Network Engineering: Towards Data-Driven Framework for Network Configuration

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Abstract. In this paper, we want to introduce a new research area "network engineering". The main research question is how the network configuration can be automatically and adaptively decided, given various dynamic contexts (e.g., network interference, heterogeneity and so on). The aim of this work is to design data-driven framework which is in three layer architecture (i.e., network entity layer, complex semantic analytics layer, and action provisioning layer).

Keywords: Network ontology · Network engineering · Data science Automated-Provisioning

1 Network Engineering as a New Research Area

With the developing of Internet of Things (IoT), there have been a large number of networking technologies which enable wired/wireless electronic devices to communicate with each other (Fig. 1). However, the most important development trends of IoT is integrating with existing network system. For instance, given various dynamic contexts (e.g., network interference, heterogeneity and so on), it has been difficult to decide how to build the appropriate configurations for heterogeneous network.

As technology progresses, more and more processing power, storage and battery capacity become available at relatively low cost and with limited space requirements [1]. This trend is enabling the development of extremely small-scale electronic devices with identification, communication, and computing capabilities, which could be embedded in the environment or in common objects. The development of such a new class of services will, in turn, require the introduction of novel paradigms and solutions for communications, networking, computing and software engineering.

In this paper, we introduce a new research area "network engineering". Summarizing, the aim of our research focuses on key system-level issues which are defined as follows:

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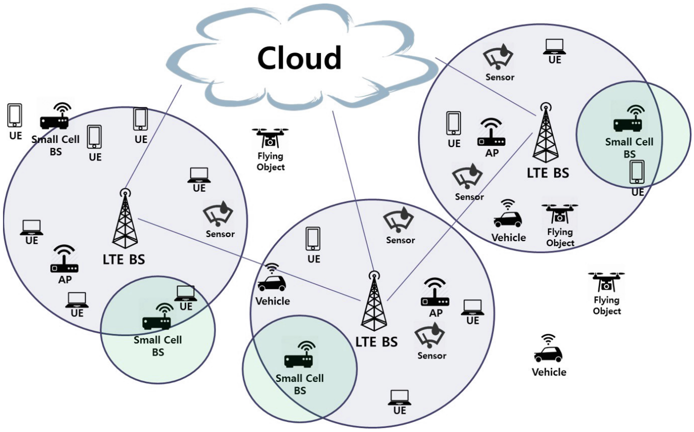

Fig. 1. IoT-based heterogeneous network

- *Devices Heterogeneity*: IoT will be characterized by a large heterogeneity in terms of devices taking part in the system, which are expected to present very different capabilities from the computational and communication standpoints. The management of such a high level of heterogeneity shall be supported at both architectural and protocol levels [2].
- *Network Interference and Scalability*: When large numbers of devices are deployed in urban environments where the ISM bands are already overcrowded the interference from external sources. But how can we allow the devices to really talk to each other without increased signaling in the network and long delays? How can we be sure that when an alarm is raised by an IoT device, this information will be prioritized and sent immediately to the respective target device without being lost due to collisions or interference? they are research questions that we take into account in this work [3,4].
- *Service Provisioning and Management*: due to the massive number of services/service execution options that could be available and the need to handle heterogeneous resources.

2 Data-Driven Framework for Network Configuration

The typical IoT network comprises thousands of connected device using different protocols which have various resources, complex interdependencies and security requirements. Traditional analysis techniques are not able to deal with the configuration challenges of heterogeneous network in terms of scalability, interoperability and security. In this regard, a novel data-driven framework is required to semantically model the network configuration and automated provisioning.

Figure 2 shows an example for inferring the response method for an upset condition of Network based on our proposed framework. In particular, our research context on the development of Data-Driven Framework for network configuration combining three layer architecture as follows:

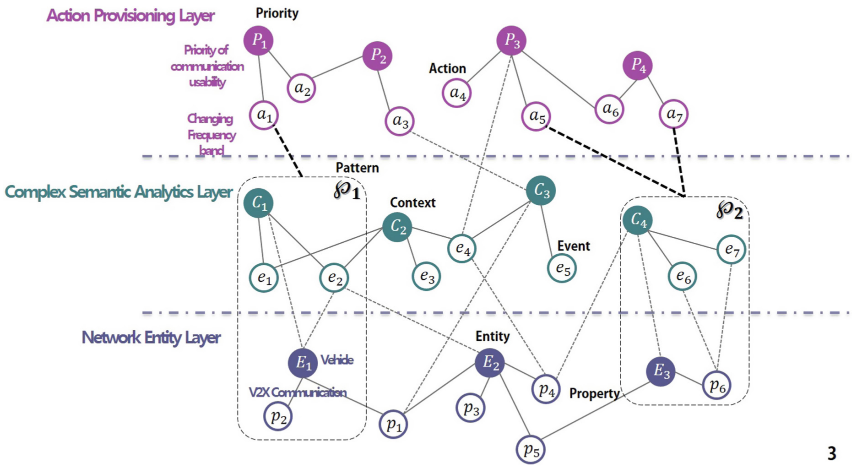

Fig. 2. An example for inferring the response method/action for an upset condition of network

2.1 Network Entity Layer

In this layer, we take into account defining the information of network entities (e.g., Mobile Devices, Sensors, Connected Vehicles and so on) in terms of situation, prior knowledge and association rule. In particular, few features should be properly accounted for:

- Establishing a classification system for entities on the network
- Establishing multi-layer network ontology model
- Describing the network entities, the situations and existing network configuration methodologies
- Inter-layer relationship technology on multi-layer network ontology
- Existing network ontology survey and ontology integration methodology
- Gradual expansion of knowledge base through network ontology integration

2.2 Complex Semantic Analytics Layer

This layer focuses on Network Learning and Context Awareness Methodologies in term of developing functions that automatically detects the situation and environment including network condition, environmental factor, user's request, service operator's requirement. The components and dimensions include:

- Establishing network phenomenon event sensing model
- Detecting methods of Abnormality
- Establishing window size of determination method according to status abnormality
- Abnormal pattern modeling and pattern library construction
- Status fault pattern establishment of high-speed detection method
- Developing event detection model and pattern library learning method

2.3 Action Provisioning Layer

Regarding the application layer, we focus on developing Adaptive Network Provisioning Methodology Module that can be applied to various network domains such as automatic, resource allocation, retrieval, relocation for optimized system resources based on perceived state and system configuration. The research context are defined as follows:

- Development of abnormal pattern analysis methodology
- Network state inference engine development
- Development of evaluation method for Action candidates
- Development of evaluation method for performance result of action
- Development of inference engine learning method based on performance result

3 Adaptive and Automated Provisioning System

Current provisioning and configuring networks are manually intensive processes focused on individual, vendor-specific, network elements rather than the holistic provisioning of data centers across distributed networks and virtual environments. These manual configurations are not able to keep up with rapidly changing devices and networks, creating outage risks for network and data center that forfeit revenue, customer trust, and delay the introduction of new services.

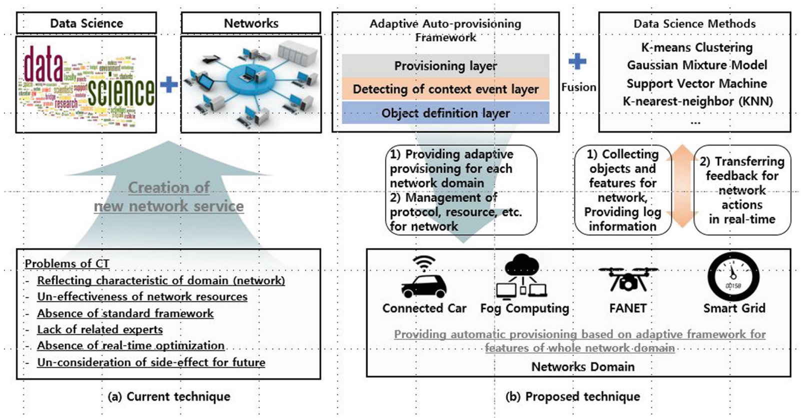

Fig. 3. Adaptive and Automated Provisioning system based on data analysis

In this regard, the objective of this research is developing an Adaptive Automated-Provisioning (AAP) framework for network engineering that can be applied to a variety of network platforms in preparation for the hyper-connected network revolution era. Figure 3 shows the proposed techniques that we consider to develop the AAP framework to improve the capacity of the network based on big data analysis.

4 Discussion and Related Work

As the number of connected things is rapidly growing, the network configuration need to transform in terms of concepts, architecture and protocols. Hence, a dynamic global network infrastructure with self-configuring capabilities becomes a hot issue in this research area. In this study, we introduce a new novel concept,"Network Engineering" which focuses on big data analysis for network configuration in case of automated and adaptive system. Our expected contributions of this study as follows:

– It relieves the user's trust and contributes to the improvement of the national status by eliminating the side effects of the wireless network market applying various algorithms based on data science or artificial intelligence [5–7].
– A system that can cope with various network phenomenon events such as shortage of wireless network resources, link disconnection due to channel and network node mobility, and so on in real time, contributes to enhance the quality of life of the people [8,9].
– Various network services can be created through various wireless network domains (e.g., Smart Grid Platform, Connected Car, Fog Computing, 5G Networks) and more intelligent and stable service can be provided [10–13].
– It is anticipated that it will provide a foundation to lead the global market by supplying low-priced standardized frameworks to domestic and overseas companies/institutes. In addition, we expect to be able to lead the international standardization market by establishing related standardization TG.
– Based on the know-how of convergence research of data science framework and network acquired through this project, we can jump to next-generation core laboratory leading the related fields and emit related research experts.

5 Conclusion and Future Work

With the development of IoTs which combines a thousand devices can be connected with different policies and protocols, a new requirement for the Network Configuration is the integration of independently deployed IoTs sub-networks which are characterized by very heterogeneous devices and connectivity capabilities. In this work, we propose a new novel concept regarding to network configuration area, which is named "Network Engineering". Specifically, our study focuses on improving and increasing the network capacity, performance gain, automated and adaptive provisioning in heterogeneous network environments based on data analysis techniques.

For the next steps of this work, we take into account developing and providing an Adaptive and Automated Provisioning (AAP) framework for Heterogeneous Network which include centralized, decentralized and hybrid systems. Evaluating the advantages of each system with the aim is optimizing capacity of the total network.

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