QoS-Aware Adaptive Resource Allocation Framework in the integrated SDN Transport and IoT

Atefeh Meshinchi, Ranwa Al Mallah, Alejandro Quintero
Presenter:
Atefeh Meshinchi
atefeh.meshinchi@polymtl.ca

Laboratoire de recherche en réseautique et informatique mobile (LARIM)
Ecole Polytechnique de Montréal, Montréal, Canada

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Bio

Atefeh Meshinchi received the B.E. degree in computer engineering from the Shahid Beheshti University, Tehran, Iran, in 2004, and the M.S. degree in Computer engineering from Montreál University, Ećole de Polytechnique, Montreál, Canada, in 2018. She has almost 15 years of experiences in telecommunication industry, and currently working as IoT Solution Architect at Bell Canada, Montreál, Canada.

Topics of research interest

- Internet of Things Unified architecture
- Software Defined Networking
- Resource allocation and performance optimization
- Security
- mathematical modeling

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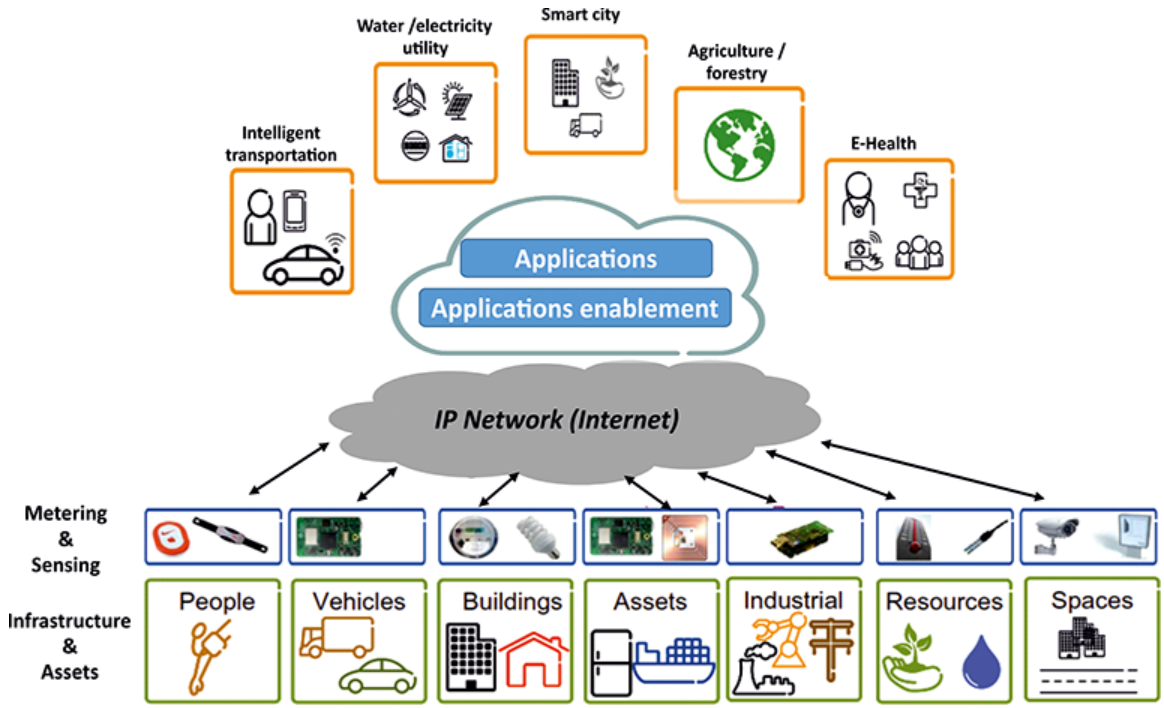
Internet of Things(IoT) vision



IoT application model [1]

Motivation

- IoT is made of a large numbers of heterogeneous devices, mostly low-end sensors. Those devices create opportunities for a wide range of applications and services with various QoS requirements.
- IoT is a multi-layer and multi-system environment, built of an extremely large variety of technologies and techniques in terms of data and connectivity. To work properly and effectively, QoS requirements of IoT applications are not only the speed of communication and error rate, but data accuracy, coverage, and device lifetime. Each technology and communication network impose their limitations on IoT framework too.
- Beside the Internet as globally shared system, sensing networks are multi-services, meaning that they serve multiple applications and services for the efficiency purpose.
- IoT system currently lacks the standardized and unified QoS support service framework which considers the inherent heterogeneous, stochastic, and dynamic nature of IoT. It is also challenging to have a standard SLA (Service Level Agreement) for IoT applications.

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Related works

QoS-support design and QoS-based design approaches:

- ✓ *QoS-aware scheduling of services-oriented Internet of things* [2]
- ✓ *Middleware to support sensor network applications(MiLAN)* [3]
- ✓ *SDIoT: a software defined based Internet of things framework* [4]

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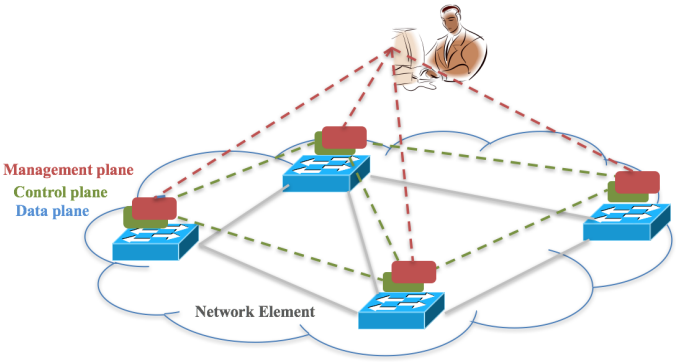
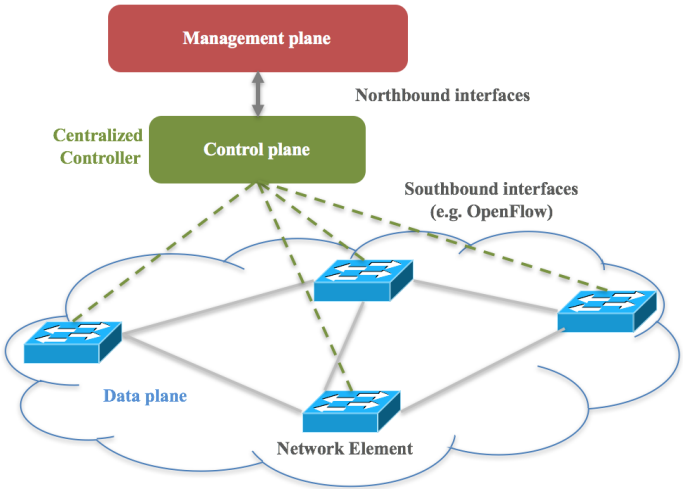
Software-Defined Network architecture

Traditional Network



- Closed equipment
- Distributed control
- High equipment and operation cost

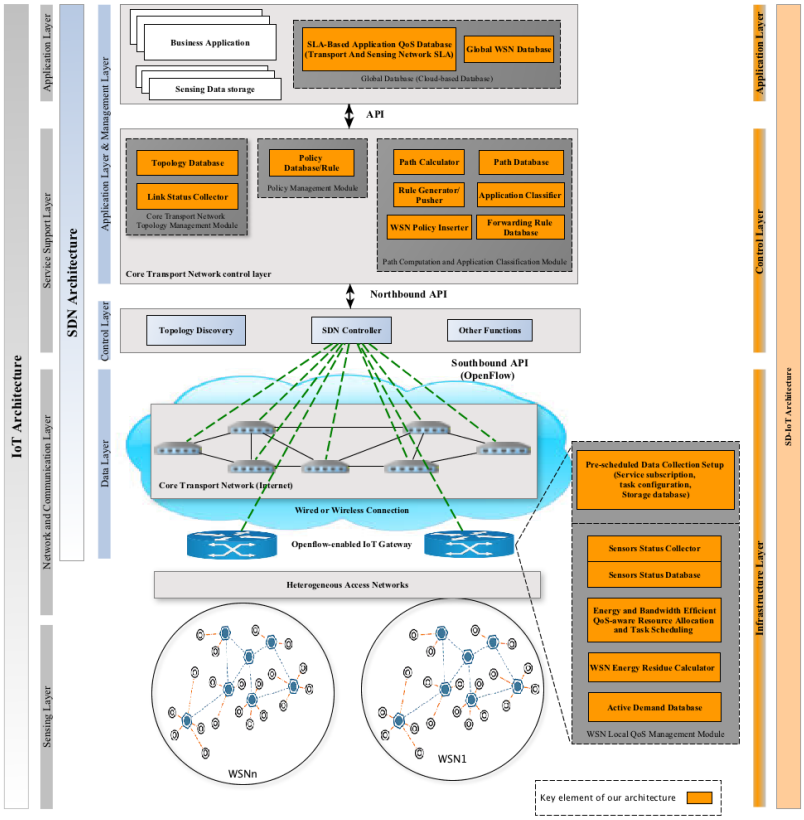
Software-Defined Network



- Centralized management
- Network programmability
- CAPEX and OPEX efficiency

Figures reproduced from [5]

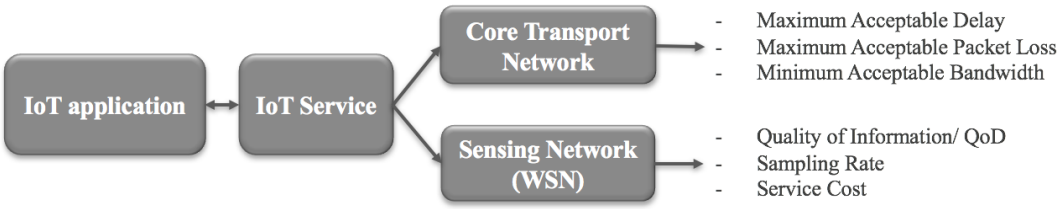
Proposed QoS support framework



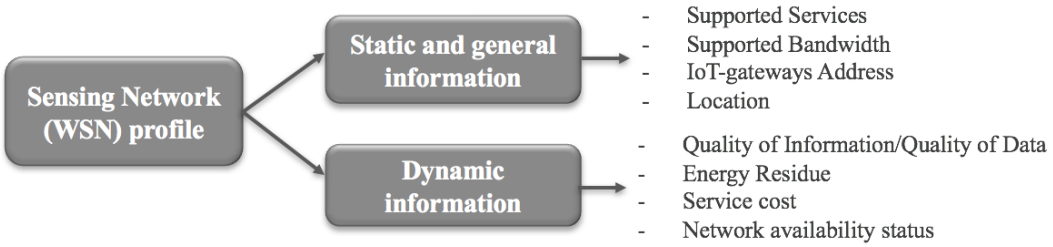
- ✓ Integrate SDN technology into IoT framework- infrastructure and communication layer
- ✓ Provide a Programmable Middlaware layer

Elements, and functions - Global Database Module

SLA-related application QoS Database:

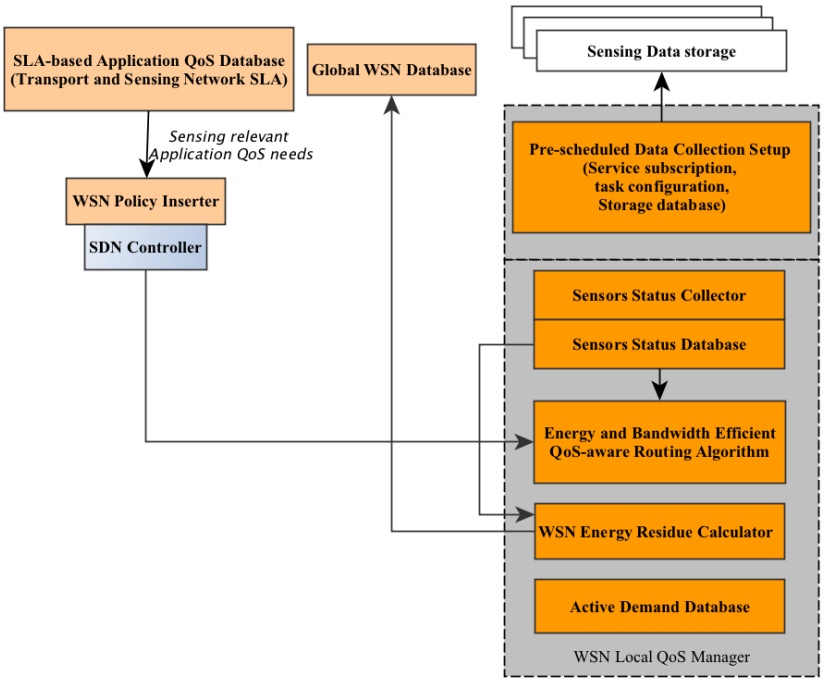


Global WSN Database:



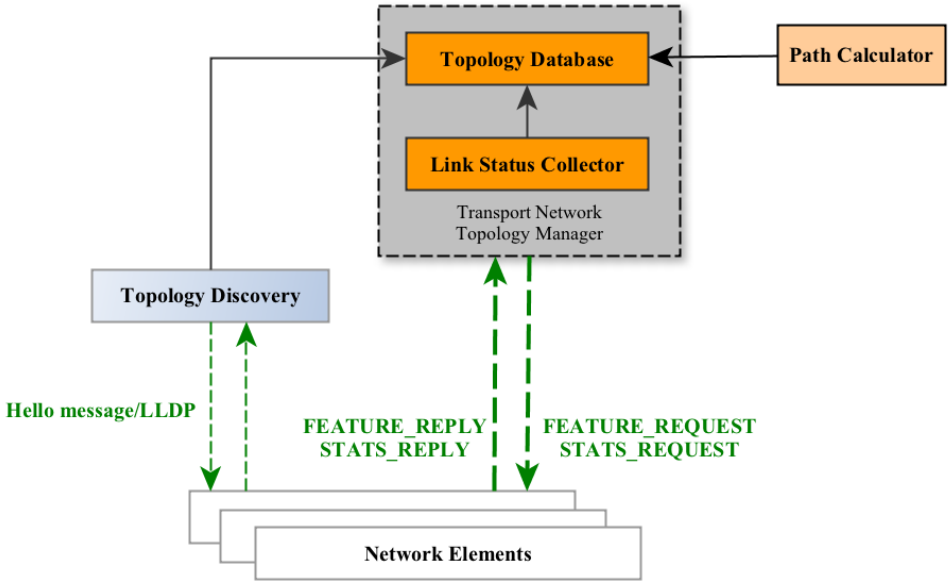
Elements and functions - WSN QoS Management Module

- ✓ QoS-aware resource allocation and efficient task scheduling
- ✓ Sensor status collection
- ✓ Estimation of the network energy residue
- ✓ Elimination of the redundant request



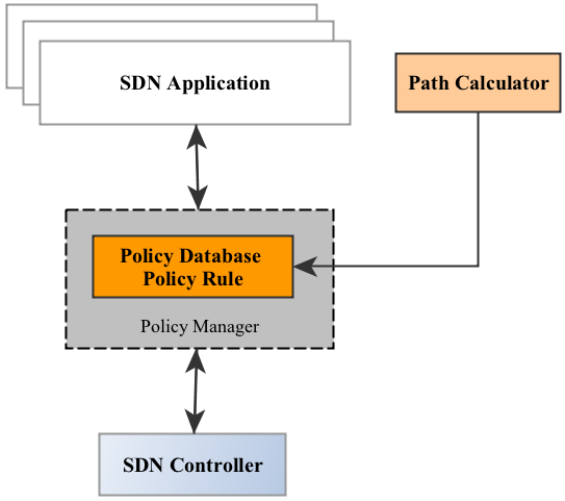
Elements and functions - Core Transport Network Topology Management Module

- ✓ Network topology discovery
- ✓ Network link status collection in terms of QoS parameters
- ✓ Updated database



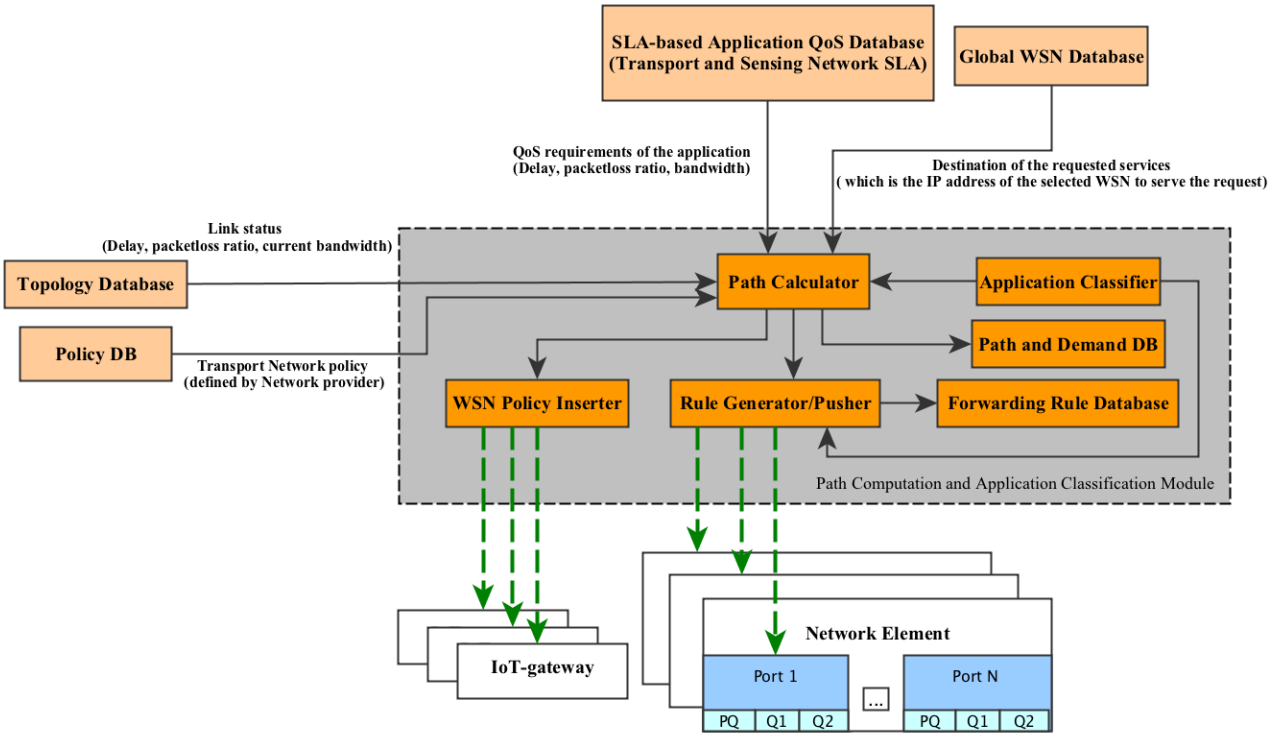
Elements and functions - Policy Management Module

- ✓ Link load distribution
- ✓ Bandwidth reservation
- ✓ Application preferences violation
- ✓ Congestion management



Elements and functions - Path Computation and Application Classification Module

- ✓ End-to-end QoS support routing across the core transport network
- ✓ WSN determination and policy update in IoT-gateway



Elements and functions - Path Computation and Application Classification Module

Rule Generator/Pusher:

- ✓ Flow rules generation based on the calculated paths
- ✓ Network element configuration along the paths

WSN policy pusher:

- ✓ Sensing-relevant application QoS requirements dynamically inserted in the determined IoT-gateway

Path and Demand Database:

- ✓ Currently active demand information and the associated paths

Forwarding Rule Database:

- ✓ Database of the active flow rules in the network elements

Elements and functions - Path Computation and Application Classification Module

Application Classifier:

- ✓ IoT application classification approach for the prioritization and queuing purpose

Application Class	IoT application	Priority	Queue
Delay-Centric	Mission-critical (event-based application)	1	PQ (Priority Queue)
Bandwidth-Centric (Multimedia application)	Real-time monitoring, query-driven application	2	Q1
General	Non-Real time monitoring, analytic application	3	Q2

Path Calculator:

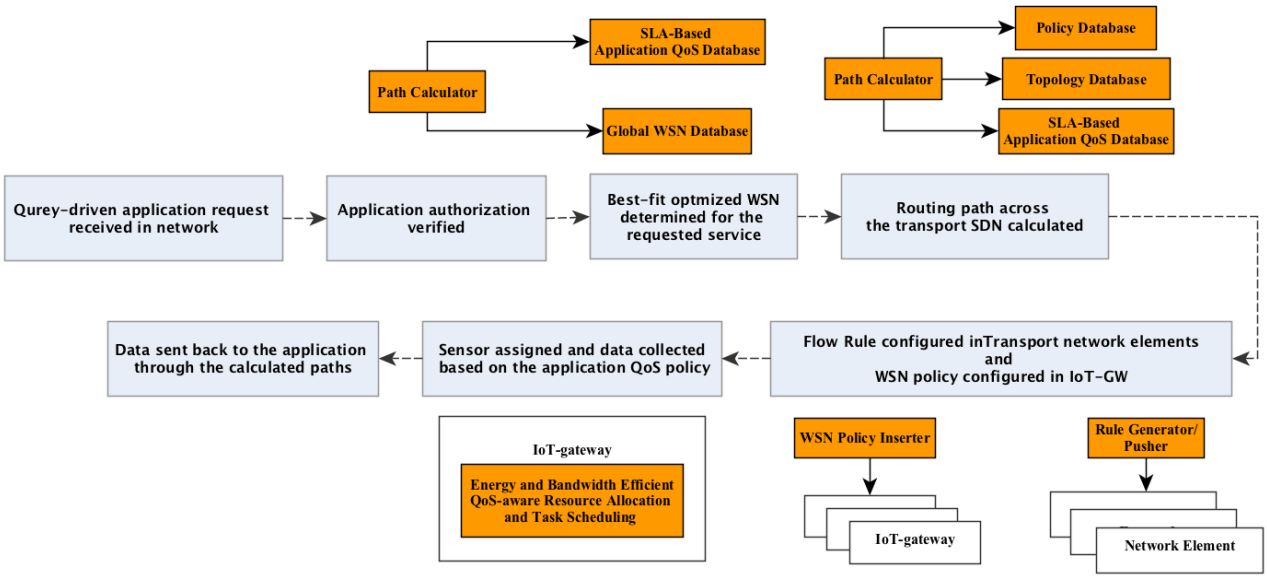
- ✓ WSNs determination for the requested services based on the application criteria and WSN profile DB
- ✓ QoS-aware routing path calculation across the core transport network

Workflow

Two main data delivery model exists in IoT:

- ✓ Query-driven
- ✓ Event-driven

Workflow for query-driven application scenario within proposed framework:



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Architectural perspective:

- ✓ Propose a programmable middle-ware between devices and network infrastructures, and applications, providing an unified support services layer for IoT application and a centralized control over security, storage, and resources.
- ✓ To develop customized algorithms and methodologies to be deployed under different conditions, Giving flexibility and fast-response to business changes
- ✓ Propose an end-to-end QoS routing across the communication network, and QoS-aware sensing network allocation and sensor assignment
- ✓ Provide an adaptive and scalable QoS management framework in terms of application classification, and application prioritization and queuing management, and resource allocation.
- ✓ Enhance overall framework performance by data processing and aggregation process at the edge of the network within localized and customized algorithms, and resource awareness within IoT-gateway

Network perspective:

- ✓ Simplify network operation and management by abstracting complexity and heterogeneity in IoT infrastructure layer, compared with the traditional, isolated, and close network.
- ✓ Develop customized network control and management services, not only in performance and QoS management, but in terms of security, monitoring, and fault-diagnosis.
- ✓ Centralize decision making intelligence in terms of resource allocation, application classification, and flow control leading to saving resources, work-forces and time.
- ✓ Increase the awareness of the resource status and application needs at any given time, and improve network performance and application experiences by preventing the congestion probabilities and increasing IoT service availability. Bring capability to learn easier the traffic pattern and predict required network expansion based on business forecasts.

Application perspective:

- ✓ Provide flexibility to customize application QoS requirements in terms of data acquisition and transmission.
- ✓ Apply application Qos needs to allocate SLA-respected resources across the communication and sensing network, increasing application satisfaction index (such as Quality of Experiences).
- ✓ No limitation on traffic differentiation and application classification, suitable for IoT system which expects innovative data-driven applications with various QoS requirements

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Work summary and future work

Work summary:

- Integrate SDN technology in IoT architecture to take advantage of a programmable middleware to develop customized service supports fro IoT applications
- Propose a flexible and adaptive common QoS support framework for IoT applications which enforces the application QoS preferences in resource allocation across IoT networking segments

Future work:

- Design and develop an customized resource allocation algorithm and deploy the proposed framework for performance evaluation purpose

References

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[5] ONF, "Openflow switch specification (version 1.5.1)," 2015. [Online]. Available: https://www.opennetworking.org/wp-content/uploads/2014/10/openflow-switch-v1.5.1.pdf