Paper

Possibilities to Optimize QoS with Next SON Versions

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Abstract—The paper discusses quality of service in LTE and LTE-A networks seen as a challenge that can be met with Self-Organizing Networks (SON) functionalities. The SON concepts have been included in the LTE (E-UTRAN) standards since the first release of the LTE technology. Self-optimization functionalities will monitor and analyze performance measurements, notifications, and self-test results and will automatically trigger re-configuration actions on the affected network nodes when necessary. The SON specifications have been built over the existing 3GPP network management architecture, the ultimate implementation of SON in 4G networks will bring many advantages. Successive SON procedures are waiting for their time and money to be implemented in 4G, though some essential issues for example of inter Radio Access Technology (RAT) interfaces must be overworked.

Keywords*—*4G, QoS, SON.

1. Introduction

New and emerging classes of mobile devices are raising large growth of wireless data usage by private and enterprise users. As a result, wireless service providers have to support a growing number of higher bandwidth data applications and services. On the other side their networks are becoming more complex and heterogeneous and the necessity to ensure quality user experience requires more complex Quality of Service (QoS) implementations. For a couple of years the main European body for new radio technology standards, 3GPP Group, has set the goal to support automated procedures in multi-vendor network environments to answer the request of free market with its whole complexity.

Since the first release of the LTE technology (3GPP Release 8) Self-Organizing Networks (SON) concepts have been included in the LTE (E-UTRAN) standards. One can point two categories for SON introduction reasons:

– repetitive processes' automating clearly reduces costs (saves time and effort),

– collecting measurements from many sources must be automated to provide accurate near real time data for algorithms to control fast, granular, i.e. per user, per application processes.

The SON specifications have been built over the existing 3GPP network management architecture, reusing much functionality that existed prior to Release 8. The focus of the Release 8 SON functionality was put on procedures relating to initial equipment installation and integration to support the commercial deployment of the first LTE networks, known as eNB self-configuration.

Release 8 of 3GPP, a basic one for nowadays implementations has several successors (Fig. 1) already and one proves that the SON capability is seen as a key component of the next and emerging networks.

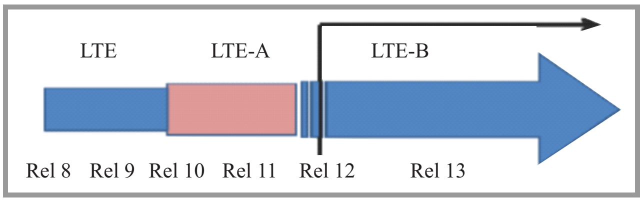

Fig. 1. LTE standardization.

Self-optimization functionalities will monitor and analyze performance measurements, notifications, and self-test results and will automatically trigger re-configuration actions on the affected network node(s) when necessary. This will significantly reduce manual interventions and replace them with automatically triggered re-optimizations or re-configurations thereby helping to reduce operating expenses. This paper aims to discuss the possibilities for QoS features resulting from present and further LTE implementations.

2. Review of Basic SON Procedures Covered by Successive 3GPP Releases

Table 1 [1], [2] shows SON procedures covered by 3GPP Releases since 8 to 12. Release no. 12 completeness was planned for 2014, and first parts of Release 13 (OAM aspects) should be ready soon.

The SON target is to maintain network quality and performance with minimum manual intervention from the operator. More automation allows to manage large networks more efficiently, which consist of thousands of base stations with hundreds of settings each. The role of SON is to enable efficient, and in some cases programmatic means of fine tuning cellular networks.

In 3GPP Release 8 standards, operators have specific SON requirements for simplifying eNodeB deployment and reducing operational cost. Approximately 80–85% of global providers focus on SON only in the 3G portion of their

Table 1
SON procedures in successive 3GPP releases

Release no.	Procedures	Remarks
8	Automatic inventory; automatic software download, automatic neighbor relation, automatic physical cell ID (PCI) assignment	"eNB self-configuration"
9	Handover optimization; RACH optimization; load balancing optimization; inter-cell interference coordination	Network optimization procedures
10	Coverage and capacity optimization; enhanced inter-cell interference coordination; cell outage detection and compensation; self-healing functions; minimization of drive testing; energy savings	SON functions for macro and micro networks overlaid on and interoperating with existing mobile networks
11	SON (UTRAN and LTE) management and coordination between different SON functions; inter-RAT energy saving management	SON Operation, Administration, Maintenance (OAM) aspects
12	High Rate Packet Data inter-RAT SON; enhancements of OAM aspects of distributed SON functions; multi-vendor Plug & Play eNB connection to the network	Next generation SON for UTRA and LTE

networks today [3]. This is because they want to first optimize what is stable and most of the network, while they work out other issues on 4G. Automatic Neighbor Relation (ANR) function, specified in the LTE context, automates the discovery of neighbor relations. It can help the operators to avoid the burden of manual neighbor cell relations management.

The ultimate implementation of SON in 4G networks will bring many advantages. For example, 4G has something called Reserved Quality (talked about on 3G, but not there, yet) as a means of managing QoS and Quality of Experience (QoE). This represents a benefit of SON on LTE in terms of optimizing network to support the QoS/QoE metrics. LTE architecture enables peer-to-peer (eNodeB to eNodeB) connections, which lowers latency and improves round-trip delay times. Successive SON procedures are waiting for their time and money to be implemented in 4G, and some essential issues for example of inter RAT interfaces must be overworked still.

3. Quality of Services in LTE

The QoS must be a particular concern in LTE as multiple applications may be running in a user equipment (UE) (for example at the same time: downloading an FTP file, browsing a Web page, chatting) at any time, each one having different quality of service requirements. Some services itself need better priority handling in the network, e.g., VoIP call, video conference. There are users being willing to pay more for high bandwidth and better network access, wanting to have better user experience on their 4G LTE devices. QoS defines priorities for certain services and customers.

In LTE Network QoS is applied to a set of bearers that are collectively called as EPS bearer. Bearer is a virtual concept and covers some network configuration to provide special treatment to various kinds of traffic. Keeping in mind the LTE architecture, one can point Radio Bearer, S1 Bearer and S5/S8 Bearer that cover QoS configuration in LTE (Fig. 2). As one must consider the end-to-end service, External Bearer is also a key issue here.

There is at-least one default bearer established when UE is attached to LTE network. When there is a need to provide QoS to a specific service, i.e., VoIP, video, etc. a dedicated bearer is established. There are two types of the Dedicated Bearer: Non-GBR and GBR.

Non-GBR Bearer does not provide a guaranteed bit rate and is associated with A-AMBR and UE-AMBR parameters (Application and User Aggregate Maximum Bit Rate). A-AMBR is the maximum allowed total non-GBR throughput to specific APN and is specified interdependently for uplink and downlink. UE-AMBR gives the maximum allowed total non-GBR throughput among all APN (Access Point Name) to a specific UE.

GBR Bearer provides a guaranteed bit rate and is associated with parameters like GBR and MBR; specified independently for uplink and downlink. GBR is the minimum guaranteed bit rate per EPS bearer, MBR – the maximum guaranteed bit rate per EPS bearer.

One should remember that the default bearer could only be non-GBR type.

There are four key parameters that make a QoS set for each bearer, describing: resource type (GBR or Non-GBR), priority (allocation and retention priority), packet delay, packet error or lost packets. Table 2 (GPP TS 23.203 V11.3.0) introduces parameters covered by nine Quality Class Indicators (QCIs) with example services.

Class 8 may be used for a dedicated premium bearer, e.g., associated with premium content for any subscriber/subscriber group or for the default bearer of a UE/PDN for premium subscribers. Class 9 is typically used for the default bearer of a UE/PDN for non-privileged subscribers.

The networks should be able to adapt their quality automatically in response to external factors or to special traffic patterns, i.e. SON procedures are the only solution for this challenge. Decisions are to be selected as the answer to the specified set of performance monitoring counters and indicators for every QCI [1]. They are, among others:

– number of successful sessions,

– number of dropped sessions,

– cell specific customer satisfaction rate,

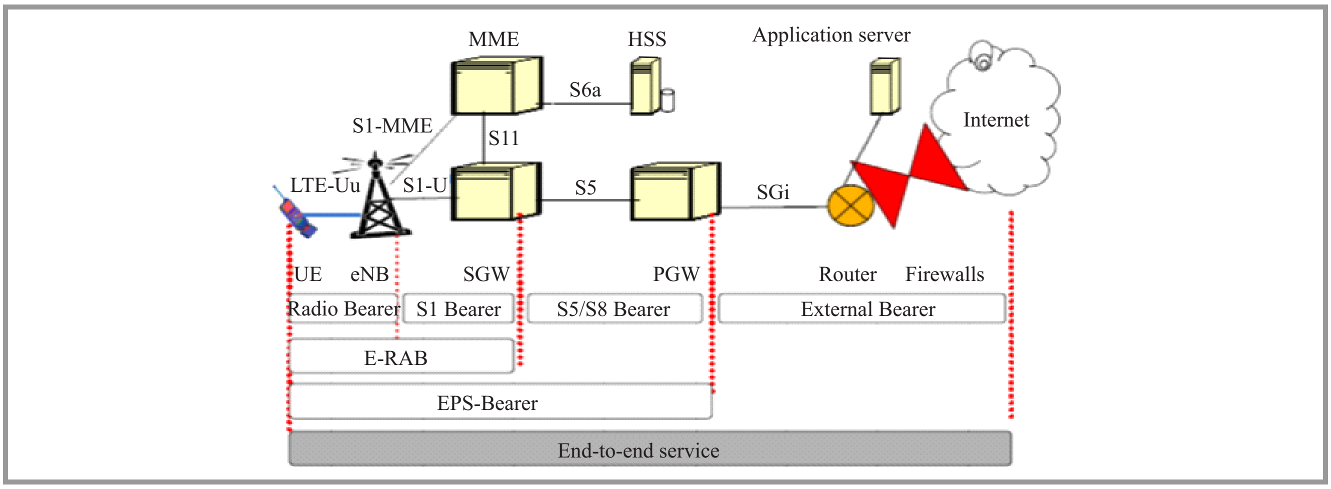

Fig. 2. LTE Bearer types.

Table 2
Standardized QCI with their parameters

QCI	Resource type	Priority	Packet delay [ms]	Packet error/ loss rate	Example application
1	GBR	2	100	10^{-2}	Conversation voice
2	GBR	4	150	10^{-3}	Conversational live video
3	GBR	3	50	10^{-3}	Real-time gaming
4	GBR	5	300	10^{-6}	Non-conversational buffered video
5	NON-GBR	1	100	10^{-6}	IMS signaling
6	NON-GBR	6	300	10^{-6}	Video (buffered streaming), www, email, ftp
7	NON-GBR	7	100	10^{-3}	Interactive gaming voice, live video
8	NON-GBR	8	300	10^{-6}	Video (buffered streaming), www, email, ftp
9	NON-GBR	9	300	10^{-6}	As above

– maximum/average/minimum throughput,

– maximum/average/minimum round trip delay,

– packet loss,

– mean number of Radio Resource Control (RRC) connected users, and users with data to send,

– percentage of users per cell that do not achieve their required GBR, experience higher data rate or delay set as a threshold.

4. Main SON Functionalities

The main functionality of SON includes: self-configuration, self-optimization, self-healing. The SON functionalities' structure is shown in Fig. 3.

According to the location of optimization algorithms, SON can be divided into three classes: centralized SON, distributed SON, hybrid SON.

In centralized SON, all functions are located in OAM systems, so it is easy to deploy them, but since different vendors have their own OAM systems, there is a low support for optimization cases among different vendors. In distributed SON, optimization algorithms are executed in eNB and SON functionality resides in many locations. In hybrid SON part of the optimization algorithms are executed in the OAM system, while others are executed in eNB.

5. After 3GPP Release 8 SON Procedures

Table 1 introduces some SON features covered by after 8 3GPP Releases (up to Release 12). One should remember that SON standards, as all the 3GPP specifications are a work in progress. The functionality of SON is and will continue to expand through the subsequent releases. Some benefits to gain from implementing SON are presented below [2].

3GPP Release 9 provided SON functionality covering operational aspects of already commercial networks, especially: mobility robustness, hand-over optimization, RACH optimization, load balancing coordination, inter-cell interference coordination. Automatic Neighbor Relation (ANR) function, specified in the LTE context, automates the discovery of neighbor relations. ANR can help the operators to avoid the burden of manual neighbor cell relations management. S5 interface (Fig. 2) has a leading role here, as a user may frequently switch on and off the home node and an operator may not be able to access the home node physically.

Minimization of Drive Tests (MDT) for E-UTRAN and UTRAN is an important topic in 3GPP Release 10. With the help of standardized UTRAN MDT solutions, Capacity and Coverage Optimization (CCO) for UTRAN should

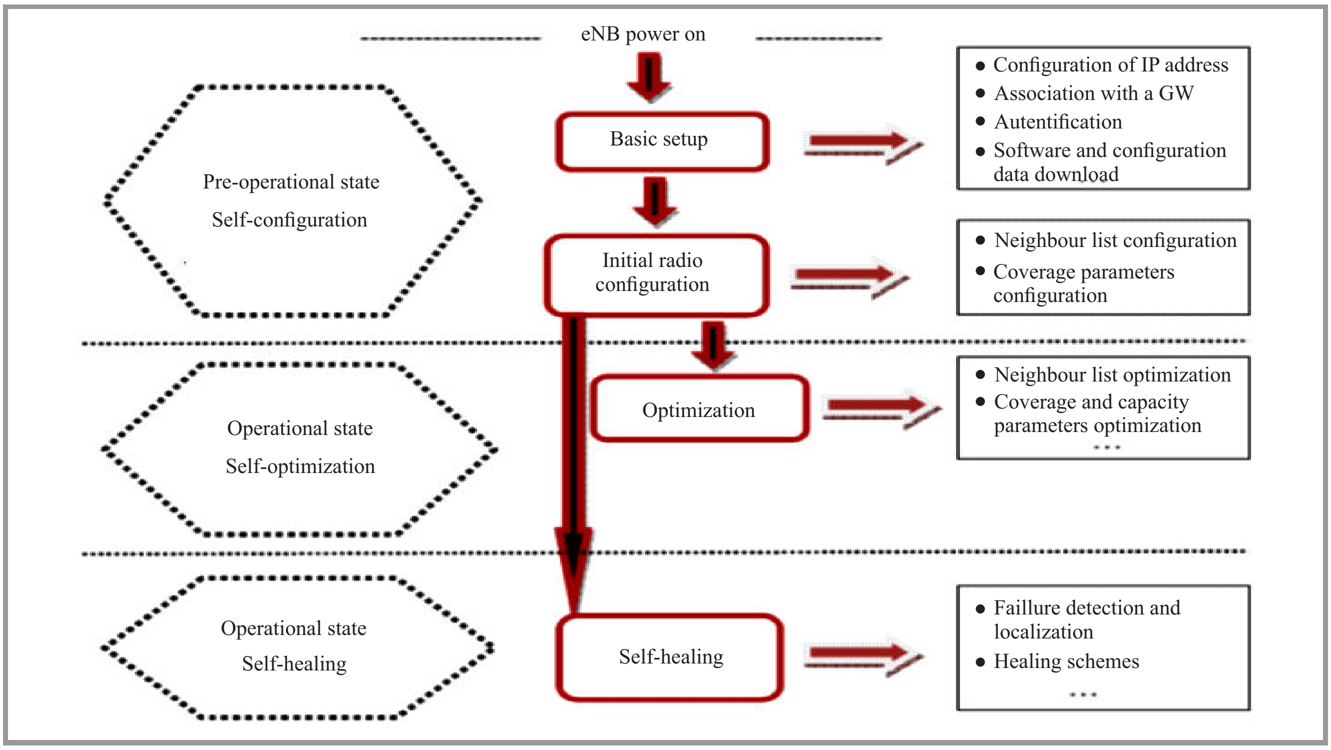

Fig. 3. The SON functionalities' structure.

also be considered in UTRAN SON activities. This Release covers also some self-healing functions and energy saving procedures in heterogeneous networks (macro-pico/femto scenarios). Any node can adjust its transmit output power to avoid interference with other nodes. Network elements can be switched into a stand-by mode and then woken up automatically, without affecting the customer experience such as dropped calls. Energy saving will not only enhance quality service experience but also will reduce operational costs related to power consumption.

In 3GPP Release 11 Mobility Robustness Optimization (MRO) is developed to identify for which UE type the failure has occurred. The release covers key aspects relating to network management, troubleshooting and optimization in heterogeneous networks. Self-testing and self-healing means that a system detects its problems and even solves them avoiding user impact and significantly reducing maintenance costs.

3GPP Release 12 covers SON procedures that can automate the network deployment based on active antennas what enables dynamic cell splitting/merging to handle changing load conditions. There are SON features for small cell functionality in the Release 12, too. Much effort is paid for multi-vendor Plug & Play eNB connection to the network to meet security problems in SON without losing its functionality.

6. Conclusions

SON can fix fundamental problems, such as poor coverage and/or dropped calls in an area and it can also be used for short-term, real-time issues (and then potentially be put back the way the network was in the first place). For example, the network may need optimization locally for a specific event such as a sporting event or live show. In all cases, SON is designed to support wireless carriers desire to provide a multitude of different services with high quality of experience for the end-user. With the SON implementation an operator can gain:

- no need for manual configuration at site, with security certificates without manual intervention,
- providing the node with planning data,
- configuring complex transport patterns with immanent security hidden within them,
- controlling plug and play processes.

All together means substantial savings with higher quality and reliability.

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