Network Slicing Based 5G: Mobility, Resource Management, and Challenges

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Guide

Background

- 5G Drivers
- 5G Development
Mobile Internet and the Internet of Things (IoT) are two main drivers for future network slicing based 5G networks.

- Exponential traffic and Massive data requirements
- Ultra dense heterogeneous networks
- Cloudization and virtualization
- "Mobile" out, wireless "connectivity" in
- New business model
- Energy challenge
- Nobody can "make" more spectrum...
5G Development

A concept for future mobile and wireless communications system that supports the connected information society.
- An end-to-end ecosystem
- Network as a service
- Fully mobile and connected society
- Consistent user experience
- Sustainable business models

- 1000x higher mobile data volumes
- 10x – 100x higher number of connected devices
- 10x – 100x typical end-user data rates
- 5x lower latency
- 10x longer battery life for low-power devices
Guide

System Architecture

- System architecture
- Slicing management
System Architecture

➢ Substantial change of 5G network architecture
➢ Perfect combination of NFV & SDWN
➢ Heterogeneous ultra dense small cell networks

Network slicing based 5G system architecture

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An end-to-end network slice is a specific collection of network functions and resource allocation modules isolated from other network slices.

- enhanced mobile broadband (eMBB) slice
- ultra-reliable and low-latency communication (uRLLC) slice
- Internet of things (IoT) slice

Network slicing management with SDN & NFV
Guide

Mobility Management

- Necessity
- Mobility management

Smart Vehicles, Transport & Infrastructure

- Smart Infrastructures
- Connected Bus-stops
- Connected Trucks
- Connected Cars
- Automotive
- Infrastructure
- Transport Companies
- Administration/Governments

Focused on massive machine type communication.
We can consider sensors embedded in roads, railways & airfields to communicate each other and/or with smart vehicles.
Network slicing based 5G systems will still face mobility management challenges caused by the potentially ultra high density of 5G networks combined with high mobility and high density of end devices.

- the simple and single RAT handover cases have evolved to managing complex, multi-RAT mobility scenarios
- the integrated control functions can reduce control signaling even for massive distribute network nodes
- different network slices have different requirements for mobility, latency and reliability
➢ Mobile devices register their locations when they first connect to the network, and then report their location information to the network periodically.

➢ The HSS will be distributed into the edge cloud, making them closer to end devices to shorten registration delays and reduce backhaul burdens.

➢ 5G networks will aggregate multiple heterogeneous RATs.

➢ Multi-RAT coordination is needed for different RATs to share location information of their mobile devices for achieving unified multi-RAT access and seamless mobility in 5G networks.
Resource Management

- System modelling
- Problem formulation
- Simulation results and discussions
A suburban environment is considered with small cells randomly distributed in the macrocell coverage area. Uplink transmission resource allocation is developed including joint subchannel and power allocation. Small cells receive two kinds of interference: cross-tier interference from the microcell; co-tier interference from neighboring small cells.

Coverage radius: macrocell, 500 m; small cells: 10 m. Carrier frequency: 2 GHz. Channel bandwidth: 10 MHz. Minimum inter-small-cell distance: 20 m. Macrocell user (requesting IoT slicing services) number: 50. Each small cell user (requesting eMBB and uRLLC slicing services) number: 2 or 4.
The uplink resource allocation problem is developed as the maximization of uplink capacity on each subchannel for small cells considering the following constraints:

- maximum transmit power
- minimum data rate requirement
- threshold of total interference power
- subchannel scheduling policy

**Objective function:**

\[
\max_{f, u, n} \sum_{f=1}^{F} \sum_{u=1}^{U} \sum_{n=1}^{N} a_{f, u, n} C_{f, u, n}^F
\]

**Constraint conditions:**

\[C1: \sum_{n=1}^{N} a_{f, u, n} p_{f, u, n}^F \leq p_{\text{max}}, \forall f, u\]
\[C2: 0 \leq p_{f, u, n}^F \leq p_{\text{max}}, \forall f, u, n\]
\[C3: \sum_{n=1}^{N} a_{f, u, n} C_{f, u, n}^F \geq R_u, \forall k, \forall u \in D_{\text{eMBB}}\]
\[C4: \sum_{f=1}^{F} \sum_{u=1}^{U} a_{f, u, n} p_{f, u, n}^F g_{f, u, n}^{FM} \leq I_{th}^n, \forall n\]
\[C5: \sum_{u=1}^{U} a_{f, u, n} \leq 1, \forall f, n\]
\[C6: a_{f, u, n} \in \{0, 1\}, \forall f, u, n\]
Simulation Results and Discussions

➢ The eMBB slice capacity rises nearly linearly with the density of small cells and increases slightly with the number of users per small cell.
➢ The total capacity of uRLLC slice increases with the number of small cells, but the capacity of uRLLC slice is 20 times less than that of eMBB slice.
➢ The total capacity of the IoT slice decreases with the number of small cells, due to the increasing cross-tier and co-tier interference.
Challenges

- Network reconstruction
- Slicing management
- Cooperation with other 5G technologies
Both RAN and CN need reconstruction to support end-to-end network slicing. Especially in UDHSNs, not only the cooperation of macrocells and small cells should be designed to meet the customized slicing demands. The cooperation of multiple RATs should be considered to provide seamless mobility and high transmission throughput.
Slicing management

- Supporting **customized configuration of resources, management models, system parameters** for various use cases in an isolated or abstract way.

- Service providers and operators have started developing **industrial solutions** for network slicing.

- To **create, activate, maintain and deactivate** network slicing at the service level.

- To **adjust load balance, charging policies, security** and **QoS** at the network level.

- To **abstract or isolate virtualized network resources**; inter-slice and intra-slice resource sharing.
Network slicing needs to coexist and cooperate with traditional wireless network technologies (such as broadband transmission, mobile cloud engineering (MCE), SDN and NFV) evolved from LTE/LTE-A systems.

However, there is still no proper approach to integrate network slicing with C-RAN, SDN and NFV.

The virtualized cloud of access networks and CN have the advantages of physical resource pooling, distribution of software architectures, centralization of management.
Thanks!