Call for Proposals

Future Networks

HIRP OPEN 2017

Application Deadline: 09:00 A.M., 16th June, 2017 (Beijing Standard Time, GMT+8).

If you have any questions or suggestions about HIRP OPEN 2017, please send Email (innovation@huawei.com). We will reply as soon as possible.

Catalog

HIRPO2017020301: QoS indicators probability distribution modeling and inference over routers

1 Theme: Future Networks

2 Subject: IP Network Theory

List of Abbreviations

IP	Internet Protocol
QoS	Quality of service

3 Background

Many network functionalities, like resource allocation and optimization, service quality management, require quantitative analysis over QoS indicators through IP networks.

Emerging technologies, like control system based on learning, bring further requirements of fast QoS evaluation of control policies over networks. Traditional network simulation in packet level fails in efficiency. While deployment of trial policies over networks supporting millions of online subscribers, is unacceptable.

4 Scope

1) Research on probability modeling of IP network traffic, QoS indicators and router: Modeling traffic on links including volume, burstiness in form of probability distribution. It might need be described over multiple time scale; Modeling QoS indicators in form of probability distribution. QoS indicators include latency, jitter and dropping rate; Modeling router in form of a function

mapping ingress traffic distribution to QoS distribution of the traffic going through the router. Assume routers can forward in wire-rate. Forwarding latency and egress queue size are known;

2) Research on QoS inference: based on traffic, QoS and router models, infer QoS distribution of routers under given network status (i.e. predict QoS of certain traffic class going through the router, with known background traffic); Infer path QoS distribution over known QoS distribution of routers in path;

5 Expected Outcome and Deliverables

Technical reports describing modeling and inference method, analysis, result of simulation.

Simulation source codes and description;

6 Acceptance Criteria

Project proposal is accepted by the evaluation team, Huawei.
Project deliverables are accepted by the evaluation team, Huawei.
QoS prediction accuracy rate in simulation is over 90%, using open traffic trace like WIDE (http://mawi.wide.ad.jp/mawi/).

7 Phased Project Plan

Phase1 (~3 months): survey the state of the art of IP traffic, QoS and router modeling and inference.
Phase2 (~5 months): Research on modeling and inference method.
Phase3 (~4 months): Evaluation proposed method by simulation with open traffic trace.

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HIRPO2017020302: Research on network and protocol architecture for Industry 4.0/IIOT

1 Theme: Future Networks

2 Subject: Network and Protocol Architecture

List of Abbreviations

IIOT: Industrial internet of things

3 Background

Industrial manufacturing is moving to the era of 4.0, which is called industry 4.0 or industrial internet of things. The most significant feature of industry 4.0 is intelligent manufacturing, which means high efficiency, low cost and customized product.

Under industry 4.0, the cooperation and relation among customer, producer and supplier become more and more close, the service mode will also be changed totally. So, the producer must adjust its internal operation mode to meet the new request and challenge for diverse customized production, it means that the network at producer side should make a vertical integration named IT/OT convergence and support flexible manufacturing.

Due to there are few researches about the requirement and impact on network under IT/OT convergence and flexible manufacturing scenarios, even they are the foundation of industry 4.0. So, it's significant to do the research on them to complement our shortage and increase our competition on the innovation about industry 4.0.

4 Scope

1) Research on network and protocol architecture for IT/OT convergence:

- Analyze the technical challenge for IT/OT convergence
- Build and simulate network traffic model (such as, but not limited, traffic flow orientation, traffic type, proportion) after IT/OT convergence.
- The impact on network after IT/OT convergence: Such as, the impact on network architecture, network device and protocols.

- The research suggestions on network technical innovation based on IT/OT convergence.

2) Research on network and protocol architecture for flexible manufacturing:

- The typical scenarios about flexible manufacturing, the specification and evolution trend about flexible manufacturing.
- Analyze the impact on network and key requirement under flexible manufacturing. Such as, the change about traffic model, network organization requirement (agile/smart topology, connection method, function requirement (latency, bandwidth)).
- The impact on network architecture, network device and protocols under flexible manufacturing.

5 Expected Outcome and Deliverables

1) Research on network and protocol architecture for IT/OT convergence:

- One report about network traffic model module;
- One analysis report includes network challenge, network traffic model, and impact on network and research suggestions.

2) Research on network and protocol architecture for flexible manufacturing:

- One analysis report includes typical scenarios, evolution trend and impact on network, requirement about network and research suggestions.

6 Acceptance Criteria

- Project proposal is accepted by the evaluation team, Huawei.
- Project deliverables are accepted by the evaluation team, Huawei.
- The network traffic model should be based on more than one scenarios. Maybe not limited only in manufacturing field.

7 Phased Project Plan

Phase1 (~6 months): Research on IT/OT convergence network challenge, network traffic model, and impact on network and research suggestions, output corresponding report for review.

Phase2 (~2 months): Simulate the traffic model about typical scenarios of IT/OT convergence, and generate the simulation report for review.

Phase3 (~4 months): Research flexible manufacturing topic listed in item 4.2, generate report for review.

Note: It's better to do phase 1 and phase 3 parallel if resource is enough..

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HIRPO2017020303: Distributed decision/intelligence for network control

1 Theme: Future Networks

2 Subject: Self-X

3 Background

Routing is a classical distributed decision mechanism. Each routing peer shares the same knowledge of the whole networks' links; and they make the same decision according to the same law (SPF algorithm etc.).

The routing approach could be considered as "Peers Sharing the same Whole Knowledge (PSWK)". Moreover, we could explore another more thorough distributed approach "Peers Sharing different Parts of the whole Knowledge (PSPK)", in which each peer is only aware of some local knowledge and follows simple rules, but they represent advanced intelligence when cooperated together. (E.g. swarming and colony behavior)

Either the PSWK or the PSPK approach might be potentially expanded to some decision making other than routing. For example, the traffic paths or the flow features (latency, bandwidth etc.) need to be dynamically adjusted to satisfy a certain of QoS requirements. In this case, network nodes would need more sophisticated behaviors other than static graph-based calculation in traditional routing.

These kinds of distributed approaches might bring an opportunity for solving some problems that considered very difficult for current mainstream centralized approach (e.g. SDN); or they could solve some other network problems via a more simple and efficient way.

4 Scope

The scope of the research project is the theory of distributed decision/intelligence theory.

The topics of the research project include but not limited to the following：

1) The research and analysis on current state of art of distributed decision/intelligence theory (including but not limited to: swarming and colony etc.) applying in networking.

2) Distributed algorithm(s) for dynamically controlling the network according to a certain QoS requirements.

3) Coordination mechanism for avoiding network behavior conflicts, state synchronization etc. among distributed nodes.

5 Phased Project Plan

The suggested duration of the research project:

Phase 1: 1 year for theory research and use case development

Phase 2: 1 year for prototype development.

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HIRPO2017020304: Intrinsic Flaws of IP and the Research Directions of Next Generation Network Architecture and Protocol Suite

1 Theme: Future Networks

2 Subject: Network Architecture

3 Background

The application scenarios, requirements and scales of today's Internet have changed tremendously from the day when it was invented. However, the Internet's technical corner stones, i.e., packet switching and TCP/IP protocol suite, are still in use and show incredibly strong viability.

Researches on Future Internet Architectures (FIA) claim that the current Internet architecture has intrinsic flaws in mobility, trust, security, heterogeneity and evolvability. These arguments are theoretically sound, but in practice the Internet has successfully survived by patches like CIDR, NAT, IPv6, IPSec, CDN and overlay network technologies. So, the fundamental questions to ask are what the REAL flaws of the Internet are, what future major application requirements will radically challenge these flaws, and what research directions we should devote to build the next generation Internet.

4 Scope

1) Based on the analysis of current Internet and NSF FIA projects, uncover the REAL flaws of the current Internet architecture, including the TCP/IP protocol suites, statistical multiplexing based packet switching, and the core infrastructures like BGP, DNS and PKI. The analysis should be

accompanied with detailed use scenarios to show why application requirements will radically challenge these flaws.

2) Based on the identified flaws of the current Internet, as well as its essential advantages that must be reserved, analyze the research directions for the next generation Internet and the state-of-the-art designs and related work that can be referenced.
3) [Optional] Propose the essential communication principals (e.g., ID, name and descriptor), protocol suite, theoretical model, system, technique and algorithm for communication and trust, and related infrastructures. Experimental verification of the proposal. Analysis of the possible deployment path of the proposal and the potential new business model.

5 Phased Project Plan

The suggested duration of the research project: 1-2 Years

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HIRPO2017020305: Intelligent routing based on traffic prediction

1 Theme: Future Networks

2 Subject: Future Optical Networks Intelligent Routing

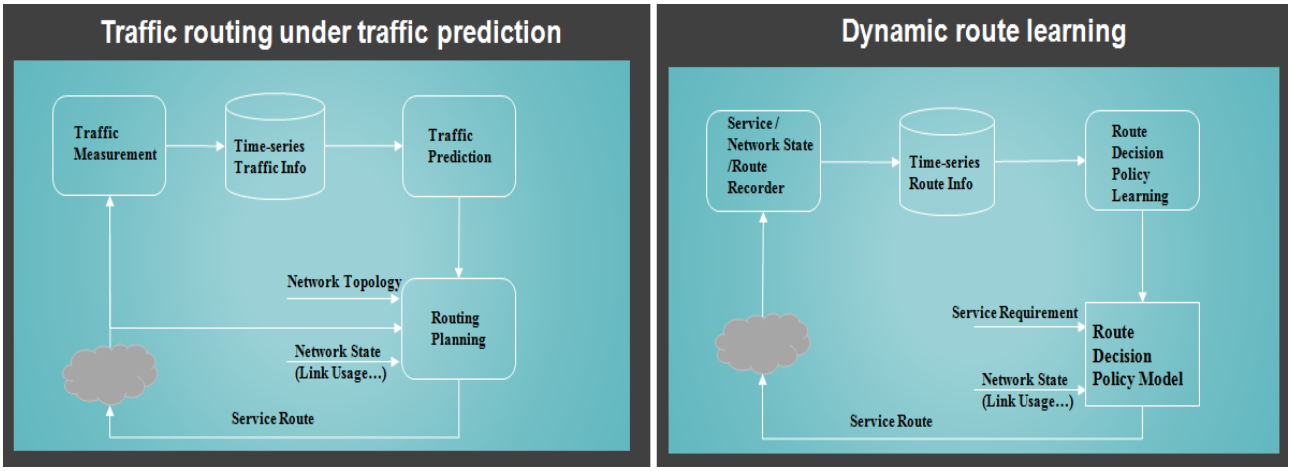
3 Background

Existing routing algorithms and strategies cannot provide flexible routing algorithms and policies through real-time perception of the traffic. Therefore, intelligent routing algorithm based on traffic prediction is needed to effectively prevent network traffic congestion and improve the utilization of network resources.

4 Scope

1) Intelligent routing under traffic prediction

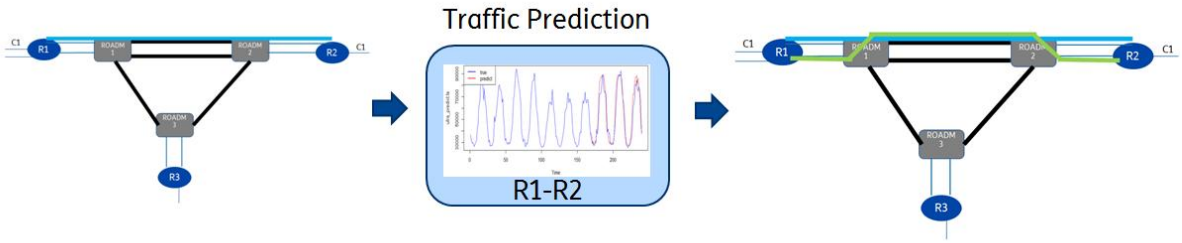
Network traffic dynamically changes, a reasonable service route now may not be reasonable later. And also, the route adjust too often will pay a high price. How to achieve the balance between the utilization of network resources and the expanses of route adjustment? Therefore, if we consider future traffic information in the traffic routing, we can find an optimal solution for the routing problem as the traffic changes. Moreover, we can avoid the traffic congestion before it happens. It will improve the user experience and prevent the network performance deteriorate.



The use case scenario is typically in IP+Optical solution:

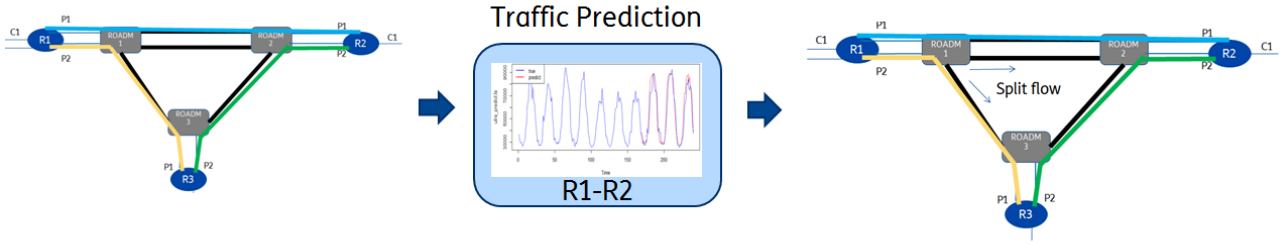
a) Bandwidth on demand

Some network paths could need a periodic adjustment of bandwidth to satisfy special traffic requests (f.i. heavy backups between data centers). This could be managed automatically by periodically provisioning additional capacity that will be released afterwards



b) Automatic re-routing

Automatically split the flow to the already provisioned link to avoid traffic congestion.



2) Dynamic route learning based on reinforcement learning

The traffic is dynamic changing in a static network structure. The dynamic route decision influences the network traffic. It makes the traffic dynamics more complex. The reinforcement learning is a possible solution for this complex problem. We build the route decision policy model based on routing strategies. And, we apply the traffic prediction algorithm to predict the reward of each route decision policy.

As a result, we can achieve an automatic and intelligent routing machine, which has traffic awareness ability.

5 Expected Outcome and Deliverables

Technical reports of:

1. Intelligent routing based on traffic prediction;

2. Dynamic route learning algorithm: the feasibility of applying the reinforcement learning technology to solve this problem.

Source code of prototype implementation.

1~2 Paper/patents;

6 Acceptance Criteria

Project proposal is accepted by the evaluation team, Huawei.

Project deliverables are accepted by the evaluation team, Huawei.

7 Phased Project Plan

Phase1 (~3 months): Surveys the state of the art of intelligent routing based on machine learning or artificial intelligent technology and provides the related technical report.

Phase2 (~4 months): Research on analyze and build the intelligent routing model based on traffic prediction and provides the related technical report.

Phase3 (~5 months): Research on dynamic route learning based on reinforcement learning and provides related algorithms, simulation results and paper/patents.

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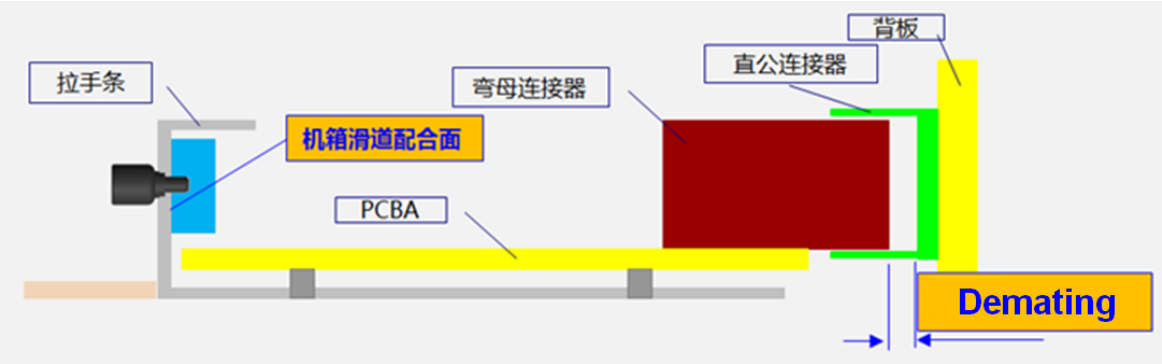
HIRPO2017020401: Structural Demating Design of the High-speed System

1 Theme: Future Networks

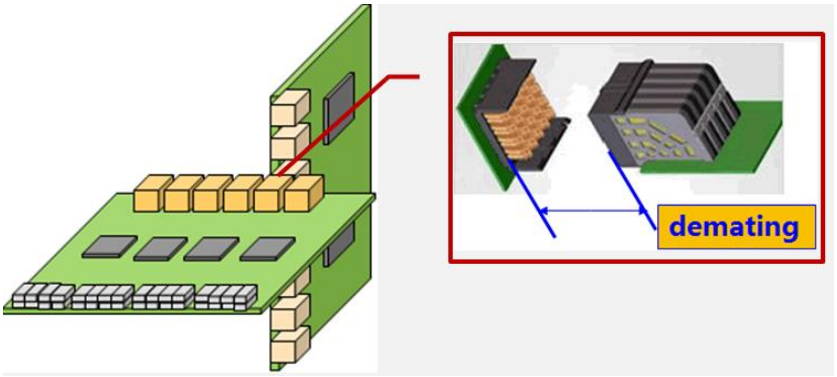
2 Subject: Structural Demating Design of the High-speed System

3 Background

As a basic requirement, the structural demating of structures must not exceed the demating tolerance of connectors. For systems with a fixed backplane, this means how securely a board is plugged into the backplane connector; for system without a backplane, this means the demating between the male and female connectors of two interconnected boards. For high-speed systems, the demating tolerance should be very small and preferably be 0. See the following figures for the schematic diagrams.



Schematic diagram for demating (system with the fixed main board)



Schematic diagram for demating (system without the main board)

This innovative research steers the direction of structural demating design and constitutes the design scheme as well as the design guideline for checking methods. The proposed design meets the requirement for mass production of 2000 PCS/year. In addition, the increase in cost of the integrated equipment is less than 20% compared with the existing solution and no quality issues will arise therefrom.

4 Scope

This research is essentially an open research on the precise mating of mechanical structures. With the focus on replicability, productivity, and cost-effectiveness, the research surveys the current situation and development trend of precise mating of connectors used by communications equipment. It proposes a structural design for zero demating and proves the feasibility of mass production and measurability. In addition, it also summarizes the application principles for the proposed design.

5 Expected Outcome and Deliverables

A report on the current situation and development trend of precise mating of connectors used by communications equipment

Design scheme for zero demating of connectors

Analysis on the feasibility of mass production for the zero demating design of connectors

Methods for measuring the zero demating design of connectors

Application principles for the structural design

6 Acceptance Criteria

Project proposal is accepted by the evaluation team, Huawei.

Project deliverables are accepted by the evaluation team, Huawei.

Project solution should have the feasibility of mass production

The whole cost than the existing solution growth is no more than 20%

7 Project Plan

Phase1 (~3 months): Survey the current situation and development trend of precise mating of connectors used by communications equipment

Design scheme for zero demating of connectors

Phase2 (~5 months): Sample analysis; Research the feasibility of mass production for the zero demating design of connectors

Phase3 (~4 months): Methods for measuring the zero demating design of connectors；Application principles for the structural design

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HIRPO2017020501: Securing Micro Services through Symbolic Execution

1 Theme: Future Networks

2 Subject: Micro Services Security

3 Background

It is a clear trend that more and more software is going to be deployed in the cloud. With the software, more and more sensitive data is moving into the cloud as well, for instance, business transactions, health information, photos and videos, etc. This inevitably makes the cloud software high-value targets for security attacks. There have been numerous incidents where compromised cloud software led to major leaks of sensitive data into the wrong hands. A major cause of cloud software vulnerabilities is bugs in the software, which have escaped the validation process due to time to market pressure and/or insufficient methodologies and tools.

4 Scope

We propose to detect vulnerabilities caused by bugs in cloud software, particularly micro services, through a combination of virtualization and binary-level concolic testing. Micro services are, almost without exception, enabled by virtualization where the services are executed on a virtual machine or in a Docker container. Such a virtualization layer provides a better way for us to monitor the micro services than their direct execution over a physical machine. Binary-level concolic testing directly applies to the binaries of micro services without source code, and it combines concrete and symbolic execution to enable deep exploration of micro service execution and achieve better coverage than testing with just concrete values. We will enable the

application of concolic testing to micro service binaries through the virtualization layer, i.e., we will extend the virtualization layer with a light-weight plugin that can capture the trace of a concrete execution of micro services. The captured trace will be sent to a backend engine which conducts symbolic execution for test generation only by analyzing the trace. The test cases generated by the backend engine will again be applied to micro services while they execute over the virtualization layer. This process is automated and executed recursively to detect bugs and improve test coverage.

5 Expected Outcome and Deliverables

We expect the outcome and deliverables as following:

- MSCT: A open-source concolic testing framework for micro services
- 1~2 publications

6 Acceptance Criteria

The items under the delivery table will be checked for completeness.

7 Phased Project Plan

Phase No.	Phase description	Time (months)	Main task content	Output Standard that should achieve
1	Micro Service Run-time Trace Capture	3	Develop plugin for virtualization layer to capture run-time traces of micro services	Tracing plugin implemented
2	Micro Service Trace Offline Relay	3	Extend symbolic execution engine to replay the run-time traces of micro services	Replay module implemented
3	Micro Service	3	Extend symbolic	Test generator implemented

	Test Case Generation		execution engine to generate test cases for micro services	
4	Evaluation	3	Integrate the tracing plugin, replay module, and test generator into a cohesive framework and evaluate it on micro services	Framework assembled; Evaluation done on practical micro services; Bugs detected and coverage improved

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HIRPO2017021101: Dynamic resource scheduling algorithm of network slice

1 Theme: Future Networks

2 Subject: Network slice

List of Abbreviations

NFV	Network Function Virtualization
SLA	Service Level Agreement

3 Background

5G networks must support a variety of very diverse use cases with different requirements for latency, throughput, and availability. The dynamic network slicing concept offers a way to optimize 5G networks to address all use cases efficiently. With dynamic network slicing, operators could create a fully programmable network architecture which suits the requirements of various use cases, subscriber types and apps. They could allocate dedicated and optimized end-to-end virtual network functions and physical resources for each use case or group. And within a slice, the functional elements could be instantiated according to the needs of a specific service offering. So how to achieve the above goal through efficient resource scheduling algorithm is the important direction of 5G network slice research.

4 Scope

1) Research and analysis of the characteristics of 5G network slices and the main application scenarios, as well as industry, academia on the network slices dynamic resource management research trends.
2) Studies the business characteristics and SLA requirements of different types of network slices, and the resource allocation modeling method combining network architecture and business characteristics of network slicing.
3) Design dynamic resource scheduling algorithm for network slices, comprehensive utilization of load forecasting, business migration and scaling, coordination and other technical means; Under the premise of satisfying the reliability of carrier level and the best of business experience, we can make use of infrastructure resources as much as possible and optimize the global resource utilization of multi-slice.

5 Expected Outcome and Deliverables

1) 1 survey report on dynamic management of 5G network slice.
2) 1 research report on the modeling of network slice resource allocation.
3) 2-3 algorithms for dynamic resource scheduling of network slice.
4) 1-2 patents for network slice dynamic resource scheduling process.

6 Acceptance Criteria

1) A detailed deliverables in section 5.
2) The model and algorithm proposed in this paper are practical and can not only be applied to a particular kind of scene, but also can adapt to the dynamic adjustment of different types of network functions in 5G network.

3) The algorithms can effectively guarantee the service SLA, improve the utilization rate of network slicing resources, and has the actual commercial value.

7 Phased Project Plan

Phase1 (~2 months): 5G network slices research, including application scenarios and resource management programs, and output the research reports.

Phase2 (~4 months): Research on resource allocation modeling method of network slicing scene, and output the analysis report.

Phase3 (~6 months): Design dynamic resource scheduling algorithm for network slices, comprehensive utilization of load forecasting, business migration and scaling, coordination and other technical means, and output the algorithm design and performance evaluation report

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HIRPO2017021102: Ultra Low Latency Edge Network (ULLEN) via Cooperative Resource Scheduling

1 Theme: Future Networks

2 Subject: Ultra Low Latency Edge Network

List of Abbreviations

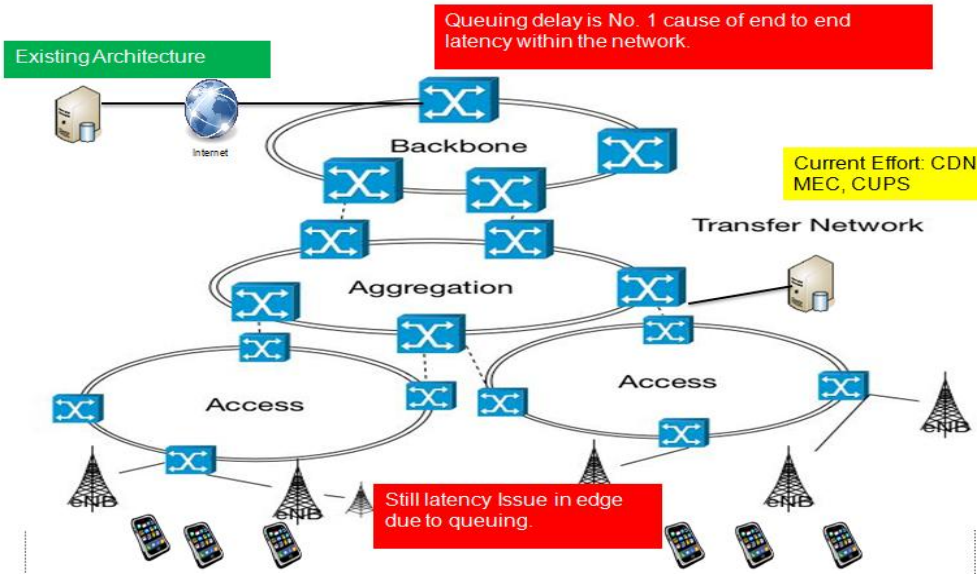
CDN	Content Distribution Network
MEC	Mobile Edge Computing
CUPS	Control and User Plane Separation
OTT	Over-the-top (content)
RAN	Radio Access Network
DGW	Distributed Gateway
ULLEN	Ultra Low Latency Edge Network

3 Background

Current architecture of mobile network aggregates traffic at central EPC and has challenges in supporting low latency applications. Future Network use cases such as VR/AR, Online Gaming, IoT/Tactile Internet, V2X are more demanding in latency.

Existing efforts like CDN, MEC, and 3GPP CUPS provide solutions such as distributed GW/EPC and move content servers closer to UE. Even after

content server is moved to edge, we still see latency issue in edge networks. Edge becomes the bottleneck of latency and queuing delay in cellular network is No. 1 cause of end to end latency within the network.



In MEC various edge resources are co-located together, such as Core Network resources like DGW, OTT resources, and RAN resources. This brings the possibility of doing cooperative edge resource scheduling among OTT, RAN and Core Network functions. The feedback from various components such as UE, DGW, RAN can be used in edge resource scheduling to eliminate queuing delays in mobile networks without sacrificing spectral efficiency and statistical multiplexing and push the envelope for ultra low latency future network use cases. Such approach complements existing efforts such as CDN, MEC, and CUPS, helps in business collaboration opportunities in edge between Operators and OTTs and allows building service, subscriber, OTT, customers differentiated smart pipes to create value added opportunities.

4 Scope

We propose doing research on cooperative edge resource scheduling to reduce queuing delay in mobile networks to push the envelope for low latency

future network use cases with focus on video delivery. The research topics include:

- Conduct research in the areas of cooperative resource scheduling, video delivery mechanisms and real-time decision framework;
- Investigate and propose cooperative edge resource scheduling framework to build Ultra Low Latency Edge Network (ULLEN);
- Propose new or recommend existing protocols, interfaces, network architecture signals, measurements, functions that needs to be added to RAN, CN and MEC functions in order to do efficient delivery of low latency video;

5 Expected Outcome and Deliverables

- Technical report on cooperative resource scheduling, video delivery mechanisms and real-time decision frameworks;
- Overall proposal of Ultra Low Latency Edge Network (ULLEN) system architecture;
- Algorithms, interfaces/APIs, and functional components to feed into CN, RAN and MEC functions as well as SDOs;
- 1-2 publications in journals, conferences, and/or Huawei engineering briefs;

6 Acceptance Criteria

- Research reports on cooperative resource scheduling, video delivery mechanisms and real-time decision framework;

- System design specification of cooperative resource scheduling framework. Deliver design documents and developed software with detailed documentation;
- No needs to implement the whole protocol stack or the whole solution. It is acceptable to provide mathematical or simulation based analysis based on synthetic workloads to assess the low latency performance.

7 Phased Project Plan

Phase1 (~3 months): Survey the state of the art of cooperative resource scheduling, video delivery mechanisms and real-time decision frameworks in industry and academic, and identify the problems, metrics and requirements in this topic, generate analysis and recommendation on state-of-art.

Phase2 (~5 months): Build a comprehensive evaluation platform with realistic network simulator/emulator frameworks; propose system design of cooperative resource scheduling framework to build Ultra Low Latency Edge Network (ULLEN) with proposed signals, interfaces/APIs, and functional components.

Phase3 (~4 months): Provide an optimized video delivery solution based on the proposed ULLEN and evaluate perceptual quality of video against the state of the art solutions; provide mathematical or simulation based analysis based on synthetic workloads to assess the low latency performance

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