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A Context-based Future Network Infrastructure for IoT Services

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Abstract

According to a recent study, global IP traffic will have increased threefold over 2014 to 2018. This tremendous growth in IoT traffic and number of IoT devices, has given rise to new requirements from its infrastructure, such as for scalable content distribution, various QoS support, traffic management, security, trust, mobility and so forth. We are designing a context-based Network Infrastructure to meet these requirements. We focus on context-aware in order to support user-centric IoT services. Also we consider multi-network access, mobility, access technologies, and security function.

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Keywords: Internet of Things, Context-aware, Network Infrastructure, Software-Defined Networking, user-centric IoT services

1. Introduction

According to a recent study[1], global IP traffic will have increased threefold over 2014 to 2018, but more importantly, over half of all IP traffic will originate with non-PC devices by that time. From the assumption that most IoT (Internet of Things) devices are non-PC devices, this tremendous growth in both IoT traffic and number of IoT devices, has given rise to new requirements from its infrastructure, such as support for scalable content distribution, differentiated QoS (Quality of Service) support, traffic management, security, trust, mobility and so forth.

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However, the underlying infrastructure, also known as the Internet, was never designed to address such requirements[2]. Still, companies and organizations have introduced new designs, concepts, and paradigms to help the Internet "evolve". For example, Software-Defined Networking is an emerging paradigm that breaks the vertical integration of the control and data planes in a networking device (e.g. routers and switches), this simplifies network management and introduces new possibility in traffic management. Another example is NGSON, Standardized by the IEEE, is an attempt to have a better, more efficient way of providing services (e.g. video streaming) over a Service Overlay Network (SON) based on user contexts.

In this paper, the authors propose a *work-in-progress* evolvable IoT network infrastructure which can be characterized by edge diversity, context-awareness, creation and utilization of virtual networks, etc.

2. Related works

The Next Generation Service Overlay Network (NGSON)[3,4], standardized by the IEEE, intends to support context-awareness, dynamically adaptive, and self-organizing capabilities in Service Overlay Network (SON). Similar to NGSON, our infrastructure defines the classification of context in an analogous manner, namely *device context*, *user context*, *service context*, and *network context*. However, to provide a self-organizing network infrastructure for IoT services, we incorporate network virtualizations and traffic engineering aspects from Network Function Virtualization (NFV)[5] and Software-Defined Networking (SDN)[6] instead of the service/content delivery functions published by service providers in the case of NGSON.

Paganelli, *et al*.[7] proposed an improvement to the NGSON by incorporating SDN, and NFV, attempting to enhance support for context-aware service composition and adaptive service delivery.

What differs our infrastructure from [3,4,7] is that we take advantage of context by provisioning it to multiple blocks of our infrastructure. Such as heterogeneous access network selection, mobility support, and delivery of IoT trust to edge/fog network. Whereas, NGSON only exploits context to discover and select the component services.

3. Proposed Infrastructure

The proposed network infrastructure for IoT services can be characterized by the following.

First, it is a context-aware infrastructure. Device, user, service, and network contexts are extracted and analyzed in order to create and utilize virtual networks, select heterogeneous access networks, and implement trust in IoT services. Second, it supports Edge diversity i.e. interconnectivity of various IoT services and end devices with different network technologies, for instance, WiFi, LTE, ZigBee, and Bluetooth Smart. Third, it offers virtual network instance as a service. By virtualizing the physical network, bandwidth reservation, differentiated QoS support, flow control, and load balancing could be realized individually for different IoT services. Last but not least, it is evolvable network architecture, for it employs network virtualization and traffic engineering through NFV/SDN, and integrates edge/fog computing concepts. It is highly possible that the Next Generation Network technologies (e.g. 5G, GIGA) can be used atop of our infrastructure.

The proposed infrastructure is shown in Fig.1 and its composing blocks are detailed throughout this part.

3.1. Context Manager

The *Context Manager* extracts context from device, user, service, and network. Some examples of extracted contexts are, device location (*device*), user's activity (*user*), QoS requirement (*service*), and network resource allocation (*network*). Then the *Context Manager* delivers the extracted contexts to the *Virtualization Manager* and the *SDN based Network Manager*.

3.2. Virtualization manager

The *Virtualization Manager* receives context from the *Context Manager* and network monitoring information from the *SDN-based Network Manager*. It then creates a virtualized network instance for the *SDN-based Network Manager* to control the underlying physical network.

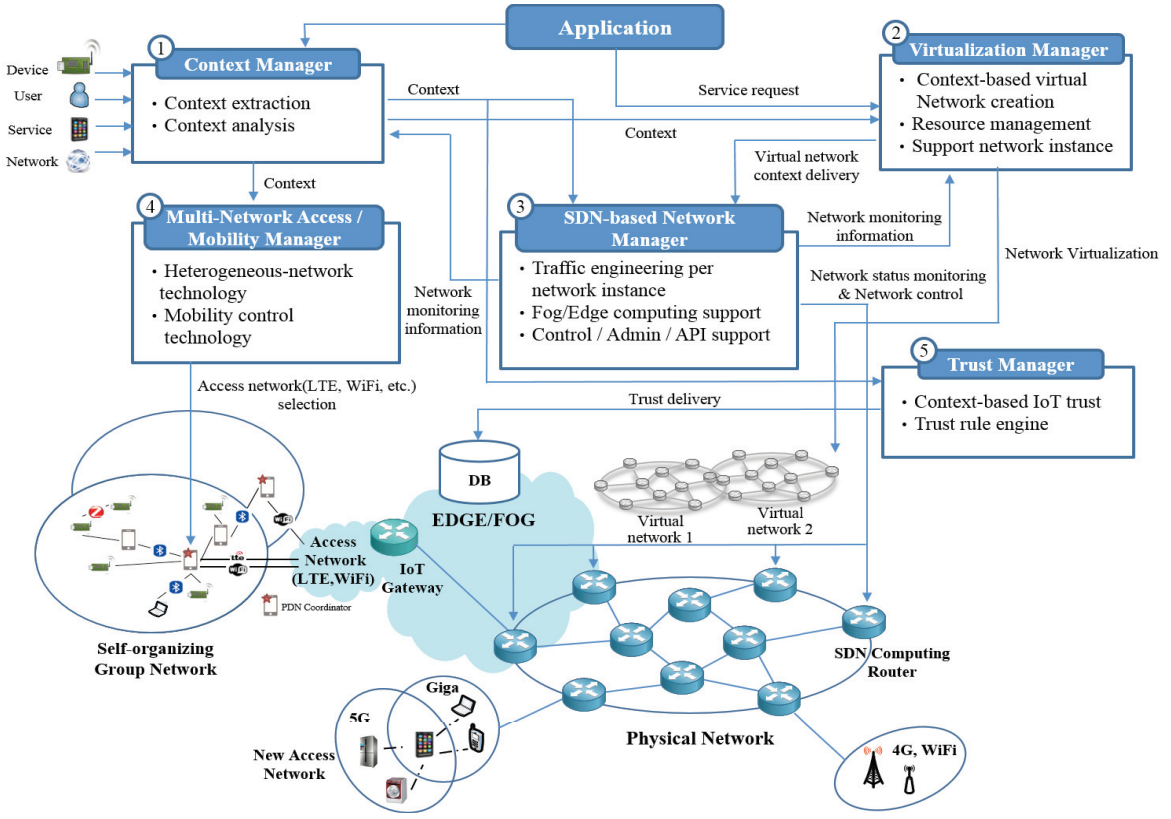

Fig. 1. Proposed IoT service oriented network infrastructure

3.3. SDN-based Network Manager

The *SDN-based Network Manager* sends network monitoring information to the *Context Manager* and the *Virtualization Manager*, and receives an instance of virtualized network created by the *Virtualization Manager*. The *SDN-based Network Manager* performs traffic engineering, load balancing, QoS administration, and fog/edge computing based on virtualized network instance. Furthermore, it provides APIs for the users to visualize and directly operate with the SDN-controller, or manage fog/edge computing.

An application example is depicted on the following page Fig. 2 and 3. A CCTV is installed for IoT home security appliance, and it provides video streaming service for the user. Upon adapting our proposed infrastructure, the *Context Manager* would recognize the service context (video streaming) and the network context, which indicates that there might be a congestion problem when sent through legacy network, Fig.2. The collected context will be delivered to the *Virtualization Manager* where the virtualized network instance is created. Since the service context represents video streaming service, it is not necessary for the flow to go through an Intrusion Detection System (IDS). Likewise, the network context signifies the possibility of lack of bandwidth, which may result in latency and QoS issues on the shared link. Thereby, it would be recommended that the flow detours the congested link as shown in Fig.3.

3.4. Multi-Network Access Mobility Manager

The *Multi-Network Access Mobility Manager* receives context from the *Context Manager*. Then it provides reliable condition to devices that context based connection for self-organizing group network. Connection between

the devices consist of synchronous, selective and heterogeneous states. The *Multi-Network Access Manager* performs which access network is the proper network (e.g. *Multi-Network Access/Mobility Manager* expects user's movement from location of device and user's activity. And it offers an additional connection (LTE) to an existing connection (WiFi) for seamless handover).

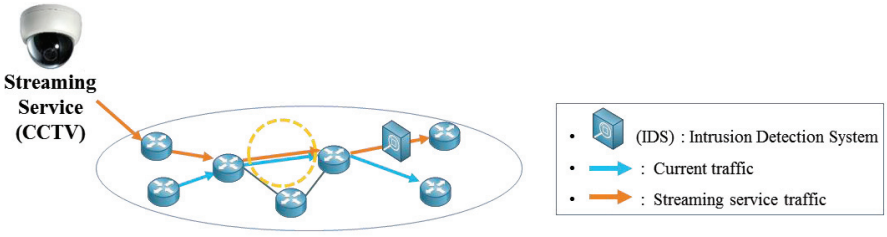

Fig. 2 Legacy network

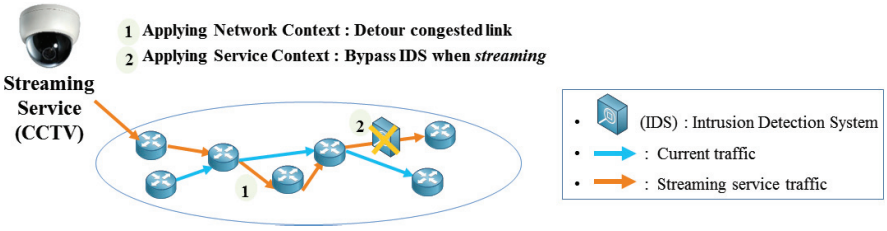

Fig. 3 Proposed infrastructure; applying context

3.5. Trust Manager

The *Trust Manager* receives context from the *Context Manager*. The trust rule engine evaluates the received context based on user's past records then determines whether additional authentication is necessary or not. For instance this process can be implemented through token exchange.

4. Conclusion and Future works

In this paper we have introduced an evolvable context-based network infrastructure that supports context-aware, edge diversity, and virtualized networks. Our infrastructure is divided into 5 parts and extensive research and development is in progress for brilliant service. Future works will be carried out to verify our infrastructure using OpenFlow and develop the *Context Manager* to support user-centric services.

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