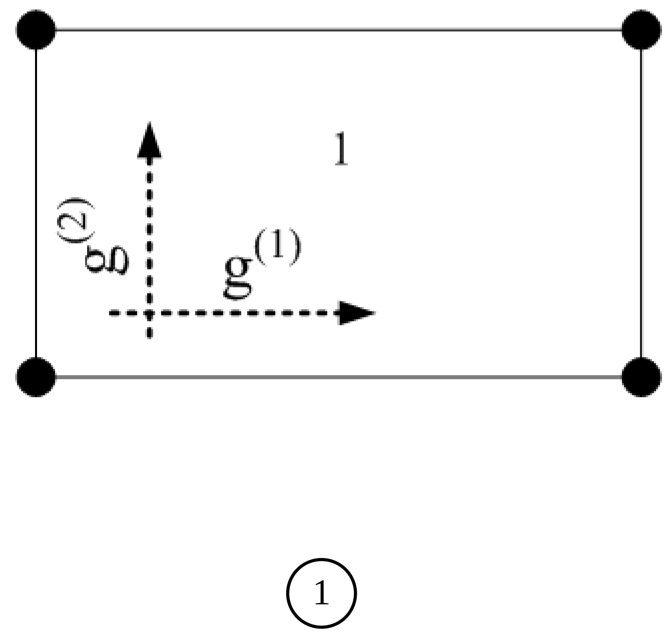
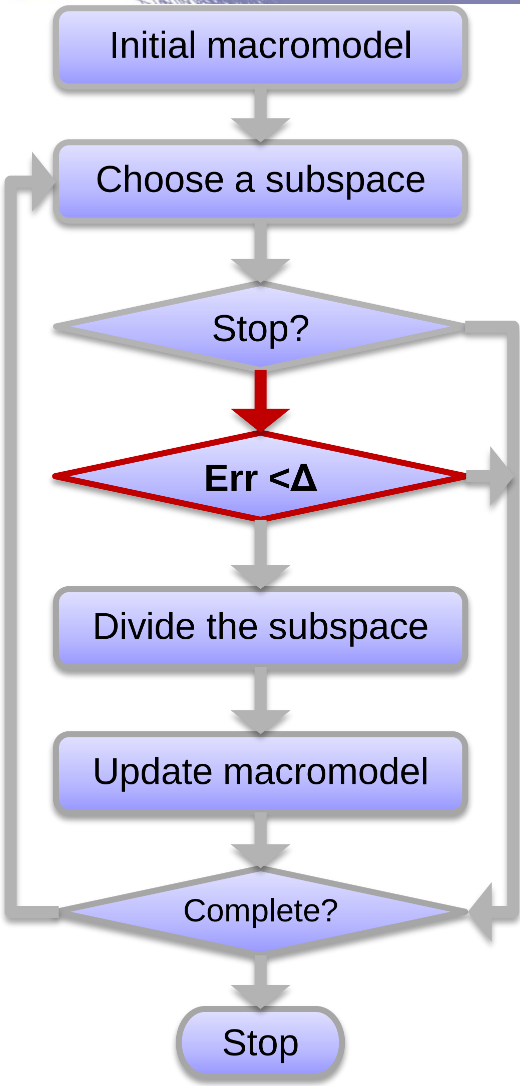

1
g(2)
g(1)
1

Flow Chart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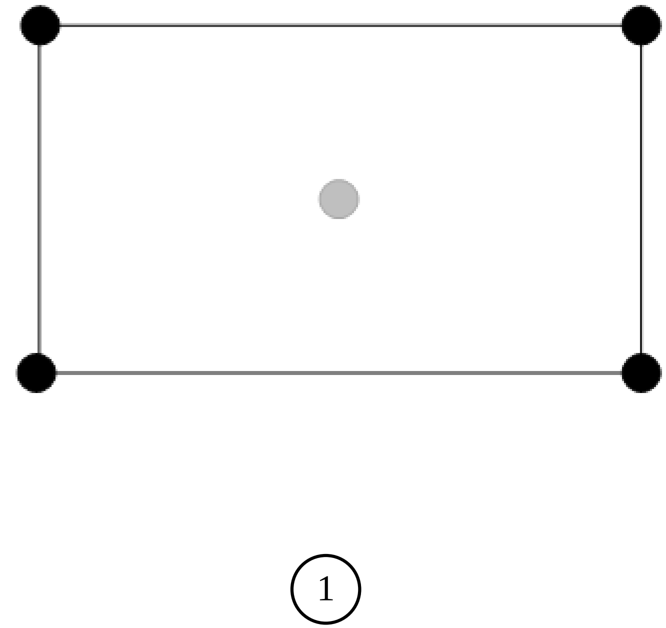
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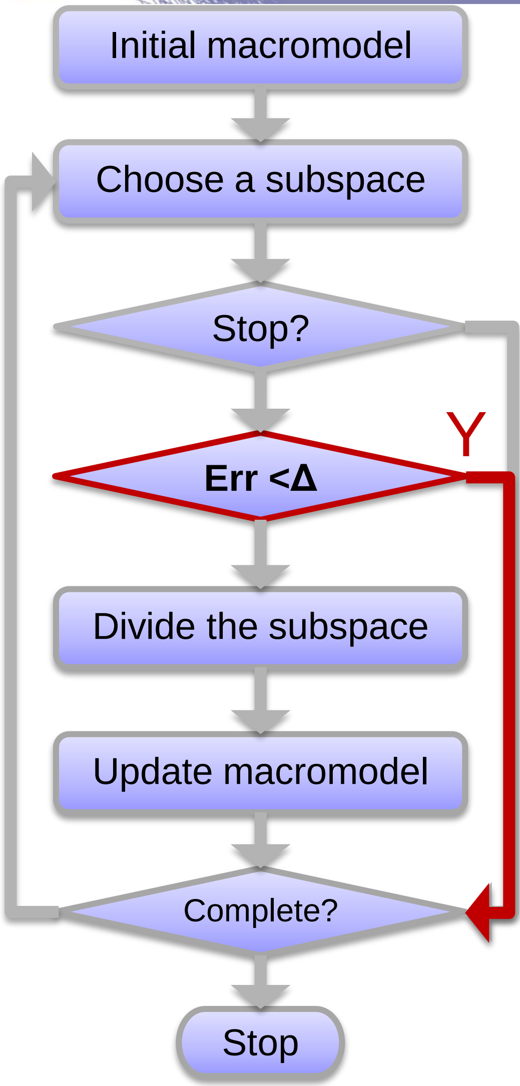
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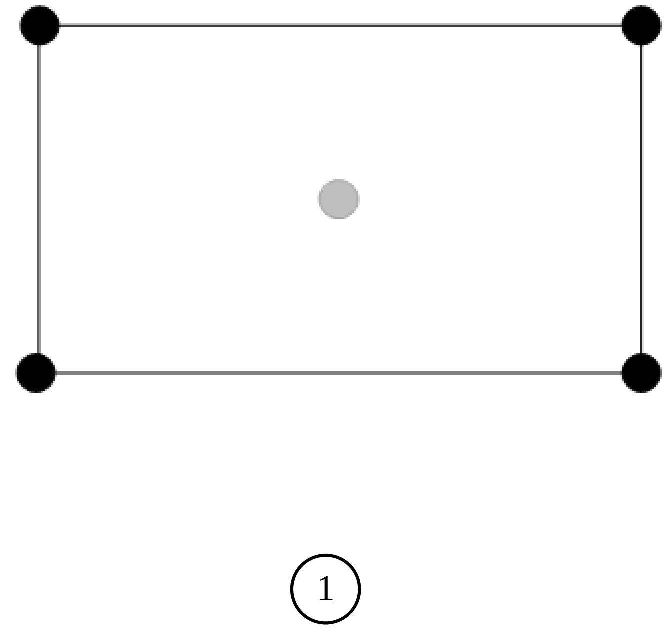
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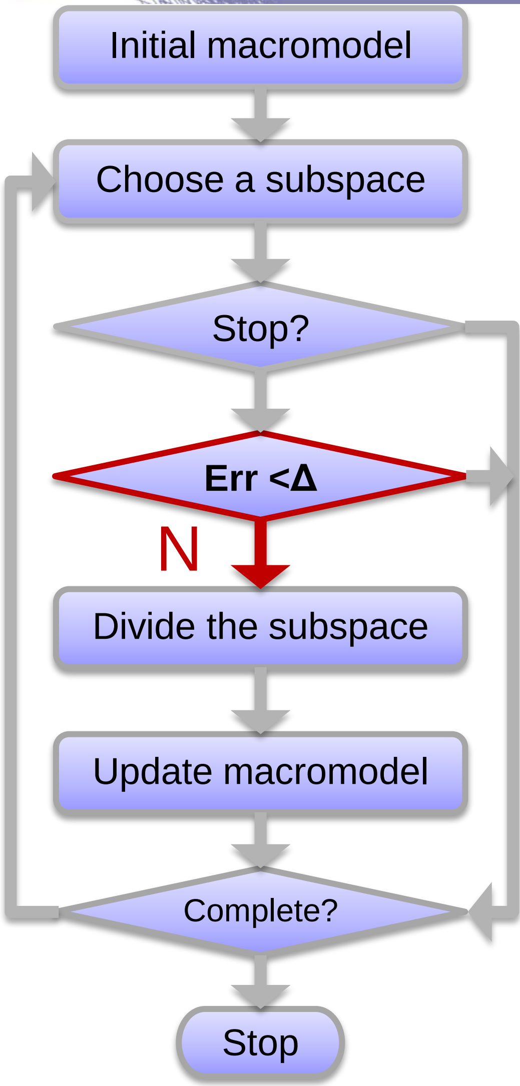

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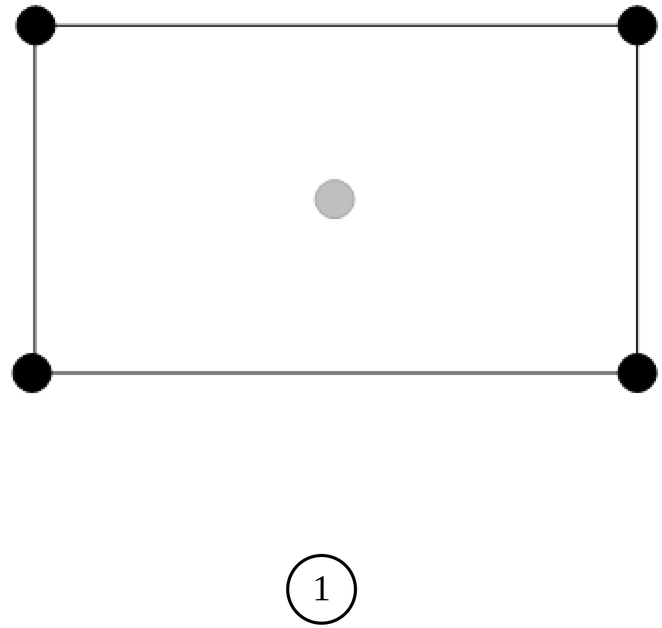
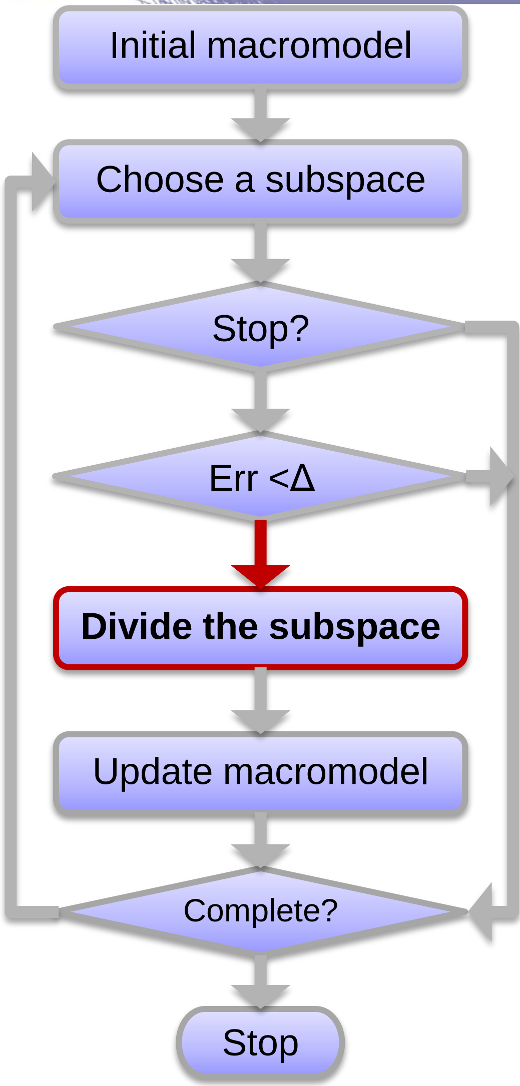


1

Flow Chart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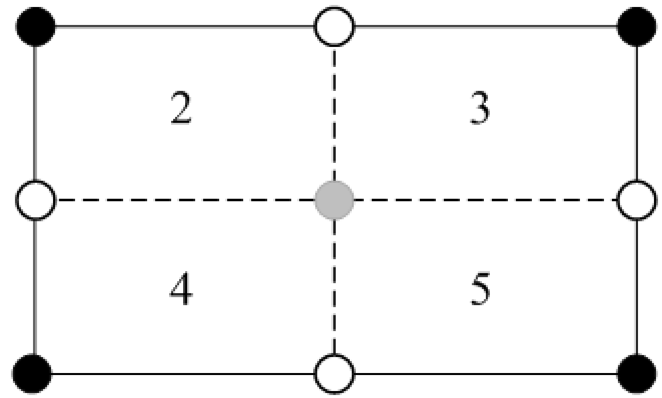
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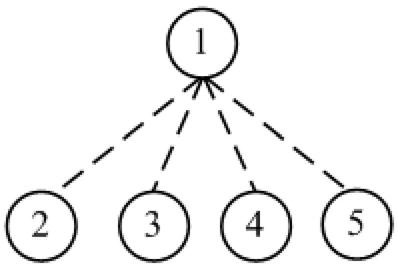
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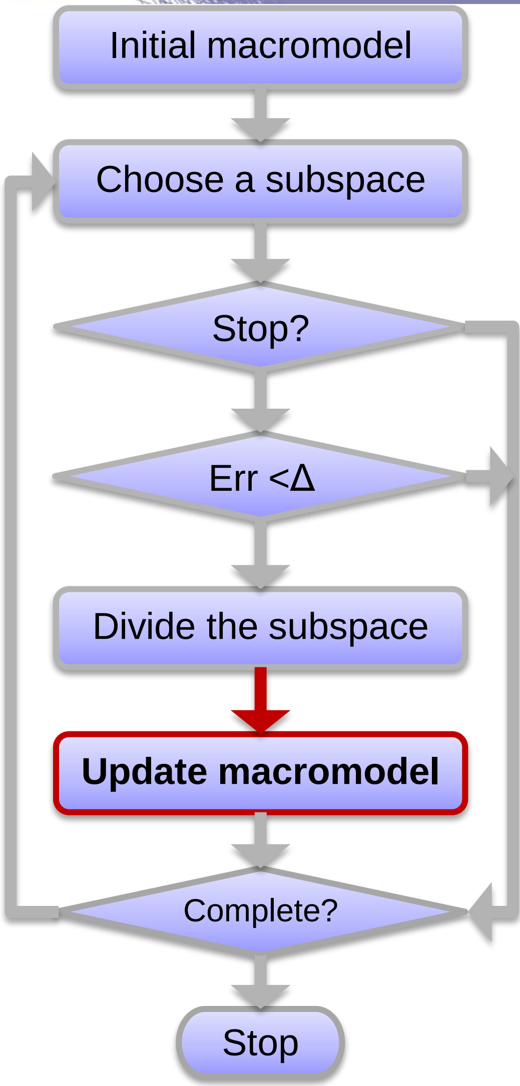
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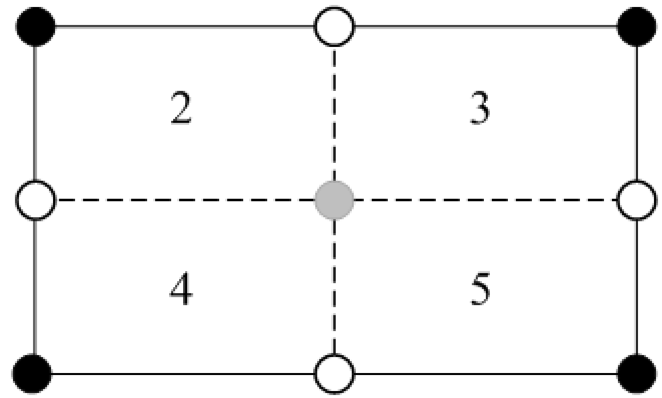
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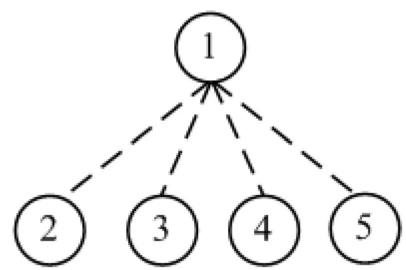
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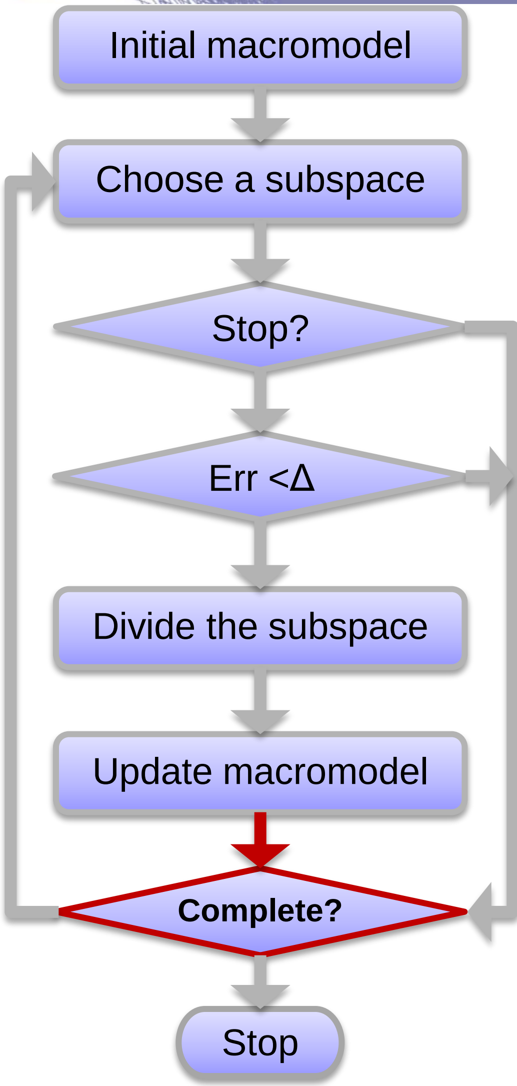
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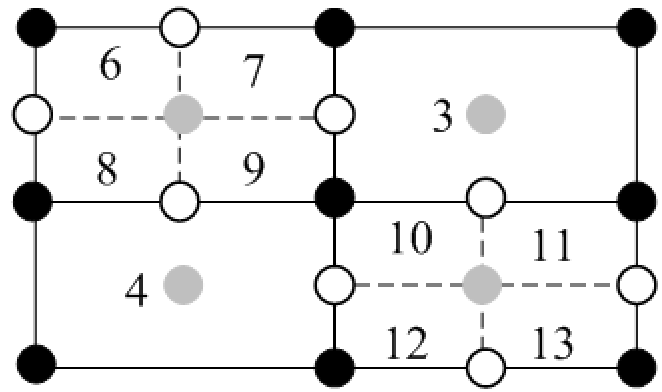
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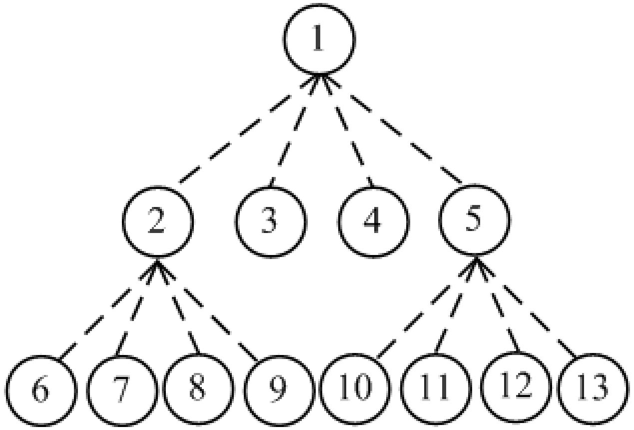
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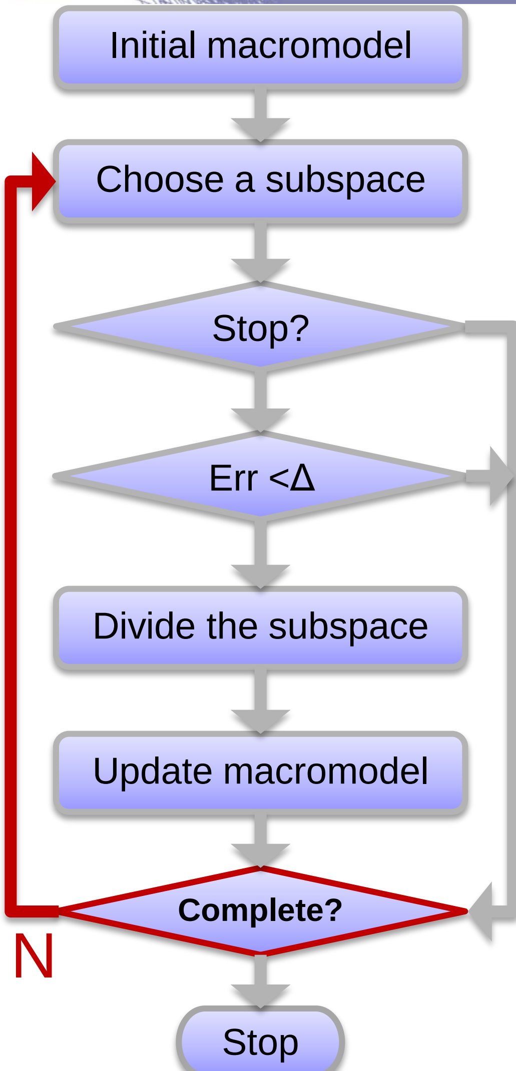

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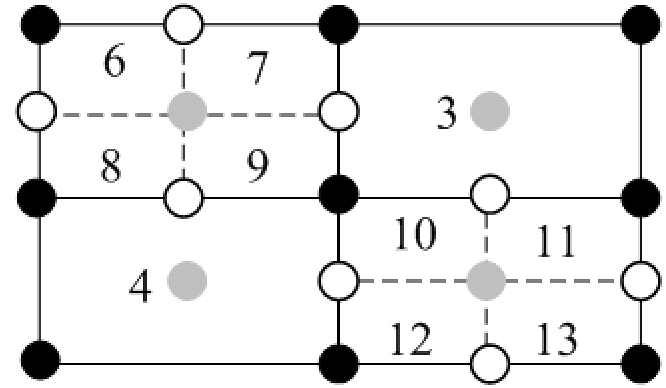

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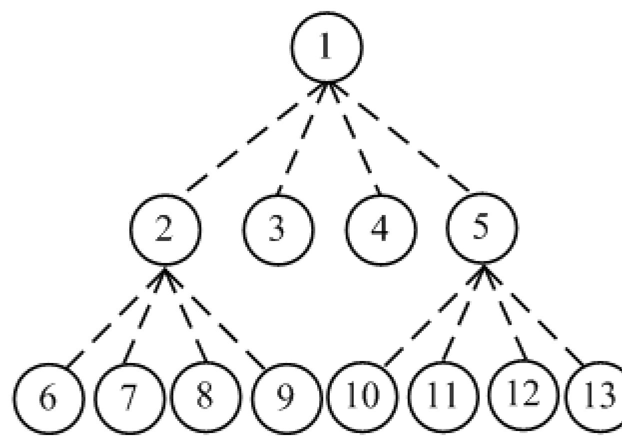

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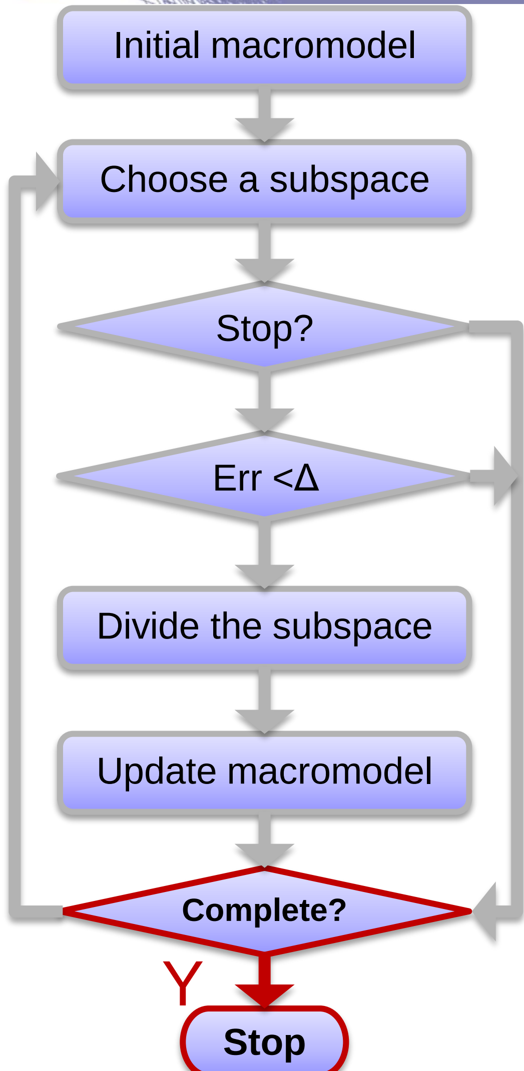
Flow Chart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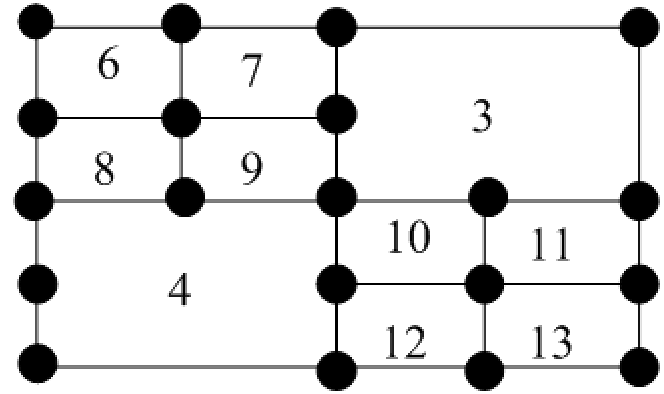
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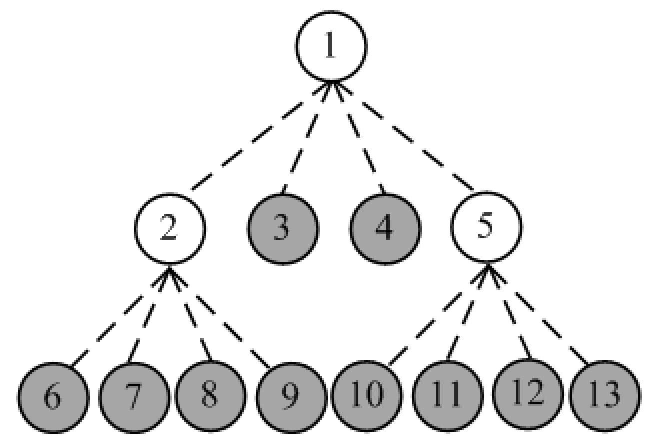
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  - Parametric macromodeling
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Parametric macromodeling

- ***Root macromodels*:**
  - System identification
    - **Vector Fitting :bottom-up approach**
    - **Passivity enforcement.**

- **Parametric macromodeling:**
  - Interpolation based.
    - **Scaling and frequency shifting ***
    - **Passivity preserving.**

*F. Ferranti, L. Knockaert, and T. Dhaene, “Passivity-preserving parametric macromodeling by means of scaled and shifted state-space systems,” IEEE Tr. on MTT, vol. 59, no. 10, pp. 2394 –2403, Oct. 2011.

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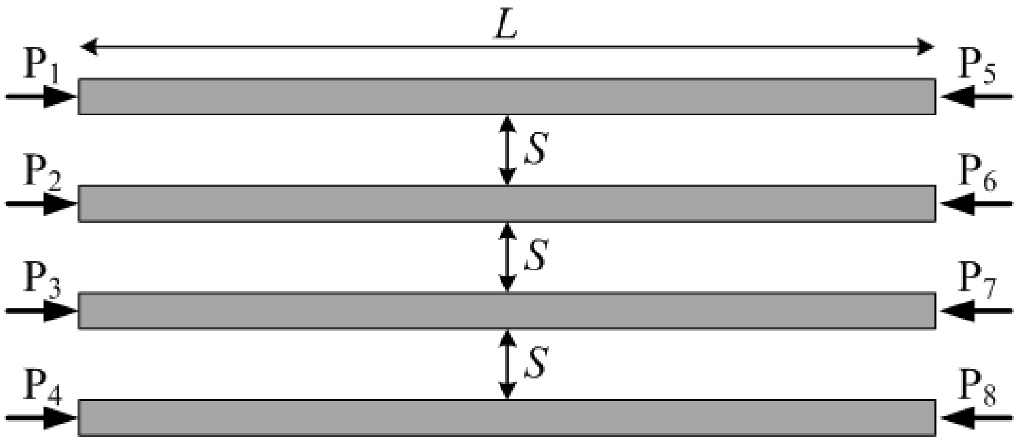
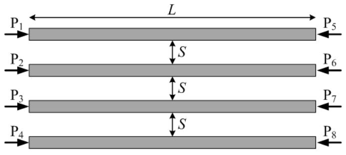
Ex.:Four Coupled Microstrips

- **Fixed parameters:**
  - Width = 0.025 mm
  - $\varepsilon_r = 9.6$
  - Thickness = 0.125 mm
- **Varying parameter**

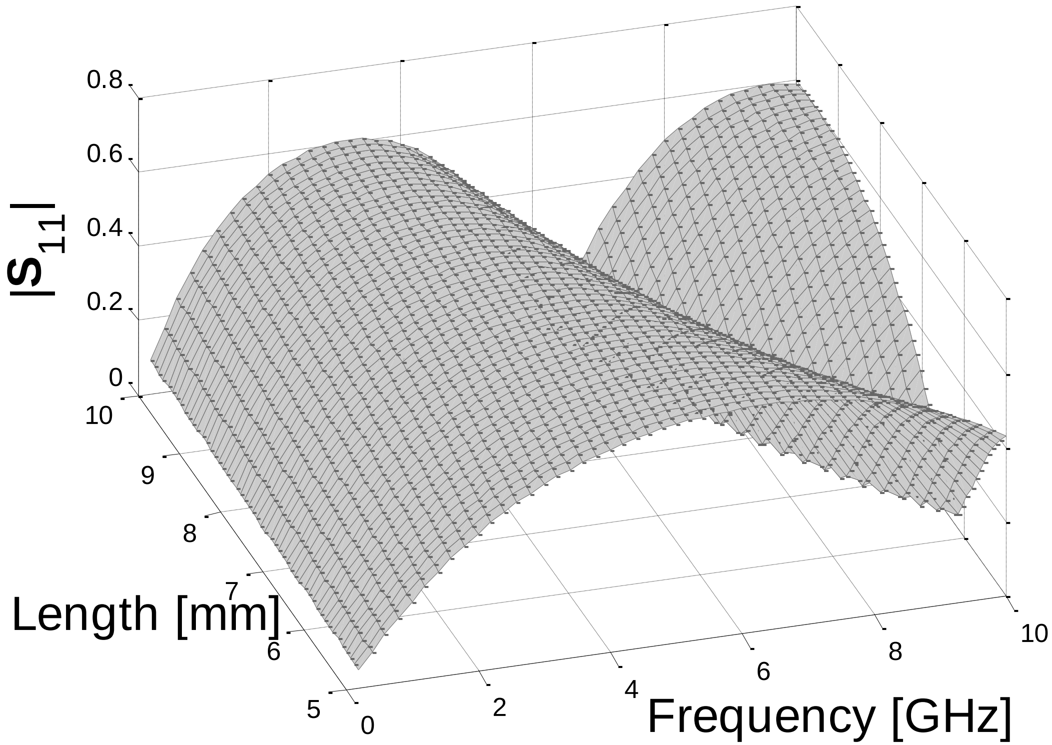


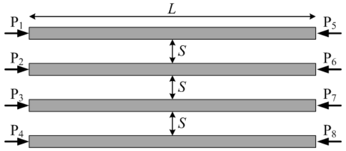
Parameter	Range	
	Min	Max
Frequency	0 GHz	10 GHz
Spacing (S)	0.05 mm	0.15 mm
Length (L)	5 mm	10 mm

Ex.:Four Coupled Microstrips

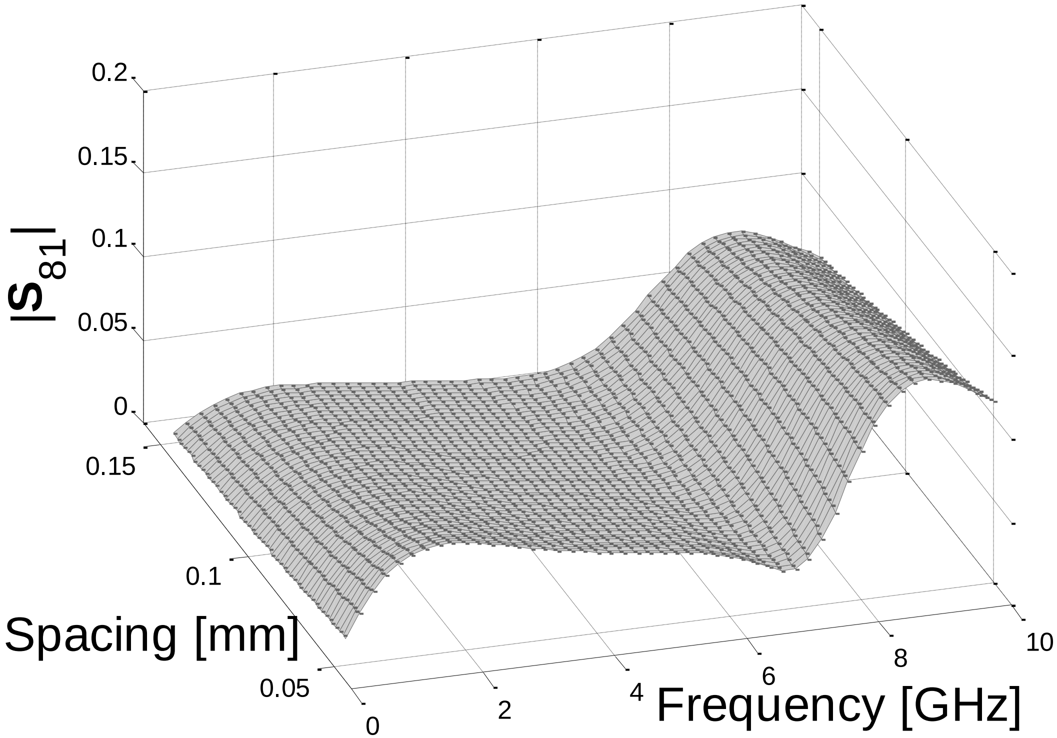


Parametric behavior of $|S_{11}|(L, freq)$; S = 0.10 mm





Parametric behavior of $|S_{81}|(S, freq)$; $L = 7.5$ mm



Ex.:Four Coupled Microstrips

- **Simulation settings**
  - Mean Absolute Error

$$E_{rr}^{\mathrm{MAE}}(\vec{g}) = \frac{\sum_{i=1}^{P_{in}} \sum_{j=1}^{P_{out}} \sum_{k=1}^{N_s} \left| R_{i,j}(s_k, \vec{g}) - H_{i,j}(s_k, \vec{g}) \right|}{P_{in} P_{out} N_s}$$

  - Stopping criteria $\Delta\mathbf{g}/\mathbf{g}$ = 0.05 (i.e., 5%).
  - # frequency samples N_S = 51.
  - Stability and passivity enforced.

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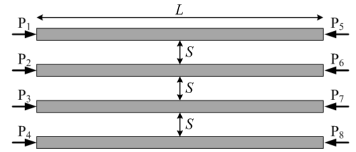
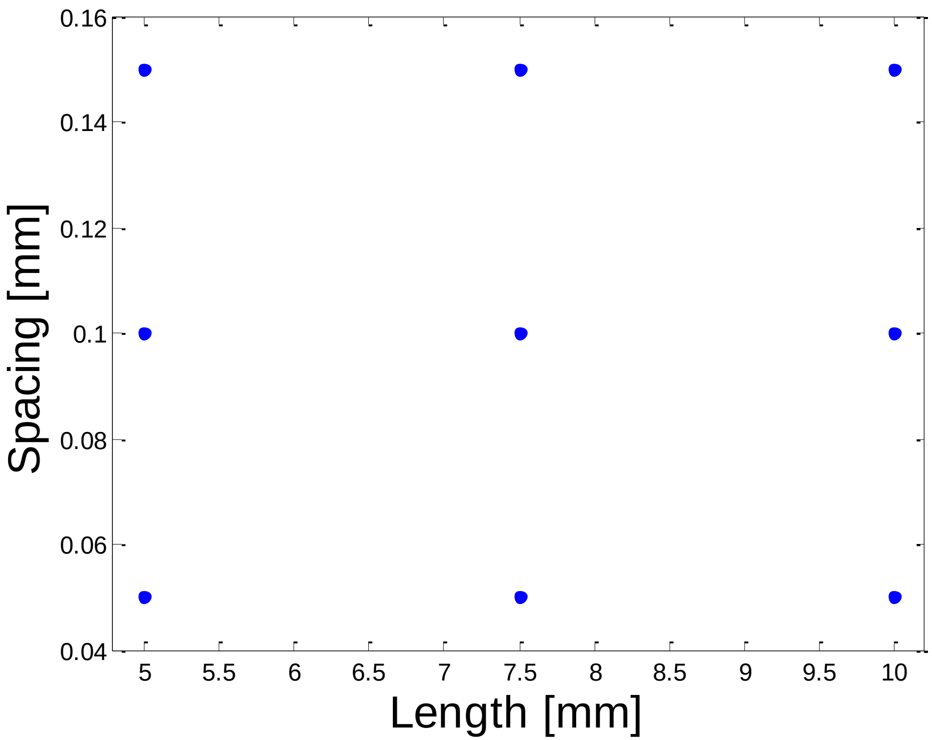
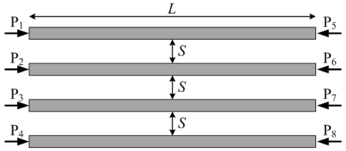
Results



Modeling accuracy		# samples
Target [dB]	Achieved [dB]	
-40	**-47.98**	**9**
-45	-47.98	9
-50	-50.80	14
-55	-55.88	22
-60	-60.07	42



Results



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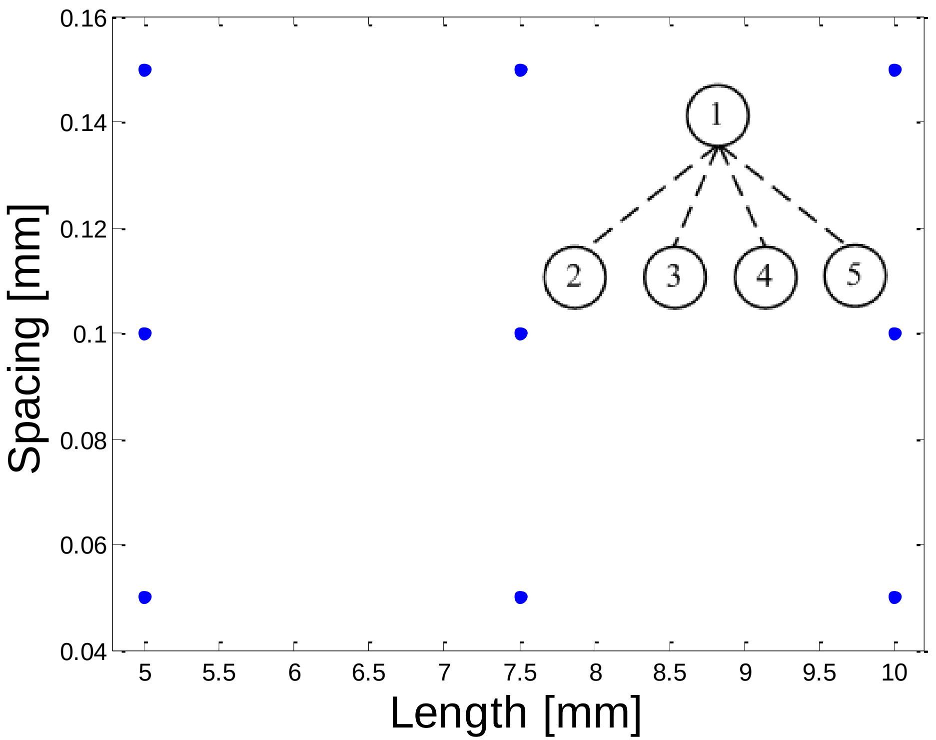

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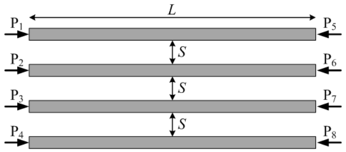

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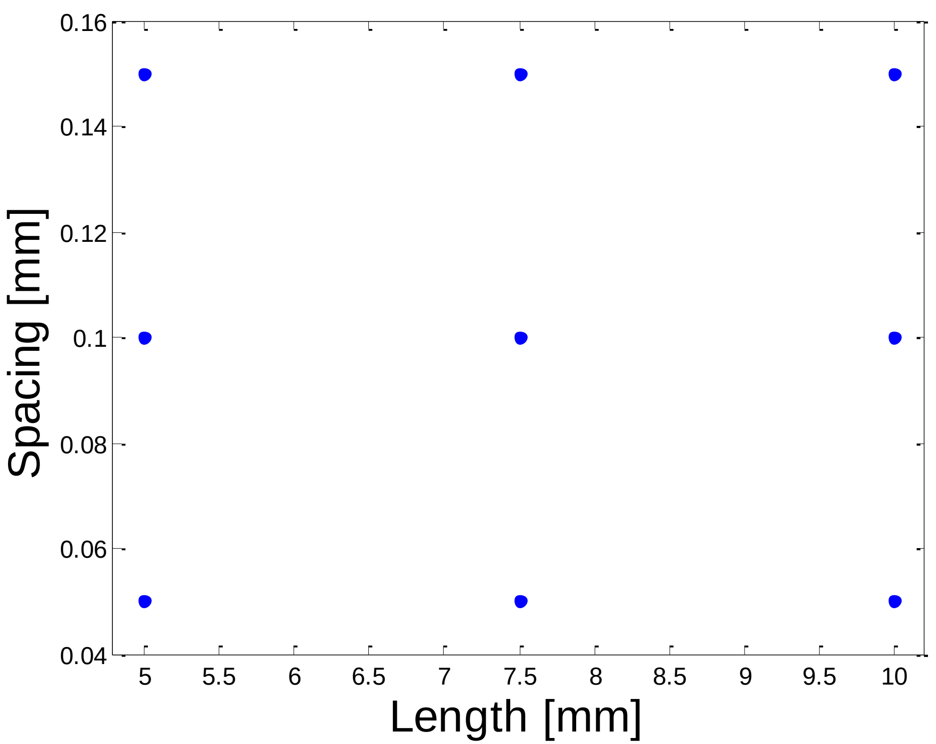

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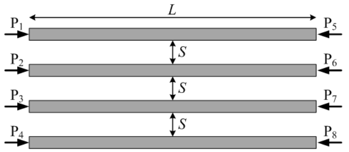

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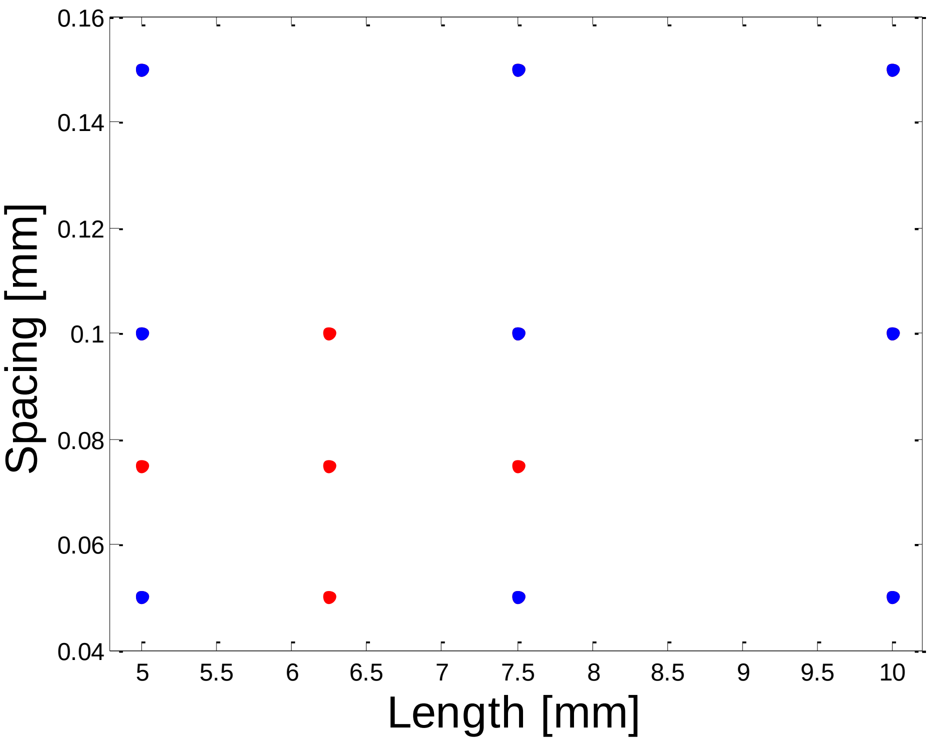

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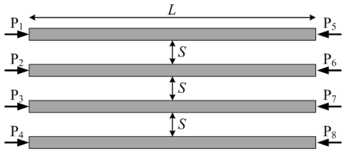

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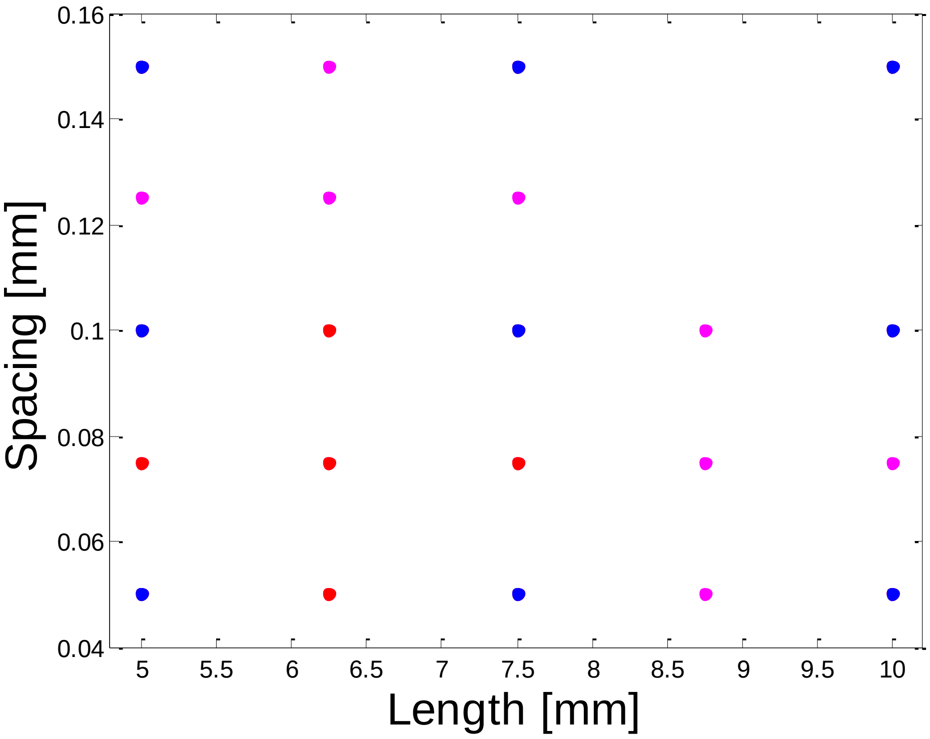
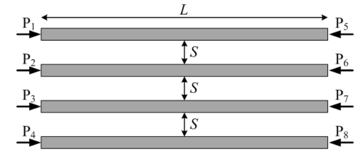
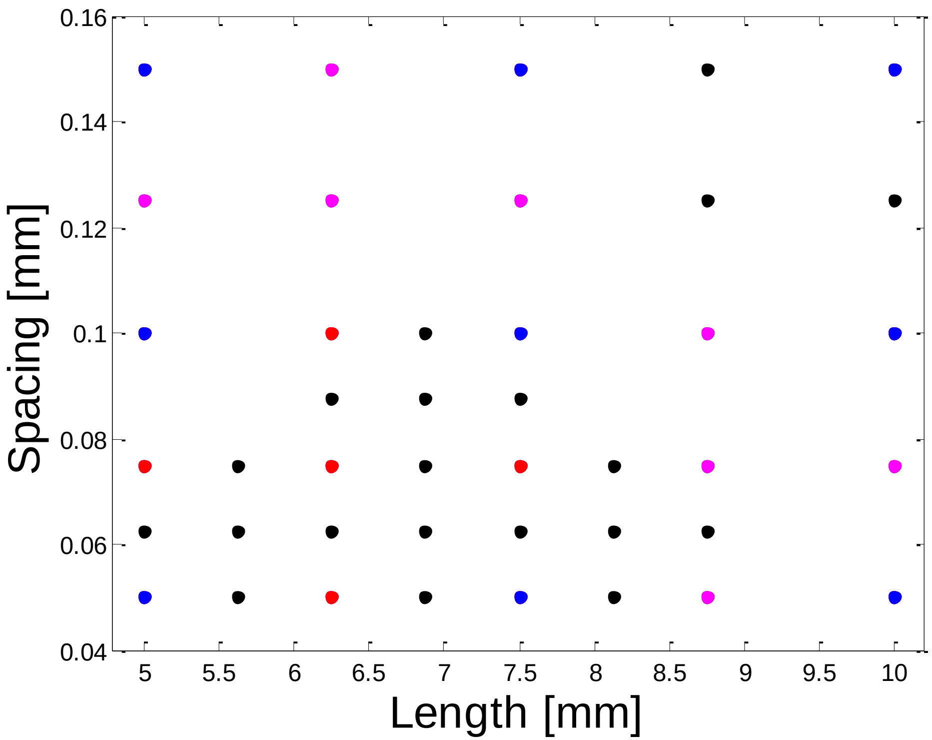
-60	-60.07	42



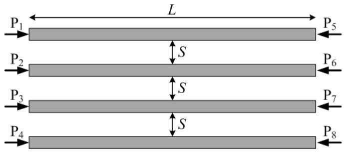
Results

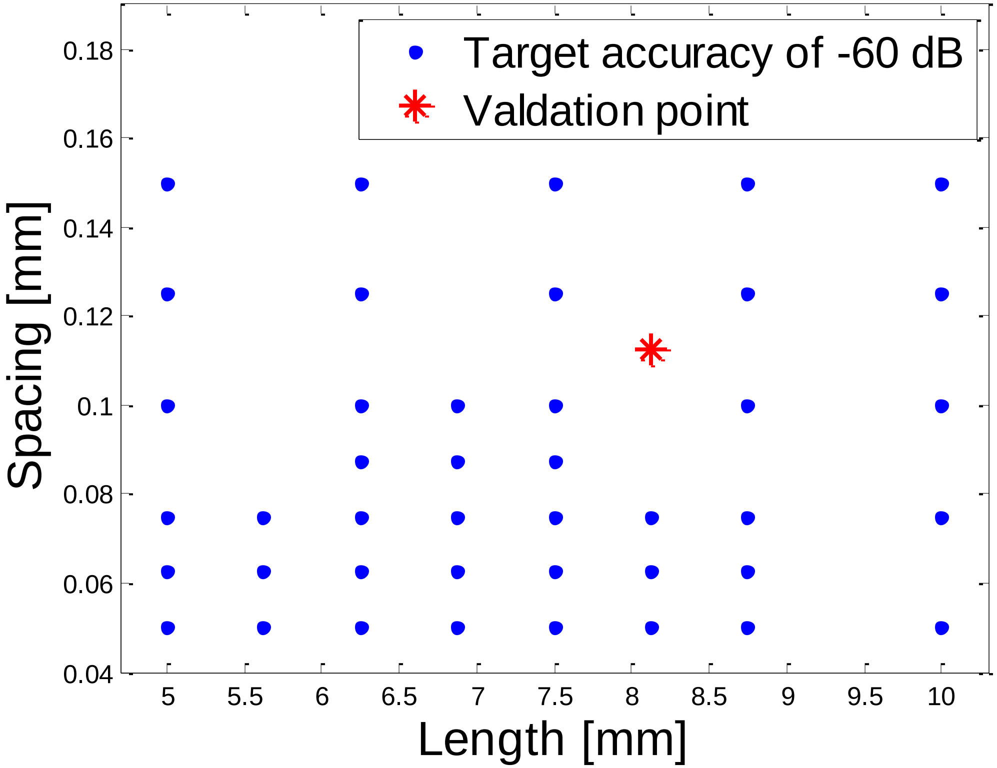


Modeling accuracy		# samples
Target [dB]	Achieved [dB]	
-40	-47.98	9
-45	-47.98	9
-50	-50.80	14
-55	-55.88	22
-60	**-60.07**	**42**



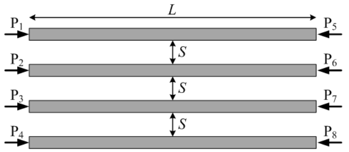
Final design space (for -60 dB).

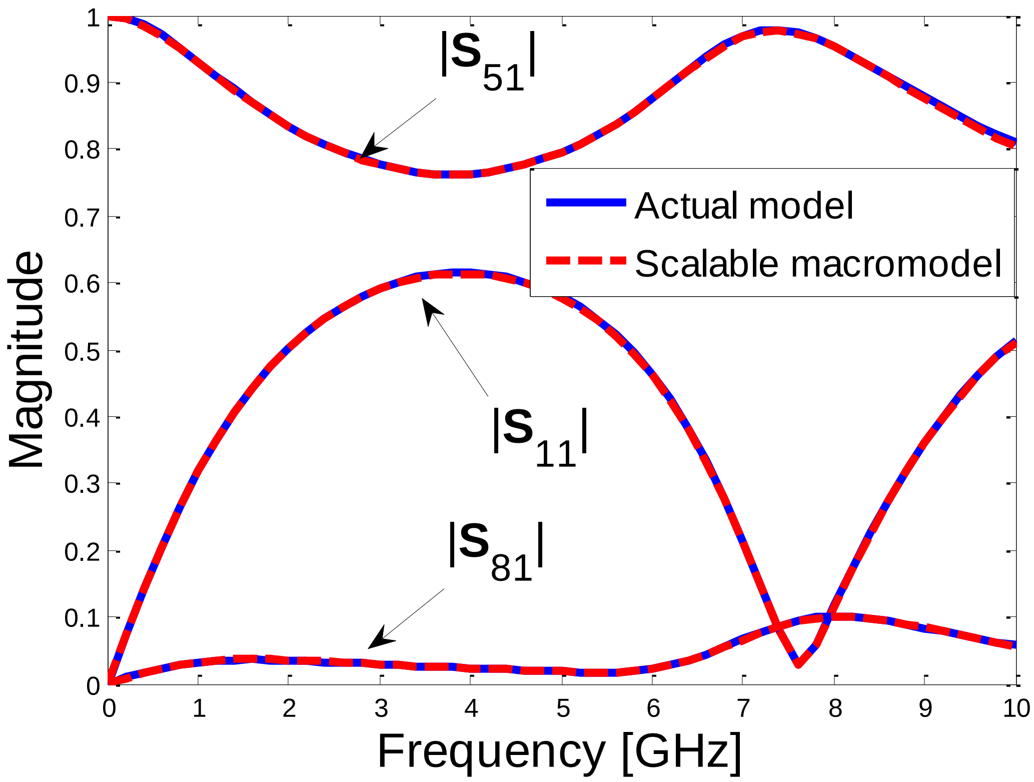




Results

Comparison at (S, L) = (0.1125, 8.125) mm.



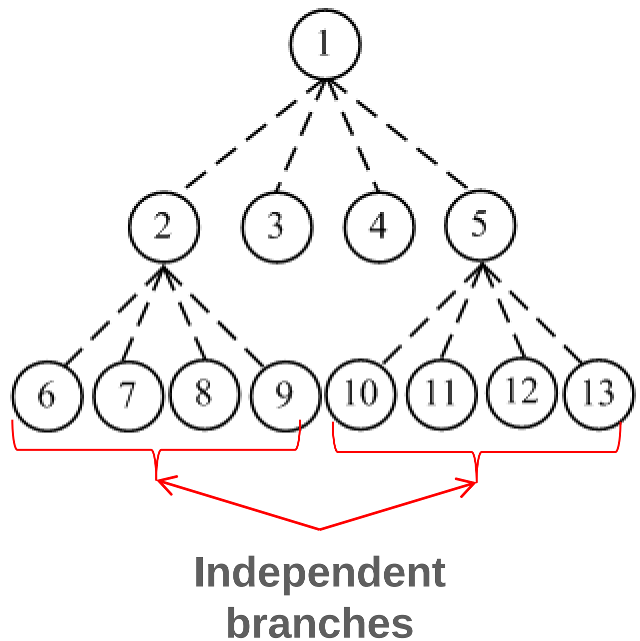


Outline

- Introduction
- Proposed method
- Numerical example
- Results
- Conclusions

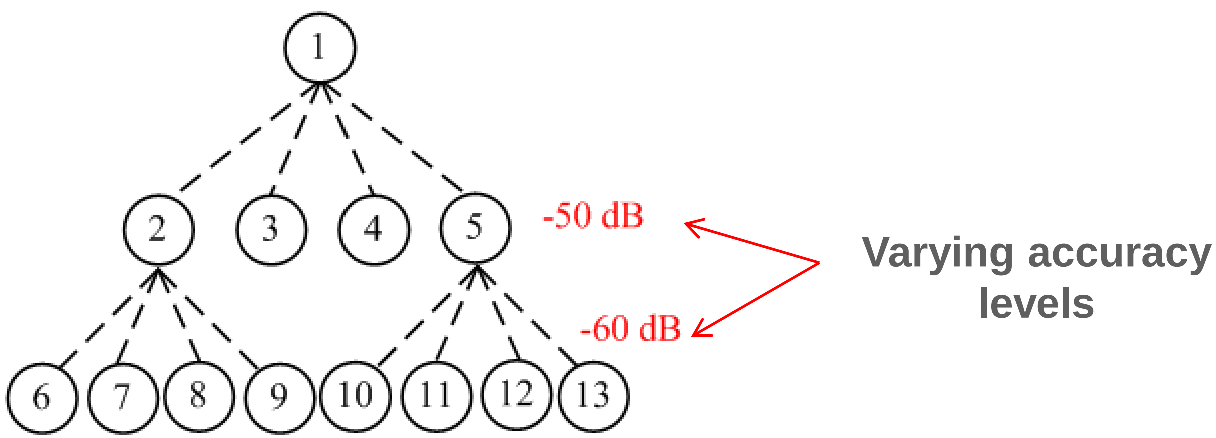
Conclusions

- **Advantages:**
  - The method is local and hence portable to parallel computing platforms.



Conclusions

- **Advantages:**
  - The method is local and hence portable to parallel computing platforms.
  - Extending the tree as per the accuracy requirement → multi-fidelity models.



Conclusions

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  - The method is local and hence portable to parallel computing platforms.
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Conclusions

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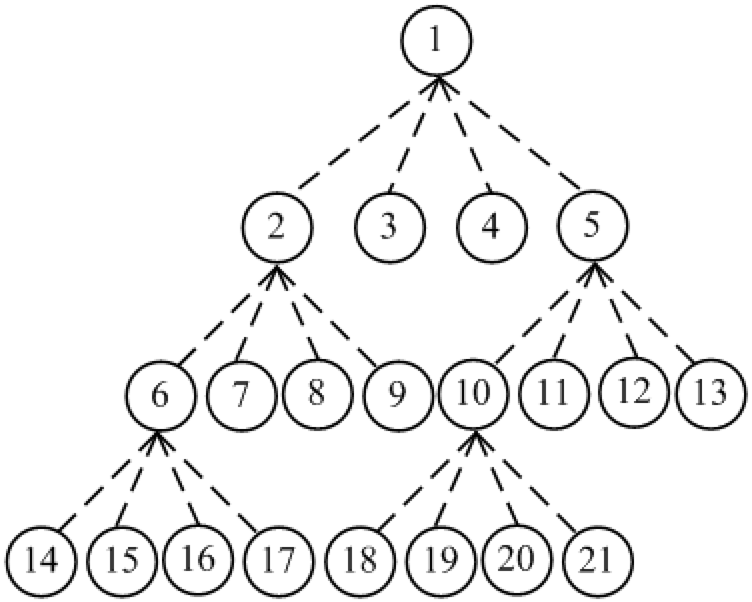
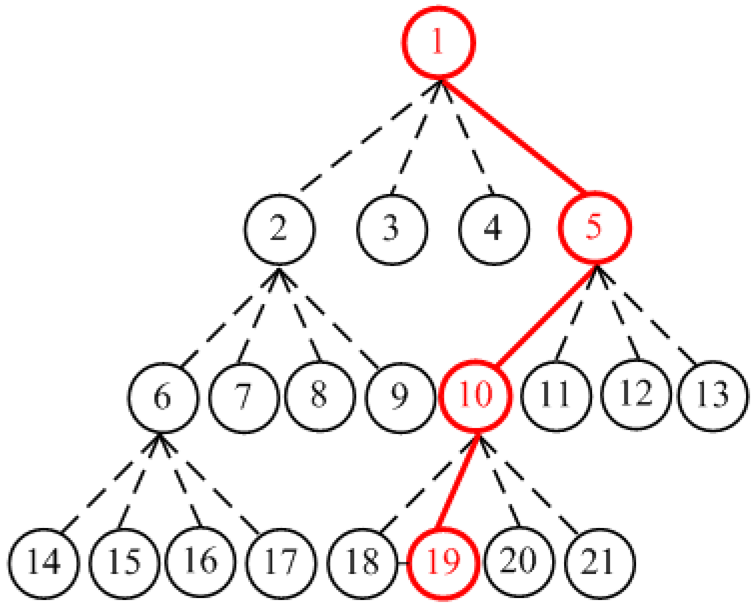
  - The method is local and hence portable to parallel computing platforms.
  - Extending the tree as per the accuracy requirement → multi-fidelity models.
  - Property-preserving parametric macromodeling methods.
- **Future direction:**
  - Extension to scattered grids.


Thank you

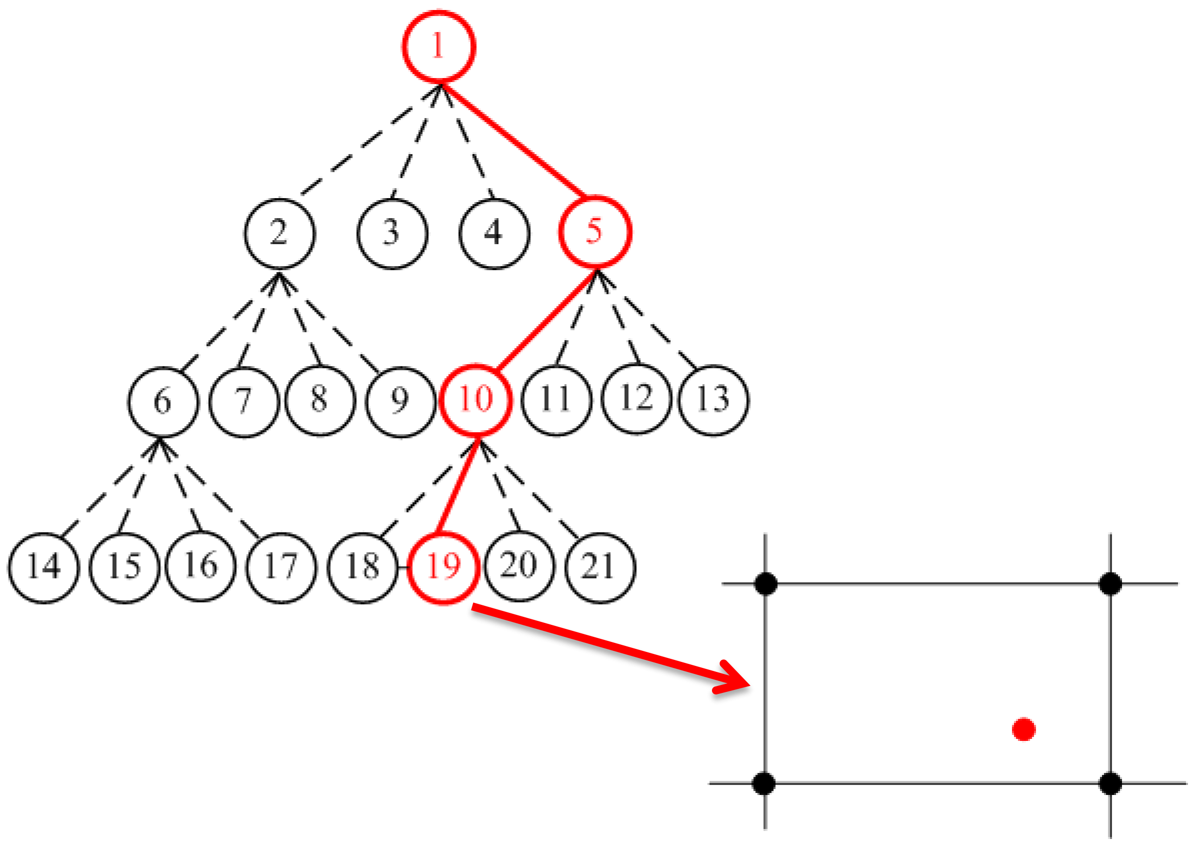
Model Evaluation



Model Evaluation



Model Evaluation



Model Evaluation