Performance Predictions for Adaptive Cloud-Based Systems using FMC-QE

Stephan Kluth
FOM University of Applied Sciences
mail@stephankluth.de

ADAPTIVE 2020
Short Resume
Stephan Kluth

• Bachelor of Science in Software Engineering, 2004
• Master of Science in Software Engineering, 2005
• Ph.D., Topic: “Quantitative Modeling and Analysis with FMC-QE”, 2011

SQS AG, Cologne (2010-2016):
IT-Consultant

FernUni Hagen, Hagen (2014-2020):
Mentor (Business Informatics, Math)

Lecturer (IT-Security, Software-Engineering, IT-Basics)

Head of IT, Product Owner, Business Analyst

FOM University of Applied Sciences (since 2019):
Lecturer (Business Informatics)

Certifications:
• Certified ScrumMaster
• Microsoft Certified Professional (MCP)
• ISTQB Certified Tester, Foundation Level
• ISTQB Certified Tester, Advanced Level, Test Manager
Fundamental Modeling Concepts for Quantitative Analysis

- Technique to model and evaluate quantitative behavior of systems

- Complexity Reduction through:
  - Hierarchical Modeling
  - Multidimensional System view based on FMC
  - Distinction of operational- and control states

- Hierarchical interpretable structure for performance prediction
FMC-QE multidimensional system perspectives

Service Request Structures

Dynamic Behavior and Control Flow
FMC-QE Calculus

FMC-QE Calculus based on:

- Little’s Law

\[ N^{[bb]} = \lambda^{[bb]} \times R^{[bb]} \]

- Forced Traffic Flow Law

\[ \lambda_{\text{int}}^{[bb]} = v_{\text{int}}^{[bb]} \times \lambda_{\text{ext}}^{[bb-1]} \]

### Experimental Parameters:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>( n_{\text{sys}} )</td>
<td>30</td>
</tr>
<tr>
<td>( \lambda_{\text{bott}} )</td>
<td>2,0000</td>
</tr>
<tr>
<td>( f )</td>
<td>0.8000</td>
</tr>
<tr>
<td>( \lambda )</td>
<td>1,6000</td>
</tr>
</tbody>
</table>

### Service Request Section

| [bb] | SRq_{[bb]} | \( p_{[bb-1],i} \) | \( v_{\text{ext}}^{[bb-1]} \) | \( v_{\text{int}}^{[bb]} \) | \( \lambda^{[bb]} \) | Server_i | \( X_{\text{measured}}^{[bb]} \) | \( m_{\text{ext}}^{[bb-1]} \) | \( m_{\text{int}}^{[bb]} \) | \( m_i^{[bb]} \) | \( \mu_i^{[bb]} \) | \( \mu_i^{[bb]} m_i^{[bb]} \) | \( R_i^{[bb]} \) |
|------|------------|------------------|-----------------|-----------------|-----------------|-----------|----------------|----------------|----------------|----------------|---------------|----------------|-----------------|-----------|
| 2    | Webservice | 1                | 1               | 3               | 3               | 4,8000    | Webserver | 1,0000         | 1              | 1              | 1              | 1.0000      | 1.0000         | 0.0000 | 4.8000 | 4.8000 | 1.0000 |
| 2    | Initialization | 1            | 1               | 1               | 1               | 1,6000    | App. Server | 0,2000         | 1              | 1              | 1              | 0.5000      | 2.0000         | 0.8000 | 3.2000 | 6.0000 | 2.5000 |
| 1    | Request     | 1                | 1               | 1               | 1               | 1,6000    |           |                | 1              | 1              | 1              | 2.0000      | 3.2000         | 5.6000 | 8.8000 | 5.5000 |       |
| 1    | Request Generation | 1            | 1               | 1               | 1               | 1,6000    |           |                | 1              | 1              | 1              | 13,2500     | 0.0755         | 0.0000 | 21,2000 | 21,2000 | 13,2500 |

### Multiplexer Section

<table>
<thead>
<tr>
<th>Multiplexer_i</th>
<th>( m_i )</th>
<th>( \mu_i^{[T]} )</th>
<th>( \mu_i^{[T]} m_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>App. Server</td>
<td>1</td>
<td>0.5000</td>
<td>2.0000</td>
</tr>
<tr>
<td>Webserver</td>
<td>( \infty )</td>
<td>1.0000</td>
<td></td>
</tr>
</tbody>
</table>
FMC-QE and (Self-)Adaptive Cloud-Based Systems

Servers cloud be represented as multiplexers
Case-Study – Example SAP-Workflow

Dynamic Behavior

Case-Study – Example SAP-Workflow

Service Request Structures

- **Request Generation**
  - Action: Generate Request
  - Server: Client

- **Order Notebook for new Employee - Request**
  - Action: Order Notebook for new Employee
  - Server: Request Handler

- **Details Request**
  - Action: Get Empl. Details
  - Server: Details Retriever

- **Get Buddy List and Equipment Request**
  - Action: Get Buddy List and Equipment
  - Server: List and Equipment Handler

- **Equipment Negotiation Request**
  - Action: Equipment Negotiation
  - Server: Equipment Negotiation Handler

- **Accept workplace Request**
  - Action: Accept workplace
  - Server: Accept workplace Handler

- **Get and Process Buddy List Request**
  - Action: Get and Process Buddy List
  - Srv: Get and Process Buddy List Handler

- **Determine Equipment Request**
  - Action: Determine Equipment
  - Srv: Determine Equipment Handler

- **C. or C. Equipment Request**
  - Action: C. or C. Equipment
  - Srv: C. or C. Equipment Handler

- **Approve Equipment Request**
  - Action: Approve Equipment
  - Srv: Approve Equipment Handler
Case-Study – Example SAP-Workflow

Server Structures

- **Client**
- **Request Handler**
  - **Details Retriever**
  - **List and Equipment Handler**
  - **Equipment Negotiation Handler**
  - **Accept Workplace Handler**
  - **Get and Process Buddy List Handler**
  - **Determine Equipment Handler**
  - **C. or C. Equipment Handler**
  - **Approve Equipment Handler**

**Logical Servers**
- **HR System** (m=1)
- **Cloud System** (m=30)
- **Manager KI** (m=1)
- **Mentor KI** (m=4)

**Multiplexer Servers**

- **X = 0.75 [s]/[Req]**
- **X = 0.5 [s]/[Req]**
- **X = 0.8 [s]/[Req]**
- **X = 0.95 [s]/[Req]**
- **X = 1.5 [s]/[Req]**
- **X = 2.1 [s]/[Req]**
- **X = 1.0 [s]/[Req]**

Stephan Kluth | ADAPTIVE 2020
## Experimental Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>n_{\text{sys}}^{[1]}</td>
<td>80</td>
</tr>
<tr>
<td>\lambda_{\text{bott}}^{[1]}</td>
<td>0.5556</td>
</tr>
<tr>
<td>\lambda</td>
<td>0.9500</td>
</tr>
<tr>
<td>\lambda_{[1]}</td>
<td>0.5278</td>
</tr>
</tbody>
</table>

## Service Request Section

<table>
<thead>
<tr>
<th>bb</th>
<th>SRq_{[ba]}</th>
<th>p_b^{[ba]}</th>
<th>m_{p_b}^{[ba]}</th>
<th>m_{m_b}^{[ba]}</th>
<th>m_{x_b}^{[ba]}</th>
<th>m_{s_b}^{[ba]}</th>
<th>\lambda_b^{[ba]}</th>
<th>N_{x_b}^{[ba]}</th>
<th>R_{[ba]}^{[ba]}</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Get Employee Details from SuccessFactors</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>0.528</td>
<td>Details Retriever</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Get Buddy List from SFSF</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>0.528</td>
<td>Get Buddy List Handler</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Process Buddy List</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>0.528</td>
<td>Process Buddy List Handler</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Get and Process Buddy List</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>0.528</td>
<td>Get and Process Buddy List Handler</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Determine Equipment</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>0.528</td>
<td>Determine Equipment Handler</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Get Buddy List and Equipment</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>0.528</td>
<td>List and Equipment Handler</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Change or Confirm Equipment</td>
<td>1.00</td>
<td>1.20</td>
<td>1.00</td>
<td>1.20</td>
<td>0.633</td>
<td>C. or C. Equipment Handler</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Approve Equipment</td>
<td>1.00</td>
<td>1.20</td>
<td>1.00</td>
<td>1.20</td>
<td>0.633</td>
<td>Approve Equipment Handler</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Equipment Negotiation</td>
<td>1.00</td>
<td>1.00</td>
<td>1.20</td>
<td>1.20</td>
<td>0.633</td>
<td>Equipment Negotiation Handler</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Accept workplace for new hire</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>0.528</td>
<td>Accept Workplace Handler</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>Order Notebook for new Employe</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>0.528</td>
<td>Request Handler</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>Request Generation</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>0.528</td>
<td>Client</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

## Server Section

## Dynamic Evaluation Section

## Multiplexer Section

<table>
<thead>
<tr>
<th>j</th>
<th>Name_{i}</th>
<th>m_{i}</th>
<th>X_{i}^{[1]}</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HR System</td>
<td>1</td>
<td>0.750</td>
</tr>
<tr>
<td>2</td>
<td>Cloud System</td>
<td>30</td>
<td>1.300</td>
</tr>
<tr>
<td>3</td>
<td>Manager Kl</td>
<td>1</td>
<td>1.800</td>
</tr>
<tr>
<td>4</td>
<td>Mentor Kl</td>
<td>4</td>
<td>2.250</td>
</tr>
</tbody>
</table>
Conclusion

- Hierarchical modeling and hierarchical performance calculations could derive performance values (response times or queue lengths) for distributed cloud-based systems.

- Performance predictions could be used to adapt Service-Level-Agreements (SLAs).

- Predictions could be integrated into the algorithms of self-adaptive systems, while the hierarchical approach reduces the complexity dramatically.

- Performance predictions are integrated into a spreadsheet but are not limited to this.

- In the future:
  - Further integrate calculations of the FMC-QE Tableau to BPMN.
  - More patterns for the hierarchical modeling to transform BPMN Diagrams.
References

This presentation is connected to the following publication:

Stephan Kluth:

*Performance Predictions for Adaptive Cloud-Based Systems using FMC-QE*

The Twelfth International Conference on Adaptive and Self-Adaptive Systems and Applications (ADAPTIVE 2020 – Nice, France, October 2020)

available through ThinkMind digital library

All further references are to be found in this publication.