SLA Management and Service Composition of Virtualized Applications in Mobile Networking Environments

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Cloud-based mobile networks: the concept

Moving cloud computing beyond datacenters…

… towards the mobile end-users.

Mobile Connectivity
Decentralized Computing
Smart Storage
offered as a single end-to-end service

- On-demand and self-service
- Elastic
- Multi-tenant
- Pay-as-you-go
LTE systems on the cloud: the MCN approach

Mobile Core Network as a Service
3GPP EPC data plane and control plane components provisioned on-demand and dynamically operated on the cloud

RAN as a Service
Offer heterogeneous radio access as a service, moving the BBU processing into DCs

Cross-domain control and management plane
The fundamental enabler for the automated, seamless orchestration and composition of heterogeneous cloud/net services and resources

Support services
A full set of integrated services for end-to-end management solutions
MCN holistic vision

A dynamic and orchestrated composition of heterogeneous resources, atomic functions, supporting services and applications

Everything provided as-a-Service!
But how to manage SLAs for this service composition?

**E2E services for novel apps**
- CDN –aaS
- DSS –aaS

**Network infrastructure services**
- RAN –aaS
- EPC –aaS

**Atomic services**
- Computing –aaS
- Storage –aaS
- Network -aaS

**Support services**
- DB -aaS
- Monitoring -aaS
- DNS -aaS
- SLA Management -aaS
- Rating, Charging, Billing -aaS

**Enhanced features**
- Follow me and VM migration
- Load Balancing -aaS
SLA management in MCN: the challenges

**End-to-end service chain** of cloud infrastructures, virtualized network functions, support services & applications

- Offered by a single provider or through federation of multiple providers
- Composition of heterogeneous, but interdependent service components
- Sharing of cross-domain cloud/net infrastructures among multiple tenants

**SLA management** as an integrated support service of the MCN platform

- Enforcement and validation of end-to-end SLAs for complex services
- Exploiting the monitoring functions offered by the MCN platform
  - Combination of heterogeneous parameters, from different layers (net/cloud infrastructure or service performance) and belonging to different domains
- Support for pay-as-you-go and SLA-oriented charging models
- Trigger for customer-driven service elasticity and baseline for service reliability
MCN framework based on a **service-oriented** architecture

- All the functional elements are modelled and delivered as services

**Service Manager**: the entry-point for all the service requests

- Business dimension to encode the business agreements
- Technical dimension to manage the Service Orchestrator instances

**Service Orchestrator**: a domain-specific component responsible of the *orchestration and binding* of MCN services and applications

- Manages inter-dependencies among service components

**Cloud Controller**: the component coordinating the *end-to-end provisioning* of atomic and support service resources
Objective: enable MCN providers to deliver end-to-end composed services compliant with the established SLAs

- Service Level Objectives at the single AND composed service level
  - Describing inter-dependencies and expected service cooperation
- Automated combination and joint evaluation of mixed information
  - From the virtual infrastructure at the resource level
  - From the different services at the application level

SLA management as a Service:

- Support service deployed and provisioned on-demand on the cloud
- Automated adaptation to the dynamicity of the other services

Features:

- SLA repository for all MCN services
- SLA enforcement in support of the Service Orchestrator
- SLA verification to detect and react to SLA violations
SLA Management System

**SLA Repository**
SLAs with QoS params, metrics, cross-service features, monitoring, elastic procedures, …

**Centralized SLA Management System**
Persistent component with global SLA repository and processing engine for all the services offered by an MCN provider

**Collector & Aggregator**
Acquisition and combination of monitoring data in periodical reports

**SLA Agents**
Distributed components deployed on-demand for each MCN service instance

**SLA Rules Engine**
Processing & validation of SLA rules
Prediction & detection of SLA breaches

**Feedback Manager**
Decision point for SLA breach detection and reaction

**Per-atomic-service distributed SLA Agents**
Monitoring Service Instance
RCB Service Instance

**SLA Repository**
Collector
Aggregator
Feedback Manager
SLA management in MCN service lifecycle

**MCN service lifecycle**

- **Design**
  - Per-service SLA definition
    - Definition of SLA rules for the specific MCN service
    - Configuration of SLA repository

- **Implementation**

- **Deployment**

- **Provisioning**

- **Runtime & Mgt**
  - SLA as input for service instantiation
    - SLA metrics for QoS and service guarantees
    - Cost model
    - SLA monitoring rules
  
  - SLA validation during service runtime
    - SLA monitoring & validation rules
    - Compensation for SLA breach
    - SLA feedbacks for service recovery and dynamic modification

- **Termination**
SLA enforcement @ service provisioning

1. Service request
2. Query for SLA spec
3. Manifest File with SLA spec
4. Service Provisioning

Centralized SLA Management System

Per-atomic-service distributed SLA Agents

Monitoring as-a-Service
RCB as-a-Service

A composed service instance
SLA validation @ service runtime

MCN Service

Service Manager

Service Orchestrator

5. SLA violation countermeasure

6. Updated Manifest File

Cloud Controller

7. Service Modification

SLA Repository

SLA Rules Engine

Collector → Aggregator

3. Consolidated SLA report

Feedback Manager

Centralized SLA Management System

2. Per-atomic-service SLA compliance reports

Per-atomic-service distributed SLA Agents

1. Monitoring data

Monitoring as-a-Service

4. SLA violation reports

RCB as-a-Service

A composed service instance
Monitoring for SLA verification: Monitoring as a Service

**SLA Agents**
as specific Monitoring Consumers deployed on-demand

**MaaS as MCN support service**
Follows MCN services lifecycle: requested via SM, coordinated through SO, provisioned by CC

**CMMS**
Centralized elaboration & storage of heterogeneous monitoring data

**Monitoring Agents**
to collect information from a variety of service components
Conclusions

Many **opportunities for cloud-based mobile networks**...

- Full exploitation of cloud concepts
  - On-demand and self-service
  - Elasticity
  - Multi-tenancy
  - Pay-as-you-go
- Seamless integration of mobile connectivity + computing + storage resources
  - On-demand end-to-end services for novel applications

... with many **technical challenges**

- Radio Access and Mobile Core Networks moved on the cloud
- A full set of enhanced functions and support services for e2e cross-layer management
  - LoadBalancing-aaS, Monitoring-aaS, RCB-aaS...

A seamless and automated composition of cloud resources and services that requires an **integrated SLA management** service

- Active during the different service phases
- Supporting SLA enforcement and validation
- Combining a mix of heterogeneous monitoring data at infrastructure and service level
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