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Preface

Dear Participants,

Confronted with the ever-increasing complexity of technical processes and the growing demands on their efficiency, security and flexibility, the scientific world needs to establish new methods of engineering design and new methods of systems operation. The factors likely to affect the design of the smart systems of the future will doubtless include the following:

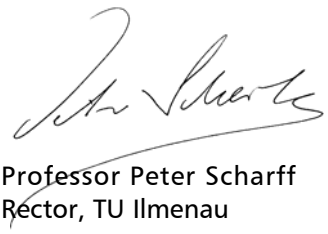
- As computational costs decrease, it will be possible to apply more complex algorithms, even in real time. These algorithms will take into account system nonlinearities or provide online optimisation of the system's performance.
- New fields of application will be addressed. Interest is now being expressed, beyond that in "classical" technical systems and processes, in environmental systems or medical and bioengineering applications.
- The boundaries between software and hardware design are being eroded. New design methods will include co-design of software and hardware and even of sensor and actuator components.
- Automation will not only replace human operators but will assist, support and supervise humans so that their work is safe and even more effective.
- Networked systems or swarms will be crucial, requiring improvement of the communication within them and study of how their behaviour can be made globally consistent.
- The issues of security and safety, not only during the operation of systems but also in the course of their design, will continue to increase in importance.

The title "Computer Science meets Automation", borne by the 52nd International Scientific Colloquium (IWK) at the Technische Universität Ilmenau, Germany, expresses the desire of scientists and engineers to rise to these challenges, cooperating closely on innovative methods in the two disciplines of computer science and automation.

The IWK has a long tradition going back as far as 1953. In the years before 1989, a major function of the colloquium was to bring together scientists from both sides of the Iron Curtain. Naturally, bonds were also deepened between the countries from the East. Today, the objective of the colloquium is still to bring researchers together. They come from the eastern and western member states of the European Union, and, indeed, from all over the world. All who wish to share their ideas on the points where "Computer Science meets Automation" are addressed by this colloquium at the Technische Universität Ilmenau.

All the University's Faculties have joined forces to ensure that nothing is left out. Control engineering, information science, cybernetics, communication technology and systems engineering – for all of these and their applications (ranging from biological systems to heavy engineering), the issues are being covered.

Together with all the organizers I should like to thank you for your contributions to the conference, ensuring, as they do, a most interesting colloquium programme of an interdisciplinary nature.
I am looking forward to an inspiring colloquium. It promises to be a fine platform for you to present your research, to address new concepts and to meet colleagues in Ilmenau.



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Rector, TU Ilmenau

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Head of Organisation

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K. Ghanem, N. Zamin-Khan, M. A. A. Kalil and A. Mitschele-Thiel

Dynamic Reconfiguration for Distributing the Traffic Load in the Mobile Networks

ABSTRACT

The widespread deployment of mobile networks drives the necessity for a novel dynamic scenario to balance the network load. Various load balancing means have been proposed to manage the traffic load of mobile networks. Building a dynamic architecture can be an optimal solution to create networks which are economic, flexible with high performance. This work suggests a new scenario (Multilink's stations scenario) based upon the idea of redistributing the peak traffic load between network elements to enhance the network performance, reconfigure the busy traffic paths and reduce the infrastructure and operation costs. Multilink's stations scenario which uses the multiple paths between Node-Bs and RNCs can be applied as a good solution to balance the load in the mobile network also it can be used to decrease the on-peak load and allows new users to join the network. The presented scenario offers a flexible solution to balance the load in the mobile networks also it can be used to decrease the on-peak load and allows new users to join the network.

INTRODUCTION

Mobile networks are the most common of all public wireless communication systems. Over the last decade the mobile communication networks have become increasingly widespread worldwide. The migration of telecommunication towards the wireless networks has become a significant phenomenon in the recent communications. Mobile networks such as GPRS, UMTS and HSDPA could provide the user demands [1] [2]. However, the increasing demands on the multimedia and data services in the recent mobile networks create a significant challenge. This challenge for the network designers is how to balance the requirements of the user and improve the operated network [3] [4]. One of the basic principles is to reuse radio resource after a certain distance. The whole area is divided up into a number of small areas called cells, with one base station giving radio coverage for each cell by its associated antenna [5][6].

Mobile operators have designed the radio access networks to cover traffic demand of the planned services in a static approach, considering the busy hour traffic in each geographic zone. That means the operator builds base stations depending on the requirements of the traffic forecasted in each area. It is worth to mention that not all the network spots have the same traffic load. The traffic load depends upon the area and it differs from rural and urban area [7]. Moreover, the peak time load appears within some delimited periods when the network resources are heavily used. So increasing the network capacity is not necessary at any time, that is because of some periods the network are empty and others are overloaded. The idea is to redistribute the usage of the existed network resources.

A significant need for a novel dynamic scenario that provides a flexible and a cheap solution to improve overall utilization and performance is required. Dynamic reconfiguration scenario for distributing the traffic load can be a mean to control the demand of the mobile network resources. Reconfigurability creates many challenges, but also provides opportunities, ranging from the scale growth to harmonization and inter-working among radio access technologies both is in the radio networks and core network. Reconfigurability offers the flexibility to adapt the settings to the actual demands, however to determine the implement the most efficient system configuration, mechanisms for advanced planning and management are required. This paper deals with these issues. An overview and related work, network traffic load, load balancing using cell breathing and Multilink's Station's Scenario are presented in the subsequent sections. Conclusion and future work have presented later on at the end of this paper.

OVERVIEW AND RELATED WORK

The increased demand for network services has led to substantial investments in the network infrastructure. The radio frequency band allocated to GSM and UMTS is limited, the obvious solution to increase available capacity is through cell splitting and frequency re-use, resulting in smaller cell clusters. Hence, urban areas now have far more cells per square kilometer than rural ones [8] [3]. The trend towards Pico-cells and nano-cells to serve a one building can increase the costs of the operating and infrastructure [9].

Previous researches on mobile cellular networks have led to many schemes to balance the traffic load [11]. Traffic load balancing in mobile cellular network has been well-studied since the first generation of mobile communication systems. Many methods have been proposed to-address this problem, such as cell splitting [12], channel borrowing [10] [4], channel sharing [13], dynamical channel allocation [8] [13], new soft handover schemes [12]. However, most of the research related to traffic load balancing only focuses on different radio channel allocation schemes.

The current solutions in the mobile networks don't offer any means for the stations to switch between the RNCs. In this work, a dynamic reconfiguration for distributing the traffic load in the mobile networks is achieved by using multilink's stations. These stations can switch from loaded RNC to unloaded one and enables more users to use the network in order to reduce the peak load. Studies on dynamic sectorization [14], and use tilted antennas [13] have shown that the system performance can be improved. However, switching the links between the node_Bs and the RNCs depending on the RNC load has not studied well so far. This work looks at a method that can utilise the existing network infrastructure efficiently. A decision has to be made of which connection should be while the network has multiple paths [15]. Real measurements can help the operator to decide which Node_Bs should provide with multilinks. Our scenario can be applied after having such these measurements and can be applied to existing networks.

As different wireless network technologies such as 3G mobile networks have been deployed at increasing rates, inter-working of these various technologies has become a significant issue. When multiple access networks are available it is possible to perform a seamless handovers between these different access technologies. Moreover, IEEE 802.21 standard Media Independent Handover (MIH) supports the network to have a seamless handovers across heterogeneous networks. Our mechanism/scenario focuses on switching between multi-links' Node_Bs, which is based on the network load.

NETWORK TRAFFIC LOAD

As the demand for cellular service increases within a particular area, the network must be re-engineered and more base-stations must be installed to meet the demand, which can be costly and time consuming. However, the dynamic nature of traffic capacity demand makes it difficult for the current cellular networks to operate efficiently and to optimize both cost and quality of service. Analysis of traffic performance implies capturing the three-way relation between capacity, demand and performance. Analysis of real network traffic can help the operator to determine the optimal solution for the best utilization of the network resources.

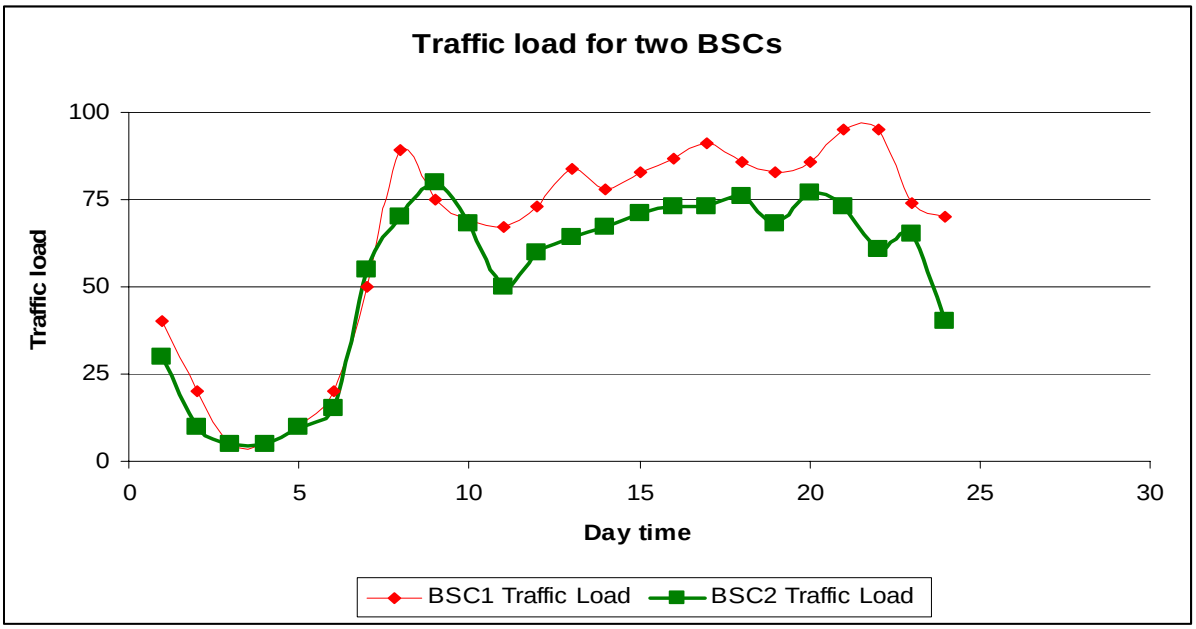

Figure 1 shows traffic load of a time-varying network for two different BSCs

Hourly time-scale variations in a customer market are shown in Figure 1 (where the x-axis refers to the measurement of time in a 24-hour format and the y-axis shows the resulting time-average traffic). It is worth to mention that the daily load differs from network to another, and it varies from time to time. Moreover, rural area peak load differs from urban area peak load. They fluctuate according to the seasons. Multilink's stations scenario utilizes from the previous idea and implements it to manage and balance the network load.

LOAD BALANCING USING CELL BREATHING

Cell breathing is a mechanism that attempts to keep the forward and reverse link handoff boundaries balanced by changing the forward link coverage according to the changes in the reverse link interference level. This technique is used to balance the radio resources between the cells [15]. Applying our scenario can enable this technique to be more efficient as we will explain later on this paper.

In the overlapping region, users are assigned to use the strongest-serving cell. Figure 4 shows that cell 1 is more heavily loaded than cell 2. When cell 1 and cell 2 belong to different RNCs, a lot of traffic can be lost to serve the users in the overlapping area. Our

scenario can be used to achieve the optimal usage of the radio resources. The primary advantage of our scenario is that it enables the mobile network to dynamically change the links between different RNCs and optimally utilize its capacity resources without having to change its hardware design. Another advantage of the proposed scenario is to serve the increased demands in a particular area. Cell breathing technique can be used to distribute the traffic after applying our scenario.

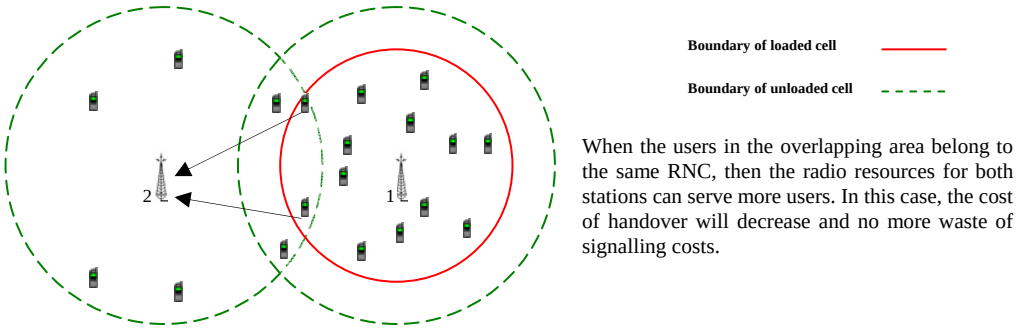

Figure 2 presents cell breathing technique

MUTILINK'S STATIONS SCENARIO

Multilink's stations scenario uses the multiple paths between Node-Bs and RNCs in the UMTS networks. The main idea here is to reconfigure the network upon the load. The traffic load differs from RNC to another one, so to achieve an optimal usage for the network; Multilink's stations scenario can be applied. The presented scenario can reconfigure the links between the Node_Bs and the RNCs according to the network load. The decision can be taken according to the availability in the network. Calculations and measurements for the load in the different RNCs can lead to select which links should rebuild. This reconfiguration can help the operator to allow more users to use the network in the peak load. The radio resources in this case can be used efficiently.

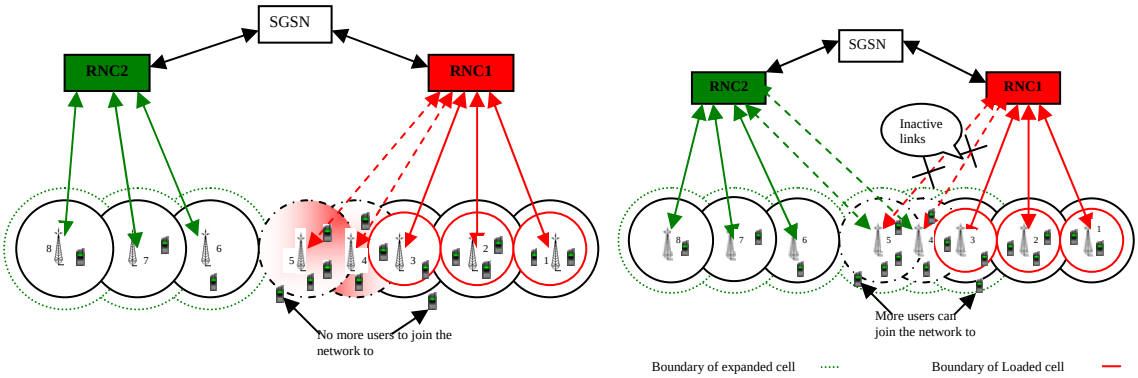

Figure 3 illustrates multilink's stations scenario which applied on an UMTS network. Before applying the scenario (Left), after applying multilink's stations scenario (right)

In UMTS networks, the network load is not regular. The traffic curve load of the network differs from cell to cell and it varies from RNC to another. Figure 3 shows the case when the network has two RNCs, one of them is loaded while the other one is not. In this case and by using a dynamic links between Node-Bs and the RNCs, the operator can switch between the links to connect the Node-Bs with the unloaded RNC2. More-download power control can be provided to each Node_B in the loaded RNC1 after switching decision. This enables the cells to expand, share the load and redistribute the load with the other network elements. As it is appear from the Figure4 both stations (4, 5) can switch their connection and move from loaded RNC1 to unloaded RNC2. After switching the links, the unloaded station 6 can share the load with loaded station 5(new neighbor). Station 5 will become unloaded cell, and then it can share the load with the overloaded station 4. In this case the network can serve more new users with good QoS. All the other loaded stations in our scenario such as stations number (1, 2 and 3) will be affected. The new load of the network can be reduced. Here, the loaded RNC1 can achieve a significant decreasing in the load which enables new users to join the network as it is shown in Figure 5. Moreover, for the unloaded RNC2, nothing will affect while the network already has the capability to serve a new user. The load between the cells themselves can be shared using the already mechanisms such as cell breathing. Applying this scenario the SGSN should guide RNC to take the suitable decision about the switching time.

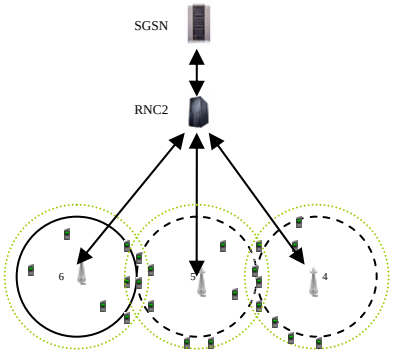

Figure 4 shows sharing the load between the cells after switching between the links in the loaded RNC1.

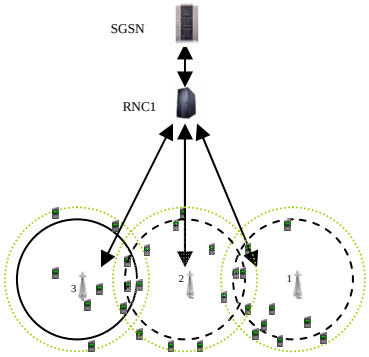

Figure 5 shows sharing the load between the cells after switching between the links in the unloaded RNC2.

It is important to notice that in this scenario we are not going to enable all the Node_Bs to have multilinks. Real measurement can help the engineers to select which Node_B has to have this capability. Under heavy load conditions at an RNC, large delays which can cause a serious degradation in the QoS for video and voice applications may be happened. Redistribute the load on the network among the existing network elements can reduce delays and collisions in order to improve the QoS perceived by users. Multilink's stations scenario can decrease especially for the mobile users in the geographic area who they are under the bing-bong handover phenomena. Our scenario can be very helpful when the bing-bong handover is happening between two BTSs related to different RNCs, and it can reduce the handover cost.

When several mobile users move in a geographic area which can be served by two stations related to different SGSNs, our scenario can be applied to reduce the signaling cost and to balance RNC and SGSN loads. The multilink's scenario can be used to balance the load among the coverage areas, reduce the signaling of the system and minimize the inter_SGSNs traffic cost.

CONCLUSION

Multilink's stations scenario to distribute the peak traffic load between network elements is presented. The study shows that our scenario can be applied as a good solution to balance the load in the existing mobile networks. It can decrease the on-peak load and allows new users to join the network in order to achieve significant increase in the overall network throughput and improve the network performance during the congestion periods. Future work will present a novel dynamic scenario to balance the network load which considers user's geographical footprints and user's movement and adjust the network up on that.

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