

# A REVIEW OF ISSUES IN SELF ORGANIZING NETWORKS

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### ABSTRACT

This paper presents the basic architecture of Self Organizing Networks( SON), some of the design issues related to SON architectures. A comparison has been made between the previous reference works done by some authors so that a better idea of the distinct features in each paper, could be made easier.

**KEYWORDS:** self-organizing networks, ad hoc networks, self-configuration, self-optimization.

### 1. INTRODUCTION

A **self-organizing Network (SON)** is an automation technology designed to make the planning, configuration, management, optimization and healing of mobile radio access networks simpler and faster.

Organizations: SON functionality and behavior has been defined and specified in generally accepted mobile industry recommendations produced by organizations such as 3GPP (3rd Generation Partnership Project) and the NGMN (Next Generation Mobile Networks). In simple words: A self-organized network is a kind of wireless network that can be deployed instantly and provide easy network communication without the support of pre-established network infrastructures, such as base stations. This network architecture brings promise of much better mobility and communication capacity. A self organizing network is an ad hoc network architecture that can be rapidly deployed without relying on a pre-existing fixed network infrastructure with minimal or no human administration. They are also known as zero-config or reconfigurable Wireless Networks (RWN). Newly added base stations should be self-configured in line with a "plug-and-play" paradigm, while all operational base stations will regularly self-optimize parameters and algorithmic behavior in response to observed network performance and radio conditions. Furthermore, self-healing mechanisms can be triggered to temporarily compensate for a detected equipment outage, while awaiting a more permanent solution. This paper is organized as follows: The second section contains the background description of Self-Organizing Networks, the third section consists of the prior related work done by different researchers, the fourth section contains the challenges associated with the Self Organizing Networks, fifth section consists of the open issues and future scope of this paper and the sixth section contains the conclusion.

### 2. BACKGROUND DESCRIPTION OF SELF-ORGANIZING NETWORKS

**SON Architectural Types:** Self-organizing networks are commonly divided into three major architectural types.

**Distributed SON** In this type of SON (D-SON), functions are distributed among the network elements at the edge of the network, typically the ENodeB elements. This implies a certain degree of localization of functionality, and is normally supplied by the network equipment vendor manufacturing the radio cell.

**Centralized SON** In centralized SON (C-SON), functions are more typically concentrated closer to higher-order network nodes or the network OSS, to allow a broader overview of more edge elements and coordination of e.g. load across a wide geographic area. Due to the need to inter-work with cells supplied by different equipment vendors, C-SON systems are more typically supplied by 3rd parties like Celcote or Cisco.

**Hybrid SON** Hybrid SON is a mix of centralized and distributed SON, combining elements of each in a hybrid solution.

**Son sub-functions:** Self-organizing network functionalities are commonly divided into three major sub-functional groups, each containing a wide range of decomposed use cases.

**Self-configuration functions:** Self-configuration strives towards the "plug-and-play" paradigm in the way that new base stations shall automatically be configured and integrated into the network. When a

new base station is introduced into the network and powered on, it gets immediately recognized and registered by the network. The neighboring base stations then automatically adjust their technical parameters (such as emission power, antenna tilt, etc.) in order to provide the required coverage and capacity, and, in the same time, avoid the interference.

**Self-optimization functions:** Every base station contains hundreds of configuration parameters that control various aspects of the cell site. Each of these can be altered to change network behavior, based on observations of both the base station itself, and measurements at the mobile station or handset. One of the first SON features establishes neighbor relations automatically (ANR), while others optimize random access parameters or mobility robustness in terms of handover oscillations. A very illustrative use case is the automatic switch-off of a percent of base stations during the night hours. The neighboring base station would then re-configure their parameters in order to keep the entire area covered by signal. In case of a sudden growth in connectivity demand for any reason, the "sleeping" base stations "wake up" almost instantaneously. This mechanism leads to significant energy savings for operators.

**Self-healing functions:** When some nodes in the network become inoperative, self-healing mechanisms aim at reducing the impacts from the failure, for example by adjusting parameters and algorithms in adjacent cells so that other nodes can support the users that were supported by the failing node. This function of SON permits to spot such a failing base stations immediately in order to take further measures, and ensure no or insignificant degradation of service for the users.

### Functional overview

Three classes of key functions figure prominently in SON.

**Self-configuration** comprises all tasks necessary to automate the deployment and commissioning of networks and the configuration of parameters. Network elements operate autonomously, running setup routines, authenticating and connecting to the OSS, as well as linking up and swapping parameters with need-to-know neighbors.

**Self-optimization** serves to improve or recoup network quality by tuning network parameters on the fly. Key tasks involve brokering handovers and balancing loads among neighboring cells. Contributing to a greener network environment, SON offers advanced energy-saving features.

**Self-healing** encompasses a set of key functions designed to cope with major service outages, including detection, root cause analysis, and outage mitigation mechanisms. Auto-restart and other automatic alarm features afford the network operator even more quick-response options.

**Self-planning** combines configuration and optimization capabilities to dynamically re-compute parts of the network, the aim being to improve parameters affecting service quality

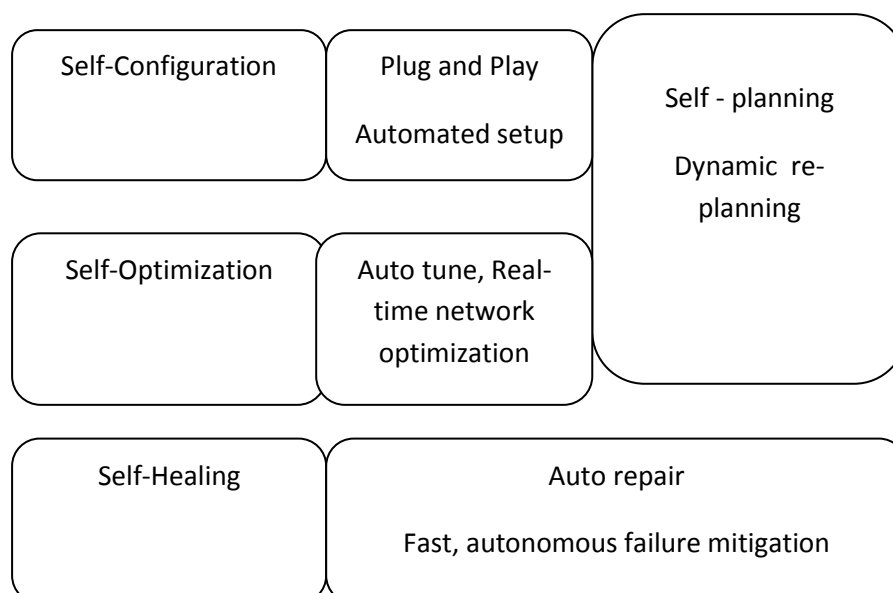


Figure: SON functions

**Challenges associated with a self organizing network:** Major challenges encountered while the designing of a Self-Organizing Network, are explained. These include:

### 1. Configuration

Most of today's networks are relatively static. They involve a large management cost to be setup and maintained. Today to setup connection to the Internet, we need to have an IP address assigned by a network administrator and some manual entries in the DNS server.

### 2. Discovery

Discovery is a very important aspect of making an ad hoc network self organizing. Discovery deals with two issues:

- a.) The discovery of the node itself within the network.
- b.) The discovery of the services available to the node once it has placed itself in the network.

The simplest way a node can discover itself is by using a Global Positioning System (GPS). The GPS can provide the node with its location and then it can start looking for nodes in its zone.

### 3. Routing

Routing is one of fundamental operations of a network. Thus there are a lot of routing protocols proposed to work with ad hoc networks. Link state and distance vector are two common approaches to solve the routing problem. In the link state each router has a good picture of the network topology and thus does not prove to be a good approach for self organizing networks.

Broadly speaking routing protocols are classified into two :

**a.) Proactive:** These types of protocols constantly evaluate the routes within the network so that when a packet needs to be forwarded the route id already known. E.g. Open Shortest Path First (OSPF), Wireless Routing Protocol (WRP), Destination-Sequenced Distance-Vector (DSDV).

**b.) Reactive:** This type of protocols determines the route on demand. E.g. Temporally-Ordered Routing Algorithm (TORA), Ad hoc On Demand Distance Vector (AODV) and Dynamic Source Routing (DSR).

### 4. Cooperation Incentive

Self organizing network are highly cooperative, since each node of the network acts as an autonomous network elements and provides all the services themselves. Since providing service to the network does not provide any direct advantage to the users of such a node, they may just consume services and not provide any. So mechanisms are required to encourage end-users to let their node act as a relay, and keep their terminal turned on and not tamper with them. Further such a mechanism should also discourage end-users from overloading the network, in particular limit the number of long distance communications.

### 5. Security

Security issues like legitimacy of the users, confidentiality and integrity of information in self organizing networks are similar to that of conventional networks. But this type of network has more complex issues as listed below:

- The medium used is wireless, thus it becomes easier to eavesdrop.
- These networks do not have a centralized monitoring or management point.
- The network configuration changes dynamically owing to the dynamic nature of the network.
- Mobile devices have a limited processing capacity and battery life, so any kind of solution has to take these factors into account.
- Mobile devices can be captured unlike fixed

- a.) To secure a self organizing network, we consider the following attributes: availability, confidentiality, integrity, authentication, and non-repudiation.
- b.) To ensure that the message delivered has not been modified a technique called diversity coding can be used. The basic idea is to transmit redundant information through additional routes for error detection and correction without message retransmission. Thus even if one route is compromised, the other routes can be used to get the correct information across.
- c.) To authenticate a user proposes a technique called threshold cryptography which takes advantage of the link redundancy of these types of network. It discusses the how distribution of trust can make Certification Authorities more robust and resistant to attack.

### 3. RELATED WORK

**Katayoun Sohrabi, Jay Gao, Vishal Ailawadhi, Greg Pottie, 1990 [1]** Wireless sensor networks will enable low-cost connections between the physical world and telecommunications networks, with applications including security, industrial automation, remote exploration, and medical monitoring. After briefly discussing the underlying technology, a protocol suite for self-organization of sensor networks, in which the number and topology of the sensor nodes are prior unknown, and no timing has been made available, is described. The scalable protocol very quickly establishes a TDMA and frequency assignment schedule, and then proceeds to establish energy-efficient routing. Simulation results will be demonstrated.

**Yasir Drabu , 2001[2]** Since the inception of communication, self-organizing wireless networks has been an intellectual fantasy of communication researchers. Self organizing networks are based on sophisticated protocols that allow diverse computing devices to establish a communication system without human intervention. This survey investigates these networks and tries to present the various issues and challenges they pose. Further the contributions made towards solving these problems are also outlined.

**Sujuan Feng, Eiko Seidel, Nomor Research GmbH, Munich, 2008 [3]** As every mobile network, LTE (Long Term Evolution) system also needs to be managed. There is a trend to simplify the management by auto-configuration and auto-optimization. However, the complexity of LTE system also place new demands on the Operations and Maintenances of the network. Self-Organizing Networks (SON) is seen as one of the promising area for an operator to save operational expenditures. SON is therefore currently discussed in 3GPP standardisation. This paper provides some background on SON principles, introduces different architectures that are considered and describes some exemplary procedures..Need of SON in 3GPP Long Term Evolution system:

1. The number and structure of network parameters have become large and complex.
2. The rapidly expanding number of Base Stations needs to be configured and managed with the least possible human interaction.
3. Increasing capacity of the network

**Francis Heylighen , 2008 [4]** One of the most recent applications of the complexity perspective is the analysis of complex networks, such as the World-Wide Web, and the non-linear processes that generate them. This has led to the identification of common statistical features of such networks: small-world, clustering and scale-free link distributions. These notions promise a wealth of applications in the analysis of information networks, potentially helping us with the organization, management, retrieval and discovery of relevant knowledge within masses of ill-structured and continuously changing data.

**Telenor, 2012 [5]** Self-Organizing Networks (SON) is a collection of functions for automatic configuration, optimization, diagnosing and healing of cellular networks. It is considered to be a necessity in future mobile networks and operations due to the increased cost pressure. The main drivers are essentially to reduce

1. CAPEX ( Cost Affective Expenditure)
2. OPEX (Operational Expenditure)

which would otherwise increase dramatically due to increased number of network parameters and rapidly increasing numbers of base stations in the network. Mobile networks are getting more complex to configure, optimize and maintain. Many SON functions will give cost savings and performance.

**Florian Kreitmair , 2013 [6]** This paper describes and reviews the mechanics of self configuration in Long Term Evolution (LTE) mobile networks. In particular the process of auto connectivity and auto commissioning in detail, with an extra look at the security setup, is done. Furthermore, the dynamic radio configuration of parameters that depend on neighboring cells, has been described. Finally, the possibilities and current status of adoption in practice, is surveyed.

**Bilal Zafar, Soheyl Gherekhloo, Aidin Asgharzadeh, Mehdi Tavakoli Garrosi , 2010 [7]** A software SONIR (Self-Organizing Network with Intelligent Relaying), in MATLAB, was developed, which implemented an end-to-end multi-hop, capable of dealing with mobility of nodes. Different methods for clustering, mobility management, routing were implemented. These methods work on different OSI layers. The main goal is to be able to visualize such a system as a whole in order to see the end-to-end performance as well as solve the possible issues that arise with it.

**Y Chun - 2000 [8]** A self-organized network is a kind of wireless network that can be deployed instantly and provide easy network communication without the support of pre-established network infrastructures, such as base stations. This network architecture brings promise of much better mobility and communication capacity. Various routing protocols have been presented. This paper gives a detailed study of whether each of them works and whether there is a superior one that can function successfully under all kinds of situations. We conclude that there is no superior protocol for all situations and look at the main issues to be considered when designing routing protocols for a self-organized network

#### 4. ISSUES AND CHALLENGES IN SON (SELF ORGANIZING NETWORKS)

On the basis of research done above, some issues and challenges in the designing of Self Organized Networks have been presented in a tabular format.

| Research Paper  | Main Features   | Remarks  |
|---|---|--|
| <b>Self Organizing Wireless Sensor Network</b>          | <ol style="list-style-type: none"> <li>1. Bandwidth utilization</li> <li>2. energy utilization</li> <li>3. network scalability</li> <li>4. formation of ad hoc sub-networks.</li> </ol> | <p>Drawbacks:</p> <ol style="list-style-type: none"> <li>1. Minimum energy required for network formation could not be decided</li> <li>2. The extent to which the algorithms can efficiently deal with more extensive mobility in the nodes and the targets.</li> </ol>   |
| <b>Self-Organizing Networks (SON) in 3GPP LTE, 2008</b> | <p>This paper provides some background on SON principles, introduces different architectures that are considered and describes some exemplary procedures.</p>                           | <p>Need of SON in 3GPP Long Term Evolution system:</p> <ol style="list-style-type: none"> <li>1. The number and structure of network parameters have become large and complex.</li> <li>2. The rapidly expanding number of Base Stations needs to be configured and managed with the least possible human interaction.</li> <li>3. Increasing capacity of the network</li> </ol> |

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| <p align="center"><b>Benefits of Self-Organizing Networks (SON) for Mobile Operators, Telenor, Research and Future Studies, 2012</b></p> | <p>The main drivers are essentially to reduce</p> <ol style="list-style-type: none"> <li>1. CAPEX ( Cost Affective Expenditure)</li> <li>2. OPEX (Operational Expenditure)</li> </ol>        | <p>Mobile networks are getting more complex to configure, optimize and maintain. Many SON functions will give cost savings and performance .</p>                             |
| <p align="center"><b>Self-Organizing Network with Intelligent Relaying (SONIR)</b></p>   | <p>A software SONIR (Self-Organizing Network with Intelligent Relaying), in MATLAB, was developed, which implemented an end-to-end multi-hop, capable of dealing with mobility of nodes.</p> | <p>The main goal is to be able to visualize such a system as a whole in order to see the end-to-end performance as well as solve the possible issues that arise with it.</p> |
| <p align="center"><b>Self-Organizing Networks (SON) in 3GPP: Release 11 – The Benefits of SON in Long Term Evolution</b></p>             | <p>The main area was Heterogeneous Networks</p>  | <p>This paper focuses on the SON use cases that play an important role in the operation of multi-vendor Heterogeneous Networks comprising of macro and metro cells.</p>      |

## 5. OPEN ISSUES AND FUTURE SCOPE

The major issues in the previous papers have been discussed but some issues in the field of Self Organizing Networks, are still open , which need to be solved. The key design issues are the available bandwidth (which is large, compared to the per hop data rate) and available energy (which is small). There are lot of technical issues involved in the designing of an ad hoc network and then making it self organizing. Configuration, discovery, routing, MAC layer adaptation, security are some of the key issues. Further , power and processing capabilities are scarce resources in mobile device, thus making protocols design even more complex. The potential benefits like ease of use, robustness and overall efficiency of such networks need further research till they can be commercially realizable.

## 6. CONCLUSION

The design of self organizing networks, involves the resolution of lot of complex issues. In this survey, some of these issues ranging from configuration to security, have been discussed. Some of the possible approaches that can be adopted to resolve them, have also been outlined. Major issues explored are: Cutting the cost of operation and improving network quality. This paper is prepared with the hope that it will be useful for the future researches in the field of wireless networks.

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