Model-based Network Analysis and Optimization

Stefan Herrnleben, Johannes Grohmann, Piotr Rygielski

Chair of Software Engineering
University of Würzburg
http://se.informatik.uni-wuerzburg.de

MMB 2018, Erlangen, Germany
February 28, 2018
Motivation

Motivation

Datacenter network

Additional virtual machines

Increased workload

New customers

SLA
- Bandwidth
- Delay
...

Adaption of network required

Which reconfiguration would prevent the SLA violation?

Our approach

Traditional approach

Evaluation

Model-based analysis and optimization

Educated guess

Stefan Herrnleben
Point of Contribution

- DML [Hub17]
- S/T/A [Hub14]

Computing Resource Modeling

- PCM [Bec07]
- PerOpteryx [Koz14]

Adaptation at Design-Time

- DNI Adaptation Framework

- DNI [Ryg17]
- Syntony [Die07]

Network Modeling

- ns-3 [Ril10]
- OMNeT++ [Var08]
Descartes Network Infrastructure Modeling (DNI)

Network Modeling

- Structure
- Configuration
- Traffic

Simulation

- Transformation to Queueing Petri Nets
- Performance evaluation
- Detection of bottlenecks
Adaptation Points Model

DNI (Network Model)

Network Infrastructure

- Structure
  - Switch Type A
  - Switch Type B

Configuration

- Routes
  - Route A
  - Route B

DNI Adaptation Points

(“Degrees of Freedom”) Adaptation Points

- Switch Type B

Alternative Configurations

1. Alternative Configuration 1
2. Alternative Configuration 2

Alternative Routes

- Route B
  - Alternative Route 1
  - Alternative Route 2
Adaptation Process

- Running simulation on DNI network model with predefined workload
- Different solvers (SimQPN, OMNeT++, …)
- Simulation returns detailed performance predictions
- Detection of violated SLAs

Performance Evaluation

SLA Violation Detection

Strategy Selection

- Selecting strategy based on violated SLAs
- Each strategy could trigger multiple tactics (branching)
- A tactic executes a specific adaptation operation on a type of components
- Multiple solving candidate configurations possible

Filters

- Filter generated candidate configurations
- Limits the number of models, which have to be analyzed in next iteration
Adaptation Process

- Performance Evaluation
- SLA Violation Detection
- Strategy Selection
  - Strategy A
    - Tactic 1
  - Strategy B
    - Tactic 2
    - Tactic 3
- Filters

Input Configuration

SLA compliant configurations

candidate configurations

Motivation  |  Modeling  |  Adaptation Process  |  Evaluation  |  Conclusion
5 Computing Nodes

4 Network Nodes

Observed traffic: 2 GB between client 1 and server 1 (1 Gbps)

Bottleneck on network interface at switch 3 to switch 4

Alternative configurations for switch 3 and 4
Efficient Pareto Front Discovery

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Brute Force</th>
<th>Optimized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>1.75 h</td>
<td>24 sec.</td>
</tr>
<tr>
<td>Number of simulations</td>
<td>3190</td>
<td>10</td>
</tr>
<tr>
<td>Number of returned solutions</td>
<td>231</td>
<td>3</td>
</tr>
</tbody>
</table>

- **Motivation**
- **Adaptation Process**
- **Conclusion**
- **Evaluation**
- **Modeling**

- **Figure:** Graph showing the relationship between investment ($\) and handling time (sec.) for both Brute Force and Optimized methods.
Contributions

Models
- DNI
- Extensions
- Analysis Result
- SLA
- Adaptation Points
- Costs
- Adaptation Plan

Adaptation Process
- Input Configuration
- Performance Evaluation
- SLA Violation Detection
- Strategy Selection
- Strategy A
- Strategy B
- Tactic 1
- Tactic 2
- Tactic 3
- Filters

Adaptation Framework
Conclusion

Benefits

- Model-based detection of SLA violations on networks
- Suggestion of network adaptations
- Efficient Pareto front discovery
- Respects user constraints
- Evaluation of suggested adaptations

Future Work

- Evaluate alternative model solvers
- Support for SDN flows
- Apply at scale
Literature


### Benefits
- Model-based detection of SLA violations on networks
- Suggestion of network adaptations
- Efficient Pareto front discovery
- Respects user constraints
- Evaluation of suggested adaptations

### Future Work
- Evaluate alternative model solvers
- Support for SDN flows
- Apply at scale

---

**Stefan Herrnleben**

stefan.herrnleben@uni-wuerzburg.de

http://go.uni-wuerzburg.de/herrnleben

Download our slides from [http://descartes.tools/dni](http://descartes.tools/dni)