Generic-Adaptive-Resource-Control (GARC) in Next-Generation-Networks and Beyond

Julius Mueller
TU Berlin
julius.mueller@tu-berlin.de

Thomas Magedanz
Fraunhofer FOKUS
thomas.magedanz@fokus.fraunhofer.de

I. Introduction and Problem Statement

The Internet is the largest global recognized communication system, which evolved in dimensions of technology, capacity, availability and subscriber, transported data, etc. since its beginnings in the 1960's continuously. As the world moves towards a data-only network environment with Long-Term-Evolution (LTE) and its advanced version (LTE-A), it is crucial to ensure Quality-of-Service (QoS) even during overload situations in the access and core network.

Information (voice and other data) is transported in All-ip networks in form of packets without taking individual application characteristics into consideration. Different application requirements on the packet data transport within the network exist due to the heterogeneity of applications, which cannot be realized because of missing communication between the application and network layer.

Due to high bandwidth demands by end users, overload situations may cause congestion in access and core networks, which in turn effects Quality-of-Experience (QoE) negatively.

Over-The-Top applications and the rapid data traffic grows which is expected to be 70% multimedia streaming, 20% file download and 5% M2M devices in 2016 [1] cause signalling storms and data tsunamis in todays operator networks.

This paper presents with Generic-Adaptive-Resource-Control (GARC) a conceptual approach, its prototypical implementation and validation for bridging the gap between application and network layer in order to optimize the overall end-to-end connectivity by applying individual adequate and application specific service control mechanisms on the connectivity. Packet loss and connection interruptions will be avoided through smart traffic management within the access and core network.

II. State-of-the-Art

There are mainly two possibilities to face the lack of bandwidth in overload situations: first: over-provisioning of the access and core network or second: smart data traffic management. Over-provisioning in this context means placement of additional radio antennas, frequency spectrum, 3GPP Diameter Routing Agent (DRA) or GSMA Diameter Edge Agent (DEA), WiFi-offload, femto-cell-deployment, etc, what in turn all leads directly to an increase of CAPEX and OPEX on the network operator side. This section outlines key related work influences out the four main fields smart traffic management of available resources defined in standards, projects, academic research and industry solutions.

The 3rd Generation Partnership Project specified the Policy Control and Flow Based Charging (PCC) architecture [2] for 3GPP and non-3GPP networks. The PCC architecture consists mainly of Policy Decision Function (PDF), Policy Enforcement Function (PEF) and Bearer Binding and Event Reporting Function (BBERF) [3], [4]. PDF determines policies which are enforced on the centralized Packet-Data-Network-Gateway (PDN-Gw/PGW) and validated on access network specific gateways providing BBERF functionality.

International Telecommunication Union (ITU-T) presents in X.641 [5] a recommendation as common basis for the coordinated development and enhancement of the wide range of standards specifying or referencing Quality of Service (QoS requirements or mechanisms in an Information Technology (IT) environment.

ITU-T Recommendation Y.2001 (12/2004) - 'General overview of NGN' specified Resource-Admission-Control-Function (RACF) within the NGN architecture. RACF acts as the arbitrator between service control functions (SCF) and transport functions for QoS related transport resource control within access and core networks.

European Telecommunication Standardization Institute (ETSI) specified the Resource Admission Control System (RACS) which implements admission control to the access and aggregation segment of the network [6].

Internet Engineering Task Force (IETF) specified Integrated Services in the Internet Architecture and provides an overview in [7].

OPENET.com introduces product enabling subscriber engagement to monetize data traffic more fine granular. Tiered price models are offered to customers, which are enabled to select real-time controlled device and data plans suitable to their demands.

III. Demonstrating GARC

Generic-Adaptive-Resource-Control (GARC) [8] is the concept of bridging the gap between application- and network-layer through creating awareness of each other by enabling direct control message exchange. The G-Lab DEEP project[1]

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focuses on developing an intermediation layer between the application and network layer, for enabling such communication and ensuring backwards compatibility to legacy networks at the same time. A demonstration shows the main characteristics of GARC:

- Network awareness for applications: Networks adjust data traffic control based on service layer requirements. A PCC architecture applies QoS on data streams and provides real-time network statistics, subscriber profiles and context information towards GARC. A network policy decision point may prioritize an emergency call in contrast to an entertainment multimedia connection.
- Application aware networks: GARC enables applications to adjust active sessions based on network types or current traffic situations. A multimedia streaming application may reduce the resolution or quality in case of missing network resource availability.
- Dynamic, application specific and adaptive resource optimization: Static QoS rules from the application into the network layer has to be supported as well as dynamic adaptations in case of network changes (handover or utilization).
- Backwards compatibility to classic IP based applications: Today's applications without network resource reservation capabilities support need in-network functionalities such as Deep-Packet-Inspection (DPI) additionally to derive QoS requirements out of real-time service invocation request.

GARC supports bottom-up as well as top-down layered signaling. Thereby client or service side applications are enabled to signal application layer demands over standardized interfaces towards the underlying fixed and mobile access and core network and vice versa. Three main layers are involved in the mediation process: application, mediation and network, which individual functionalities are presented in the following.

The *application layer* represents an abstraction of any IP or post-IP service such as a single service, complex IP Multimedia Subsystem and/or Service Delivery Platform. Network-aware applications support direct influencing the underlying network (if supported) or demanding network resources at the mediation layer interface, which enforces network specific parameters. Network-aware applications may receive a notification event in case of network changes or guaranteed bit rate violation. The main purpose of the *mediation layer* is optimizing IP connectivity and is realized by GARC. Therefore generalized application layer network resource requests are transformed into specific access- or core-network resource requests. Incoming meta-data application requirements are transformed into network specific requests. A negotiation logic computes the optimized parameters which are enforced within the network. The optimization process may includes loops or rounds in which a solution is computed, which full fills the initial application requirements, is align with the available network capabilities and was authorized by the network operator and service provider.

The *network layer* encompasses 3GPP and non-3GPP fixed and mobile access and core networks. Next-Generation-Network (IMS, EPC) as well as virtualized (OpenFlow) or functional composition Future networks are integrated within GARC. Each network exposes a north-bound interface for exchanging control messages with the upper layers.

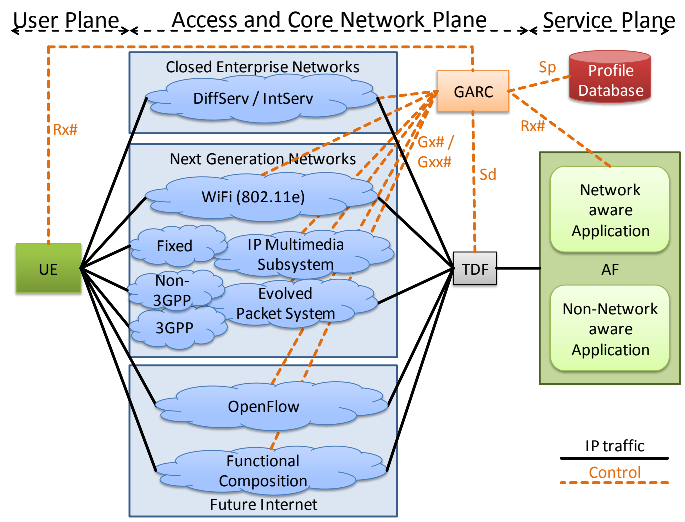

Fig. 1. Multi-Network Support of GARC

Figure 1 depicts the interaction between Generic-Adaptive-Resource-Control (GARC) and other telecommunication system related components involved in QoS control. GARC extends the 3GPP PCC architecture in the way that user and service initiated requests (Rx#), real-time network traffic situations (Sd), service utilization and context informations (Sp) are used as input parameter for the decision logic within GARC. The most suitable and optimized policy enforcement strategy given a specific network is determined and enforced(Gx#/Gxx#) afterwards.

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