Cognitive Network Management – automation for multi-tenant 5G mobile networks

DT Workshop on „Network and Service Management for Future Networks“

Henning Sanneck, Christian Mannweiler
December 7, 2016
Background: Network management vision

1. Knowledge based self-operation
   - Providing analytics via machine learning

2. Automation for multi-tenant 5G mobile networks
   - Enabling Slice Management

3. Operations DevOps
   - Programmable Network Operations Center

4. Application DevOps
   - Network management continuous delivery

5. Network DevOps
   - Fast Pass / Model driven NE support

6. Cloud architecture
   - Any datacenter, any size, always operational

7. Web/mash-up based applications
   - Best fit for operator ecosystem

8. Real-time
   - Stream processing of information

9. Flat O&M architecture
   - Shift from moving data to sharing data

10. Multi-domain
    - Operations across domains

11. Multi-vendor
    - Simplifying operator OSS environment

© Nokia 2016
Research on automation for multi-tenant 5G mobile networks

Ultra Dense Small Cells

Cloudified (Macro) RAN & Core (vNFs)

Ultra-high energy efficiency

Multi-service network

Scalable operator control

Automation $$$

Multi-tenancy

Cognitive Network Management
## 5G Network Management

### Some challenges

<table>
<thead>
<tr>
<th>Ultra Dense Small Cells</th>
<th>Cloudified (Macro) RAN &amp; Core (VNFs)</th>
<th>Ultra-high Energy Efficiency (EE)</th>
<th>Multi-service Network</th>
<th>Scalable Operator Control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Distribution</strong></td>
<td><strong>Centralization</strong></td>
<td><strong>Multi-RAT / layer</strong></td>
<td><strong>Slices</strong></td>
<td><strong>Objectives, policies</strong></td>
</tr>
</tbody>
</table>

- **Flexible VNF re-location / re-configuration**
- **Distributed coordination / decisions; Management hierarchy / aggregation**
- **Automated management of physical / virtualized infrastructure**
- **Network-level configuration & coordination of EE capabilities**
- **Coordinated slice config. & optimiz.; Separation (& sharing) of management knowledge; Embedded analytics**
- **Scalable NM concepts (distribution, autonomy; hierarchy), Embedded analytics, Objective-driven NM**

“Hybrid” NM
5G Networks and their Management: Opportunity vs. Risk

**Opportunity:** ubiquitous, unlimited connectivity for a wide range of services

**Risk:** complexity of the network infrastructure (dense small cells, mixed physical/virtual infrastructure)

---

**Capacity**
- "Ubiquitous"
- "Unlimited"

**Coverage**
- "Ubiquitous"

**Characteristics:** Scale (# users, # applications)
- Manifestation: network usage data

**Cost**
- viable
- prohibitive
- $\rightarrow$ $$$

**Network complexity**
- high

---

Cognition: drive opportunity, limit risk by "mastering data" → mastering complexity
Cognition

","Cognitive Functions" augmenting rule-based automation
  • Gaining *machine-level insights* from data with analytics

**Combining** machine-level insights with human insights
  • Closed-loop Cognitive Functions (for specific, frequent tasks)
  • Linking to human-level workflows through open-loop functions (for other, more complex tasks)

Cognition is „the brain“ of the future mobile network business (design, build, operate)

Building knowledge in silos is not sufficient
→ sharing knowledge inside an operational domain and across different, related areas
Cognitive Network Management System (multi-vendor, multi-tenant)

- Objective driven Management
- Verification
  - Multi-cell radio configuration
  - E2E Troubleshooting
  - Energy Saving
- Manage Virtualized Infrastructure / Slicing

**Analytics**
- Machine Learning
- Knowledge Management

(Trained) telco-centric knowledge models & context
Management of network slicing is “umbrella” functionality
- Across domains
- VNFs and PNFs
- Across tenants
- Across infrastructure providers
- Across vendors

Service management is not covered by current 3GPP standards
- TMForum and ITIL provide (high-level) industry specifications

Generally: Are open or standardized interfaces required between each level?
Depth of control and entry levels of 3rd party

Option 1
- Web Service
- Service Management
- Network Management
- Network Orchestration
- Element Manager
- VNF Manager
- Network Slice 1
- Network Slice 2

Option 2
- Human operator / Application
- Service Management
- BSS

3rd party (e.g., vertical)
Depth of control and entry levels of 3rd party

Number of management function instances is subject to
- operational requirements
- business relations
- number / type of administrative domains
Combining the architectural and functional point-of-views

- **Verticals**
  - OSS, Network, Domain, and Element Management
  - Network Slicing
  - Virtualized Core Functions
  - Virtualized Radio Functions
  - Physical ("bare metal") Radio Functions

- **Data Center HW, Transport HW**
- **Multi-RAT / -layer Radio HW (incl. 5G air interface), Fronthaul / Backhaul**

<table>
<thead>
<tr>
<th>CogNM use cases for (partially) virtualized radio functions</th>
<th>OAM domain</th>
<th>Cognitive Functions (CF)</th>
<th>NFV domain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto-connectivity / -commissioning</td>
<td>Install of radio HW (site)</td>
<td>Install of virtualization SW and vNE (BTS) SW</td>
<td></td>
</tr>
<tr>
<td>Load Balancing &amp; Multi-Connectivity Management</td>
<td>Radio Load (MLB, Traffic Steering), User Mobility Patterns (MRO)</td>
<td>Compute Load (Scale-in / Scale-out)</td>
<td></td>
</tr>
<tr>
<td>Energy Savings Management</td>
<td>Radio HW (frq, MIMO) energy management</td>
<td>Compute energy management</td>
<td></td>
</tr>
<tr>
<td>Healing</td>
<td>Radio HW and node SW troubleshooting</td>
<td>Compute / store troubleshooting, correlation</td>
<td></td>
</tr>
</tbody>
</table>

© 2016 Nokia
Cognitive NM: *scalable* automation for multi-tenant 5G networks

Conclusions: The major obstacles / issues which should be solved (top priority topics of cross-industry interest) regarding the management aspects

- **5G Network characteristics (ultra dense, cloudified, multi-service / -tenant) impose new operability challenges**
  - **Functional:**
    - higher resolution of measurements / data; new external data sources / context
    - per service- / tenant- instrumentation and *dynamic* operation (multiplicity of *virtual* network configurations)
    - higher degree of autonomy in management
  - **Architectural:**
    - higher degree of distribution, cooperation / coordination and abstraction
    - new building blocks (e.g., slicing management) / interfaces / APIs (incl. open source)
- **Technology enablers:** analytics / machine learning, knowledge management, policy-based management, virtualization
- **Cognitive functions to master network data → mastering network complexity**
Cognitive NM: scalable automation for multi-tenant 5G networks
Conclusions: The next steps to solve the issues

• Need for a collaborative, industry-driven research project in **(virtualized) 5G** RAN Management → platform for pre-standardization discussion & alignment
  • 5GPPP project proposal (EU H2020, phase 2) lead by Nokia submitted
  • Discussion with **verticals** on management requirements of their use cases („depth of control“ in network slicing management)
  • Nokia is co-leading the German BMBF „Tacnet“ project
  • Systematically derive management requirements from **5G architecture** characteristics
    • Nokia is leading the 5GPPP project „5G NORMA“ (EU H2020, phase 1)
  • Combination of different approaches (standardization, „retrospective alignment“: OSSii, open source APIs, proprietary integration) to achieve **multi-vendor** inter-operability
Active in shaping and aligning the global 5G end-to-end ecosystem