

Resilient Placement of VNFs and Distributed MANO Components in a WMN-based NFV Infrastructure

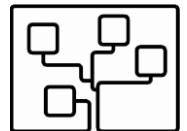
26. ITG-Fachtagung Mobilkommunikation

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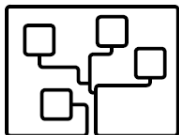
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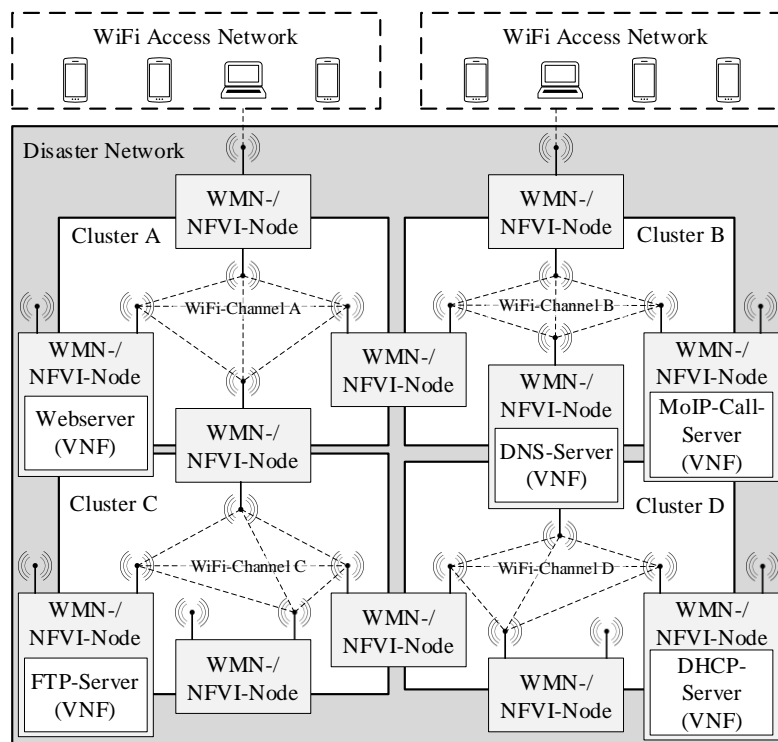
Outline

1. Introduction
2. Concept for a Resilient Placement of Network Functions
3. Model and Optimisation Target for a Resilient Placement
4. Evaluation of the Resilient Placement Concept
5. Summary and Outlook

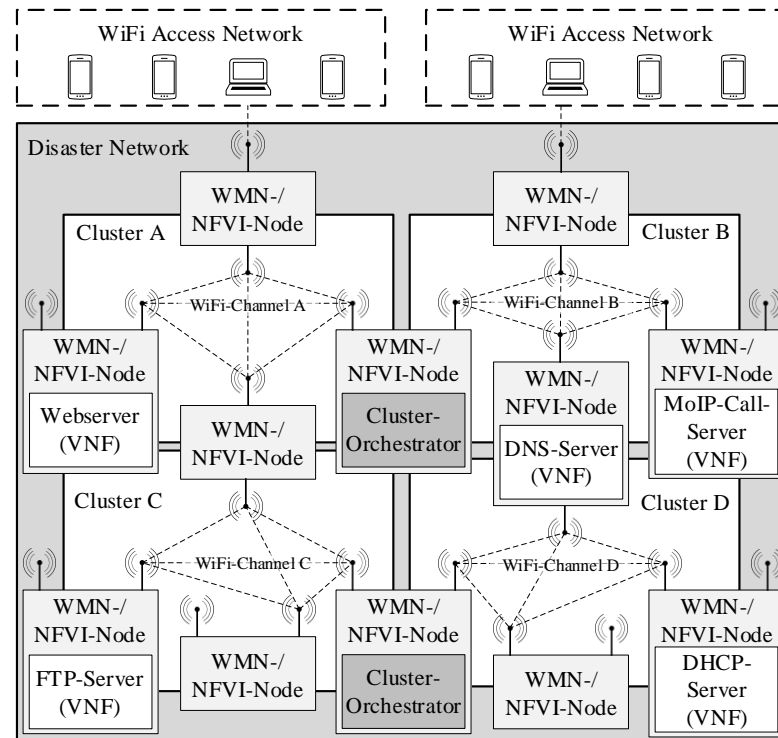


1 Introduction

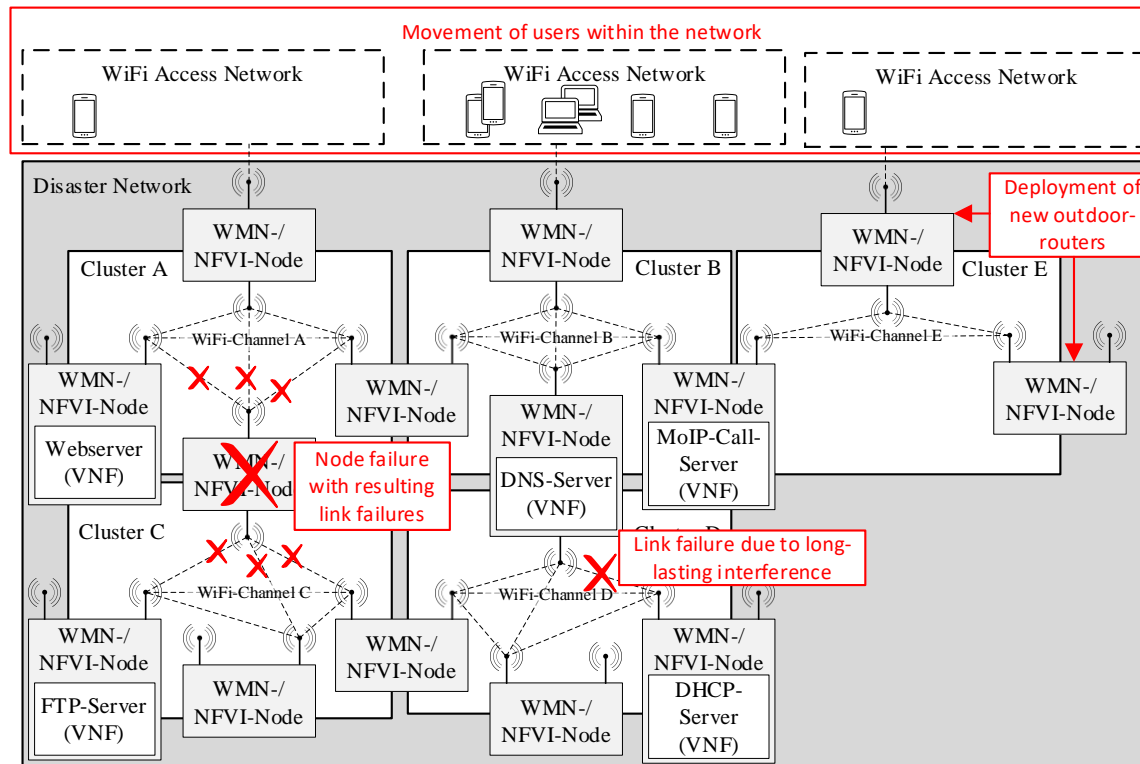
- Provisioning of a disaster network for providing an emergency communication infrastructure constructed from multi-radio wireless outdoor-routers
- Routers are establishing a multi-channel wireless mesh network (WMN) which provides the basis for an IP-based communication
- Integration and utilization of network function virtualisation (NFV) in the WMN for a dynamic and adaptable service provisioning



- **WMN-based NFV Infrastructure (NFVI) is controlled by a distributed management and orchestration (MANO) operating in-band of the network**
- **Cluster-Orchestrators in each cluster are managing and orchestrating the nodes in their assigned cluster**
- **Network-wide orchestration achieved through communication between Cluster-Orchestrators**

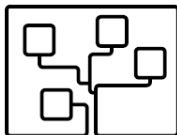


- Major task of the distributed MANO: improve network resilience to changes and events affecting the network infrastructure
- Ensure usability of the network by ensuring service availability
- Major focus within this research: placement of the required network functions for improving their resilience to node and link failures

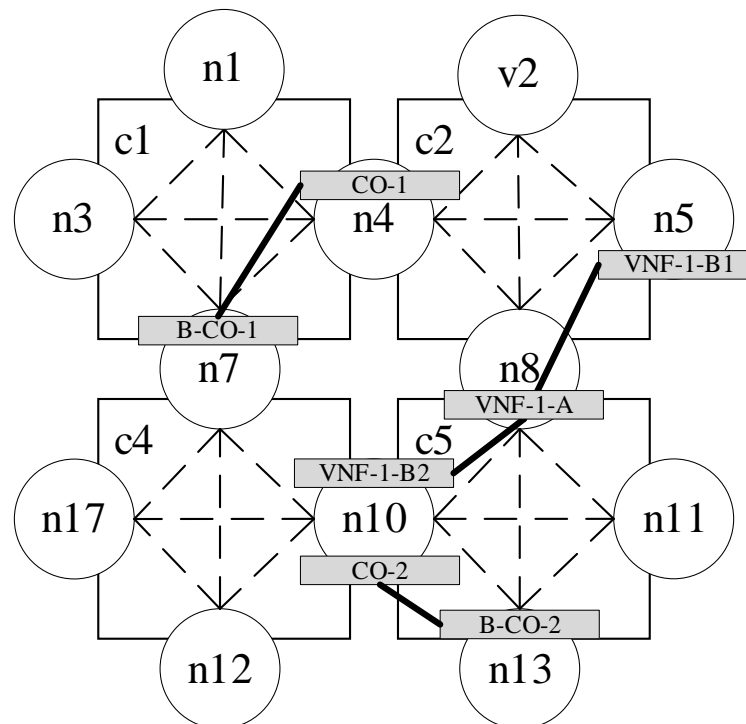


2 Concept for a Resilient Placement of Network Functions

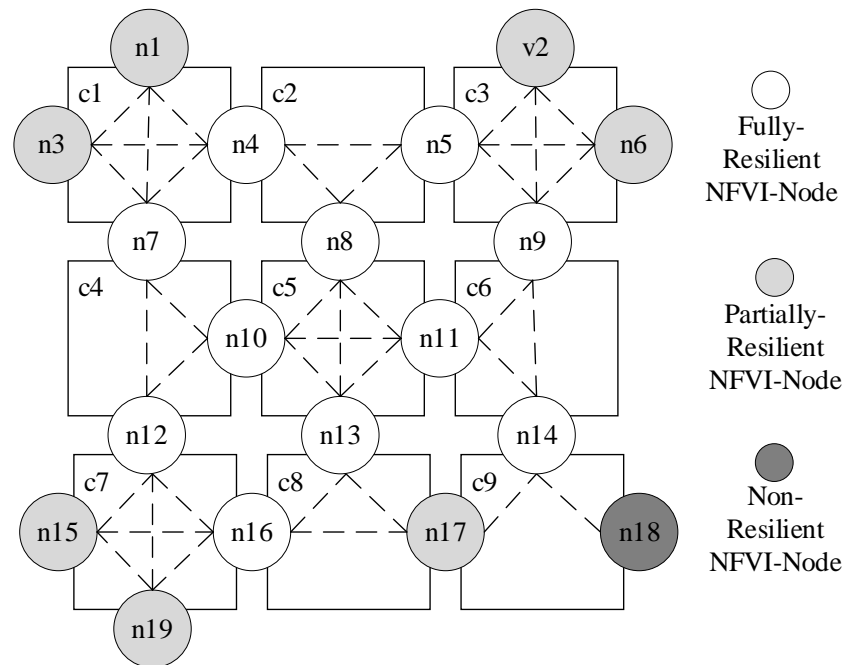
- **Different network functions must be deployed in the network:**
 - **VNFs implementing a functional service component (i.e. server implementations)**
 - **Cluster-Orchestrators building the distributed MANO**
- **Network function is considered to be resilient if it is:**
 - **Node-Protected**
 - **Link-Protected**
 - **Individual performance aspects are met**



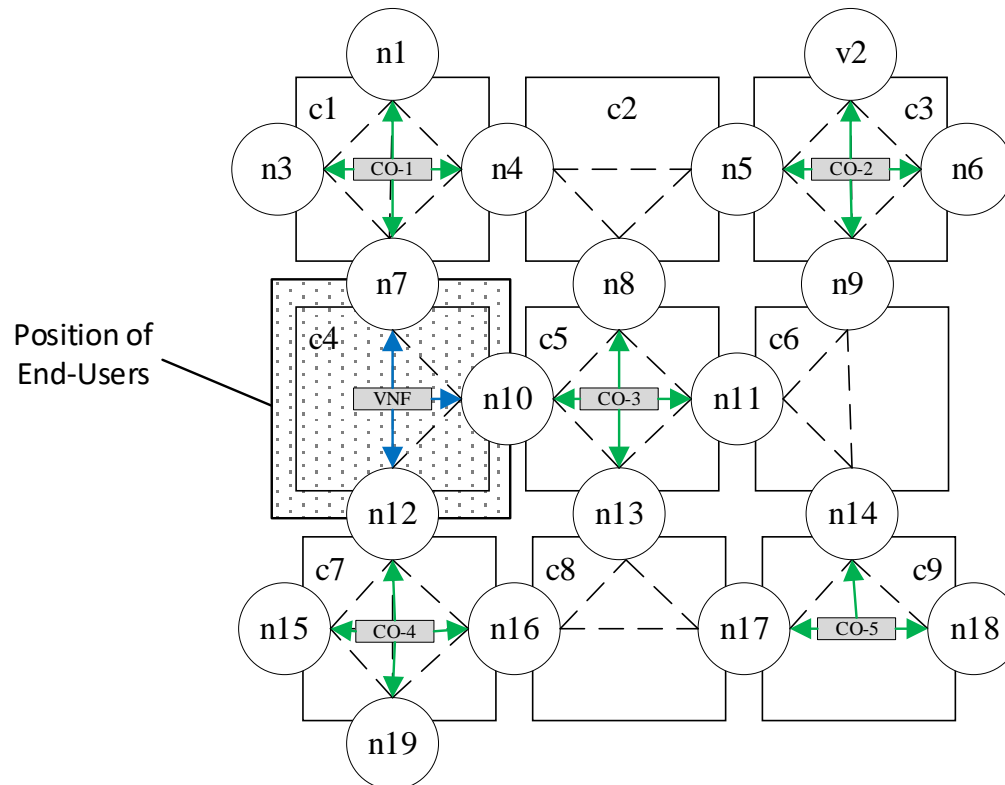
- Ensures that a node failure does not cause the loss of the functionality
- Commonly utilised approach: geo-distributed redundant deployment
- Within the concept for each network function:
 - Two redundant instances per VNF
 - One redundant instance per Cluster-Orchestrator



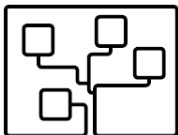
- **Ensures a link failure** (either through interferences or as a result of node failures) **does not cause the network function to become unavailable**
- **Highly depends on the connectivity of the network infrastructure**
- **Each NFVI-Node is continuously evaluated regarding its link-protection capability resulting from the nodes individual connectivity**
- **Possible link-protection states: fully-, partially, and non-resilient**



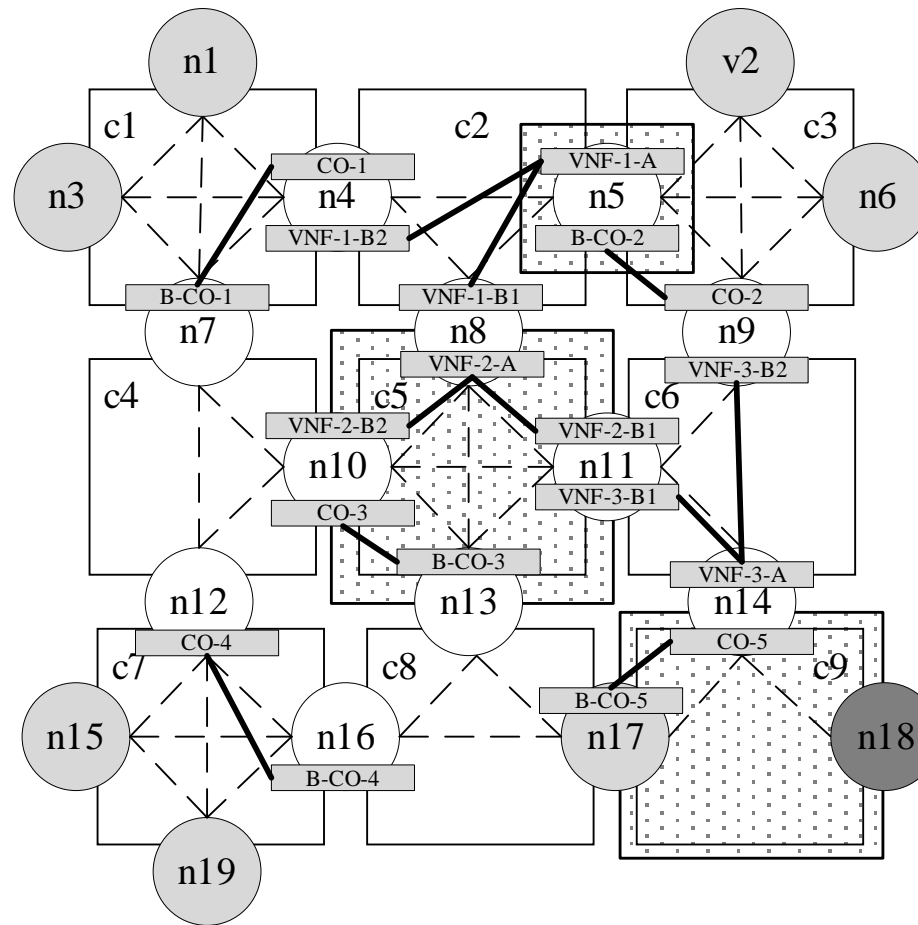
- Protection against link and node failures are insufficient if network function cannot provide its functionality as desired
- Network function must be placed in a network region suitable for its performance aspect:
 - Cluster-Orchestrators within their assigned clusters (see green arrows)
 - VNFs close to the end-user position (see blue arrows)



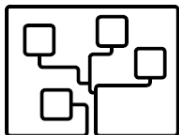
- **Due to limited hardware of outdoor-routers not every network function (and their redundant instances) might be deployable on a fully-resilient NFVI-Node**
- **For this purpose, priorities among the instances of the network functions are imposed (from highest priority to lowest priority):**
 - **Cluster-Orchestrators**
 - **Active VNF**
 - **Backup Cluster-Orchestrator**
 - **First redundant VNF**
 - **Second redundant VNF**



Exemplary placement of network functions according to the concept:



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3 Model and Optimisation Target for a Resilient Placement

Integer Linear Programming (ILP) based Optimisation Target:

$$\text{Maximise} \quad \sum_i^N \sum_j^F \sum_k^{I_j} \text{resilience}_{ijk} \times x_{ijk}$$

NFVI-Nodes *Network Functions* *Instances of Network Function j*

With:

$$x_{ijk} = \begin{cases} 1 & \text{if } n_i \text{ is assigned with } i_{jk} \\ 0 & \text{otherwise} \end{cases}$$

Constraints:

- **Each NFVI-Node is assigned with a maximum of two instances:**

$$\sum_j^F \sum_k^{I_j} x_{ijk} \leq 2; \forall n \in N$$

- **Each instance of a network function is assigned to exactly one NFVI-Node:**

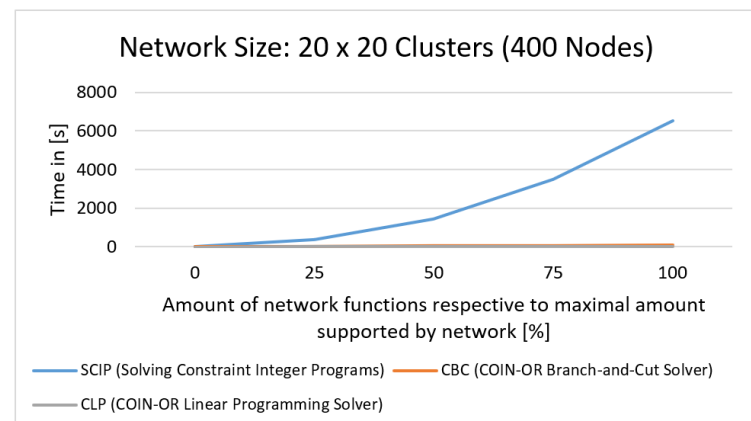
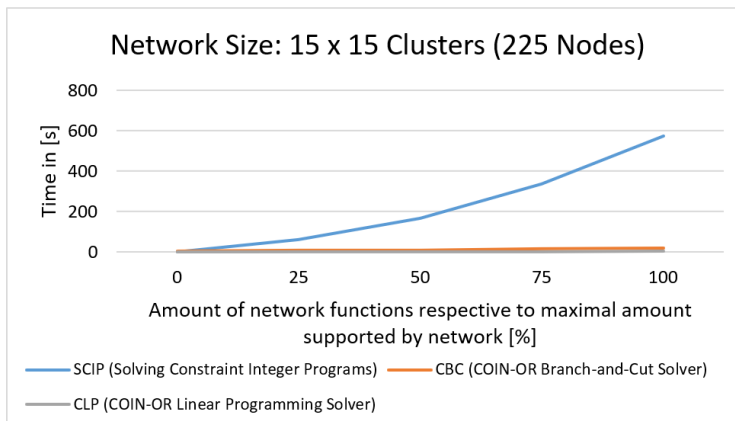
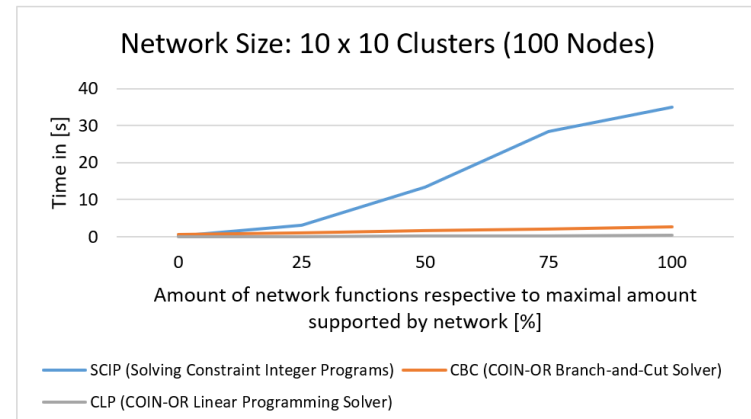
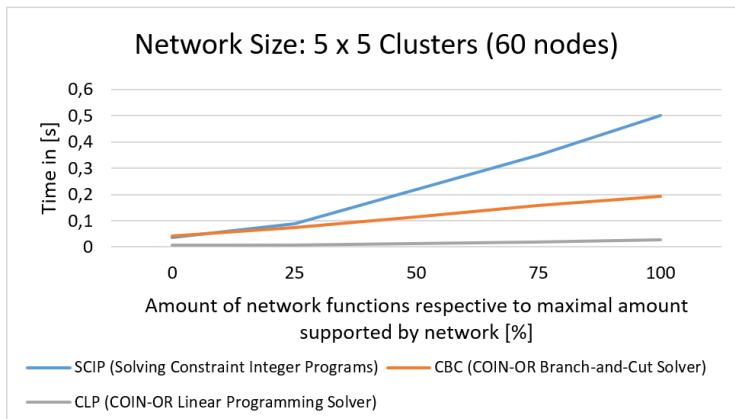
$$\sum_i^N x_{ijk} = 1; \forall f \in F, \forall i \in I_{f_j}$$

- **Each NFVI-Node is assigned with only one instance per network function:**

$$\sum_k^{I_j} x_{ijk} = 1; \forall n \in N, \forall f \in F$$

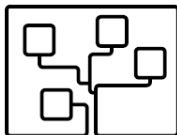
4 Evaluation of the Resilient Placement Concept

- Performance evaluation of existing ILP solvers regarding required time for providing a result at different network sizes and different amount of network functions (see figures)
- Functional evaluation of concept regarding required effort at node failure:
 - In most cases simple redeployment of failed network function instances
 - In some cases additional effort required due to migration of instances resulting from priority aspect



5 Summary and Outlook

- **Improvement of the resilience of a WMN-based disaster network to changes and events affecting the network infrastructure**
- **Concept for a resilience placement of network functions (Cluster-Orchestrators and VNFs) within a WMN-based NFVI**
- **Concept ensures node- and link-protection of network functions, as well as performance related aspects**
- **Definition of a integer linear programming optimisation target based on the concept**
- **Further work will extend the concept to support dynamic network aspects:**
 - **Position of end-users and their demand for services in the network**
 - **Synchronisation effort between the network function instances**
 - **Automatic scaling of the distributed orchestration**



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