Survivability Analysis of GSM Network Systems

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Abstract: The Global System for Mobile communication (GSM) is now a worldwide-accepted standard for digital cellular systems. With the increasing of GSM popularity, customers are expecting a high level of service, from which availability is considered the major measure of quality. This paper presents a methodology for availability assessment of GSM systems. The availability block diagram model is selected to model the system, taking into account the signal strength and signal covering overlaps exist in GSM systems. The TEMS Cell Planner, TEMS Link Planner and Relex 8 are used to simulate the model for real data. The real data is collected from Korek telecom, the first GSM system in Iraqi Kurdistan. Finally recommendations are made to improve the availability within standards.

Keywords: GSM, Survivability, Network System, Cellular System

1. Introduction

Based on the attributes of these waves, we can partition the spectrum which is based on propagation properties and the system aspects. A mobile cellular network can generally be described as a fixed communication infrastructure consisting of network elements that allow mobile users to access network services through radio channels. A typical architecture of current cellular/PCS networks is illustrated in Figure 1. A mobile cellular network typically covers a large geographical service area which is partitioned into many small regions called cells. Each cell is served by a base station (BS) that acts as a fixed access point for all mobile terminals (MT) currently residing within the cell.

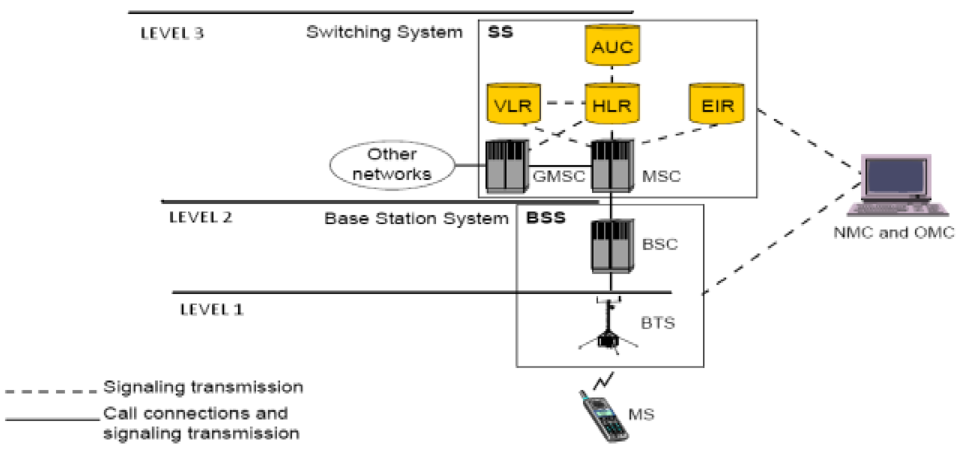


Figure 1: Mobile cellular network architecture (Ericsson Radio Systems, 1998)

The BS terminates the wireless communication links (or radio channels) to the user on the network side of the user-to network interface. The wireless links between the BS and MTs within a cell are digital and employ either time division multiple access (TDMA) or spread-spectrum code division multiple access (CDMA) techniques. The network may include base station controllers (BSC), which manage a group of base stations, as well as do radio level channel management and assist call handoffs. The BSs and BSCs are connected to backbone networks via mobile switching centers (MSC). In cellular communication systems, it is usual to suppose that a mobile user is served by the base station that provides the best link quality. In many cases, however, a mobile user can establish a communication link of acceptable quality with more than one base. Succinctly, at many locations there is overlapping coverage, usually by nearby base stations (Tai-Po & Rappaport, 97). As mentioned in Figure 1 GSM Network is divided to three different Layers; Layer 1 is access level layer, Layer 2 is transport layer and Layer 3 is intelligent layer.

Overlapping coverage areas of nearby base stations arise in cellular communications systems, especially in small cell high capacity microcellular configurations. With overlap, some users may have access to channels at more than one base station. This enhanced access can be used to improve teletraffic performance characteristics (Marano, Mastroianni & Riccardi, 98). By overlapping the cell areas of adjacent point-to-multipoint radio base stations as in Figure 2, a robust radio network design can be achieved.

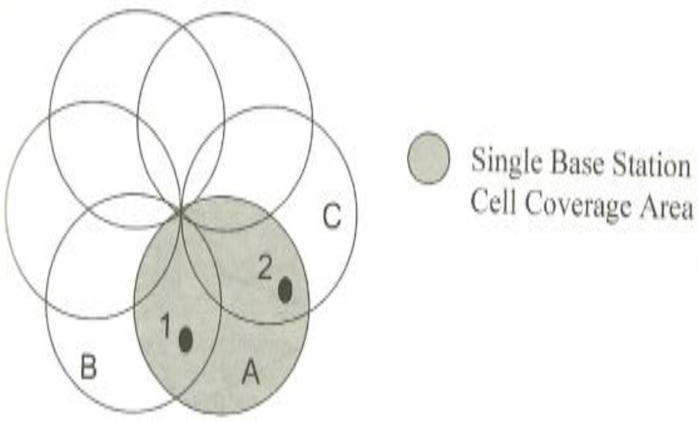


Figure 2: Overlapping radio cells (Clark, 2000)

The International Telecommunications Union (ITU-T) recommendation E.800 defines reliability as the ability of an item to perform a required function under given condition for a given time interval. The reliability means probability of a system to be free from failure while maintaining a specific performance. Reliability block diagram is a schematic representation of a model which shows reliability structure (logic) of a system.

RBDs can be used to determine:

- The probability of the integrated system to perform its function at any time
- Whether the system is operating or failed or absolute workability
- Looking at each block if it is in operating or failure mode.

The current research focuses on building an availability model for GSM systems. We propose availability model for GSM cellular networks using Availability block diagram in section II, results and finding is present in section III, and finally conclusion and recommendation is present in section IV.

2. Building Availability Model for GSM Cellular Network

In this section, a complete availability model in the form of availability block diagram is built for a GSM network system. The software Relex Studio 8.0 is used in the modeling. To be able to obtain the reliability and availability models of area covered by a radio base station, it’s necessary to have reliability data of each component to provide radio coverage in a geographic area. Any failure of mentioned components affects different number of users. Ainkawa is located in North West of Erbil. The average building height of the studied region is about 12m (from the field data). Six main radio base stations are used to cover main parts of this region. The digital map of Erbil and the studied area of this research are shown below; Figures 3 and 4 show the coverage of three sectors radio base station of the shape of hexagons for each cell in the Ainkawa region. Reliability and availability of each cell is measured using RBD model of RBS and MiniLinks. Totally 8 case study for 18 cells need to be done to measure the reliability and availability of coverage in this region. We assume that no other GSM signals reach to this region neither from KOREK TELECOM nor any other GSM operators.

Figure 3: Erbil and Ainkawa Map

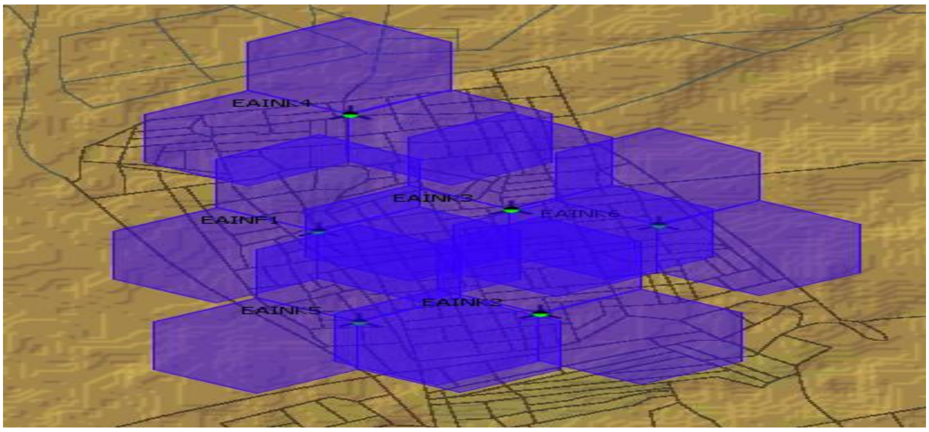


Figure 4: Coverage of Ainkawa by 3 sector RBS with Hexagons shape

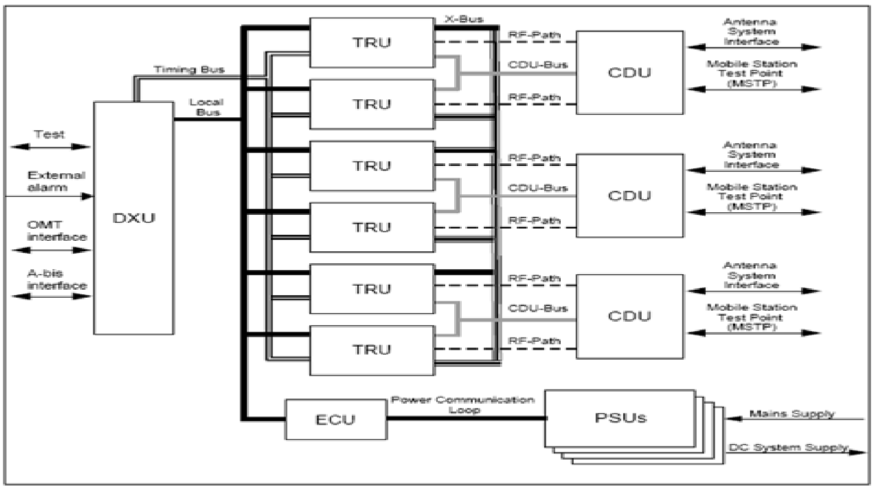


Figure 5: Block Diagram of Radio Base Station 2000 (RBS 2000) (Ericsson Radio Systems, 1998)

The block diagram of Fig (5) is modeled in Relex Architect 2008 environment is shown below.

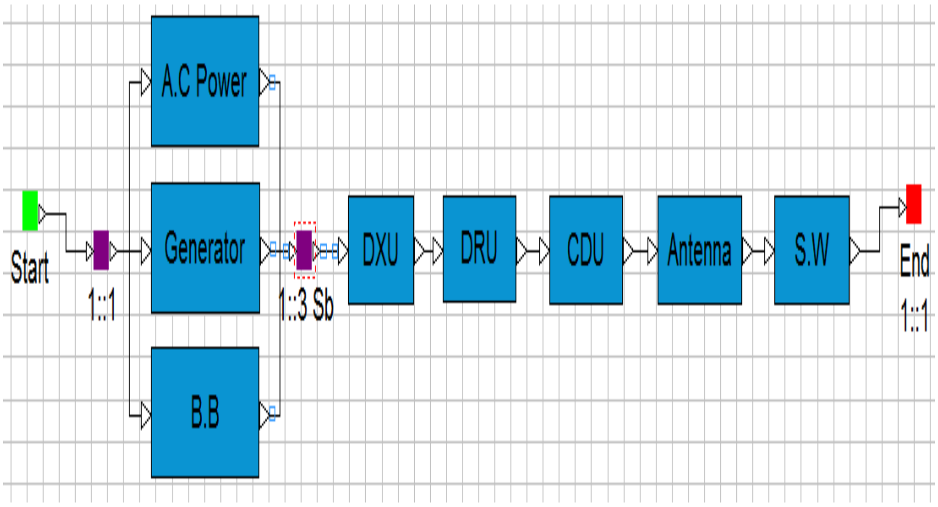


Figure 6: RBD of RBS 2000 modeled by Relex Studio 2008

Figure 7 shows the diagram of one HOP MiniLink which means that the RBS is connected to BSC by only one set of MiniLink.

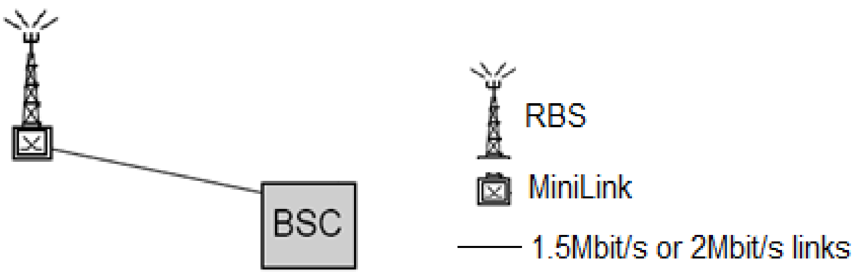


Figure 7: One HOP MiniLink

The parameter MTBF of MiniLink is taken from TLP (TEMS Link Planner) software which is used by KOREK TELECOM to design transmission network. Because of unavailability of MIniLink statistics the data of planning have been used in this study. The RBD of one HOP MiniLink is shown in Figure 8; from this picture it can be concluded that the same power supplies have been used for RBS and MiniLinks.

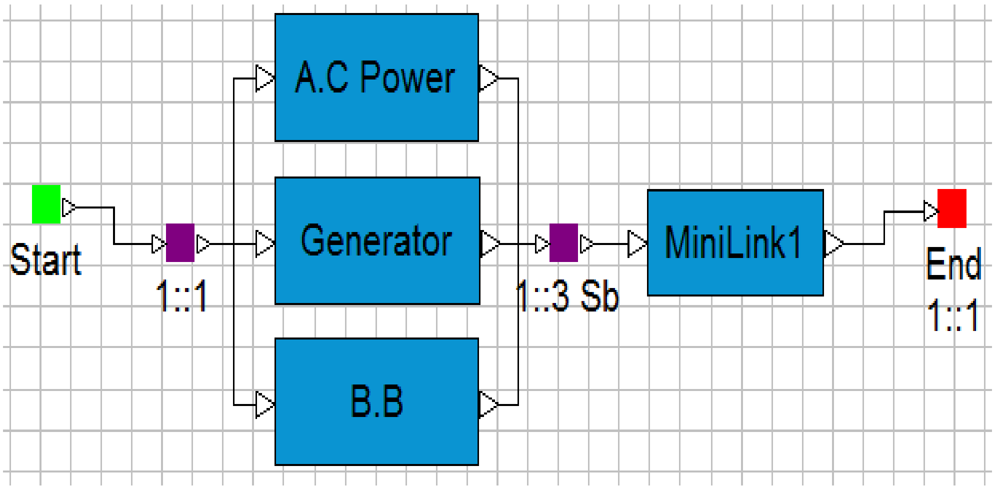


Figure 8: RBD of one HOP MiniLink modeled by Relex studio 2008

Eight case studies take different number of cells with overlap and different HOP MiniLink, in our research, case seven overlap of four cells and three cells with 3 HOP and one cell with 2 HOP Minilinks is studied and compared with other cases. Block diagram of one of the case study is shown in Figure 9 and data structure of case seven is shown in Figure 10.

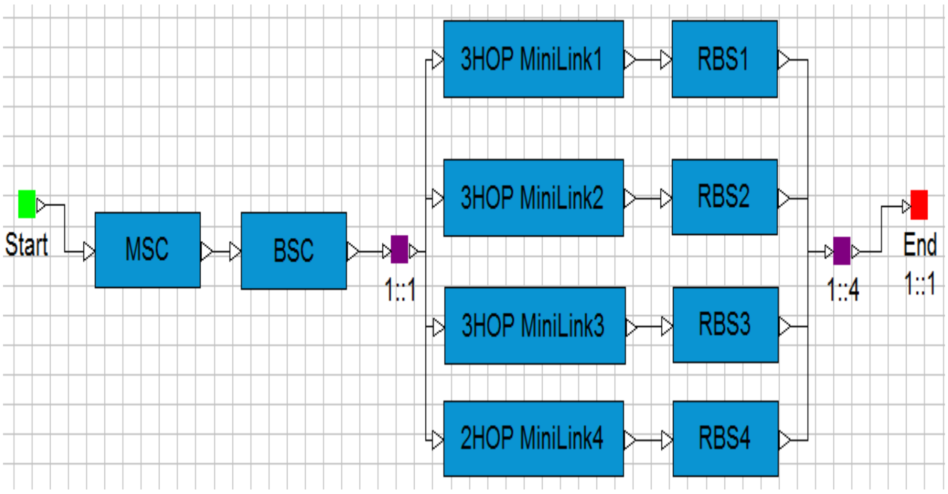
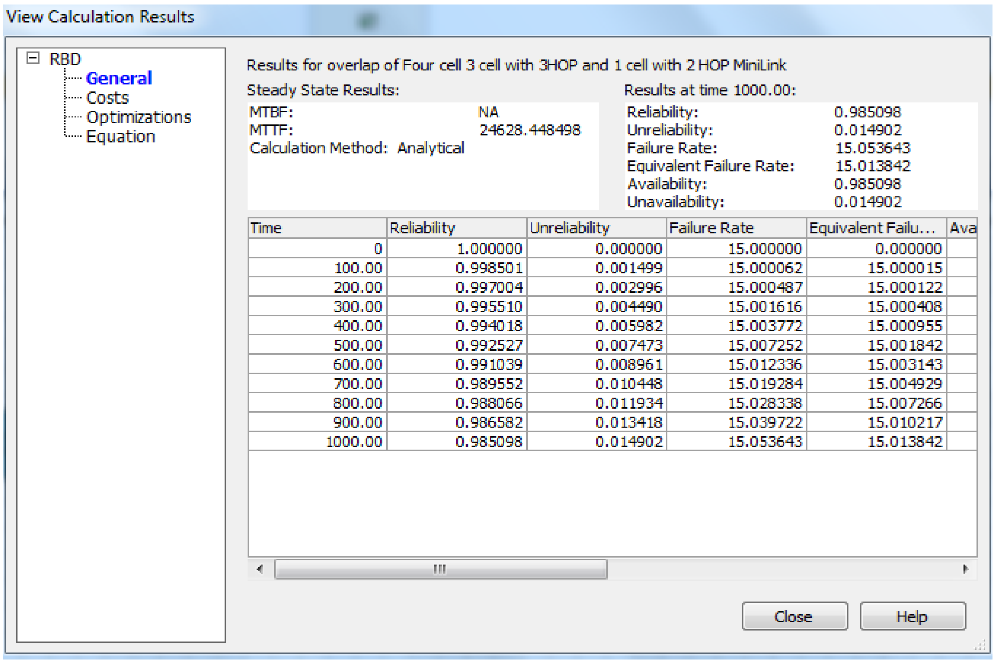


Figure 9: RBD of case Seven



Time	Reliability	Unreliability	Failure Rate	Equivalent Failu...	Ava
0	1.000000	0.000000	15.000000	0.000000	
100.00	0.998501	0.001499	15.000062	15.000015	
200.00	0.997004	0.002996	15.000487	15.000122	
300.00	0.995510	0.004490	15.001616	15.000408	
400.00	0.994018	0.005982	15.003772	15.000955	
500.00	0.992527	0.007473	15.007252	15.001842	
600.00	0.991039	0.008961	15.012336	15.003143	
700.00	0.989552	0.010448	15.019284	15.004929	
800.00	0.988066	0.011934	15.028338	15.007266	
900.00	0.986582	0.013418	15.039722	15.010217	
1000.00	0.985098	0.014902	15.053643	15.013842	

Figure 10: Data structure of case Seven

3. Data Collection, Implementation and Results

In this study, a set of data has been analyzed and used which is recorded by a software tool called GSM ISP tool. Figures 11 to 13 show the availability, reliability, failure rate and MTTF vs. case studies. It can be found easily that more overlapping provides more availability and reliability and also improves MTTF and failure rate. Case One has better indices than case Two while in both case there is no overlapping because of number of MiniLink HOP used. Figure 14 shows the comparison of two case studies which shows the region with more overlapping and more availability.

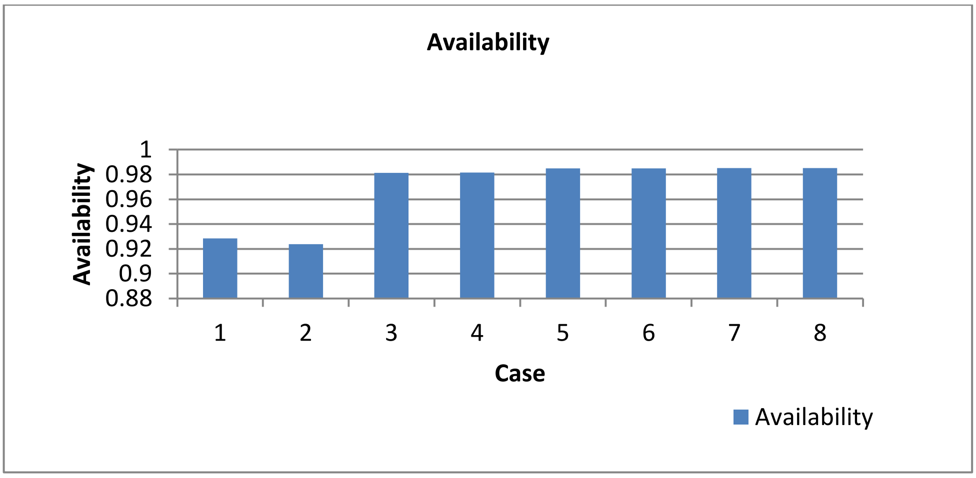


Figure 11: Availability of different case

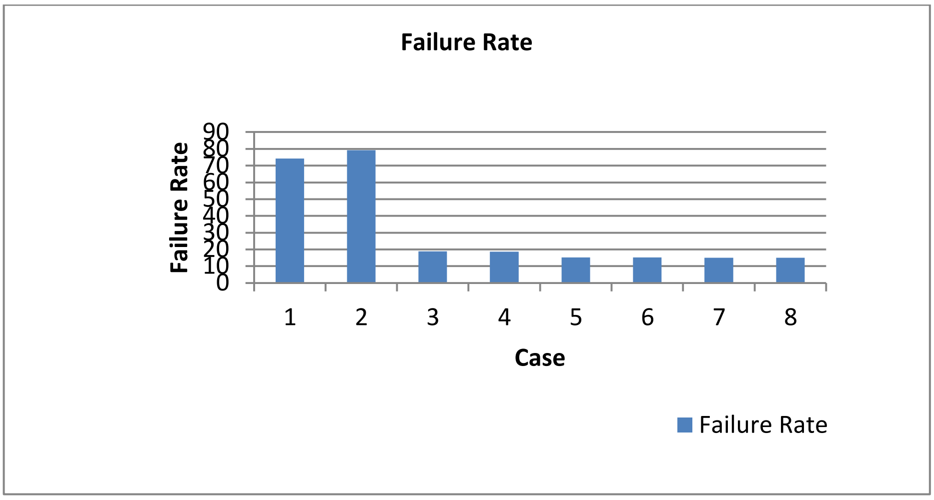


Figure 12: Failure rate of different case

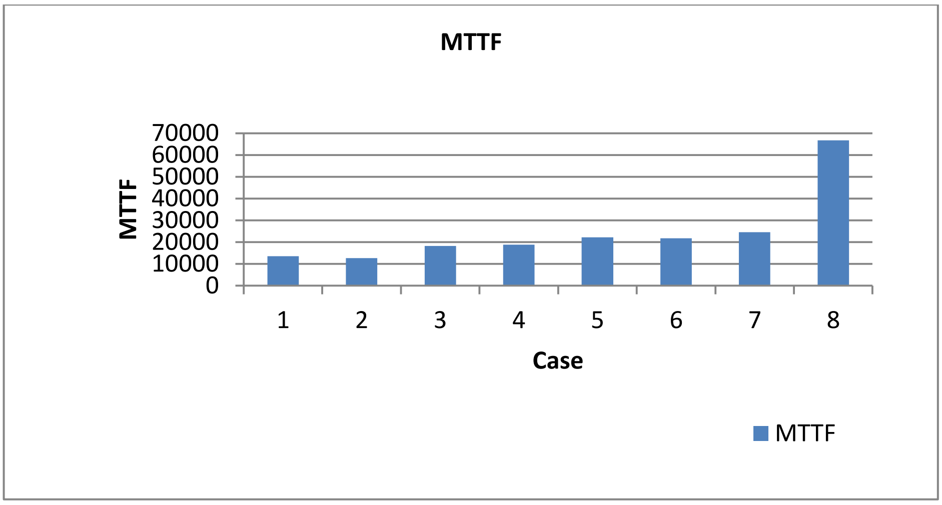


Figure 13: MTTF of different case

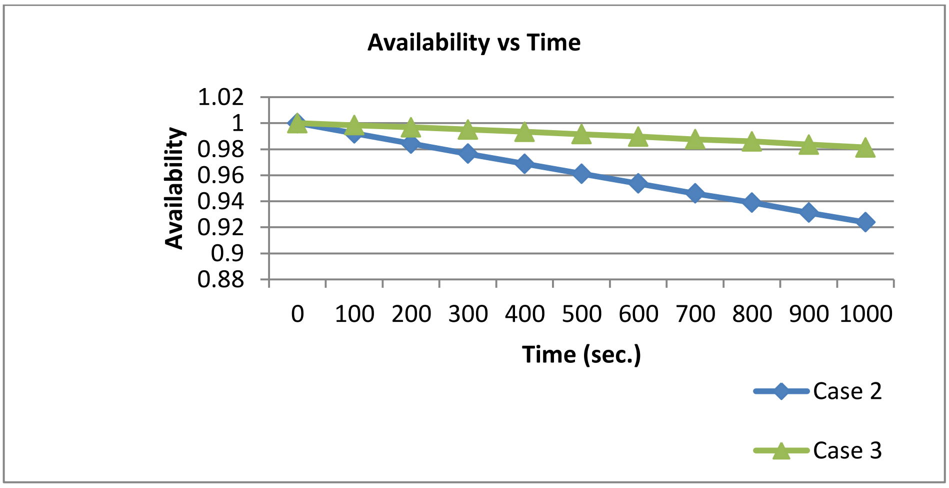


Figure 14: Availability vs. Time for two cases

Figure 15 shows that overlapping coverage improves this performance measure over fixed channel assignment (FCA). In this research there are three kinds of regions in which calls have potential access to one, two, or three base stations. These regions, which are shown in Figure 16, are denoted by A1, A2 and A3 and, respectively. Thus, region A1 is the non overlapping region while both A2 and A3 are overlapping regions. Region has the worst blocking situation because a call can only access a single base there (Tai-Po & Rappaport, 1997).

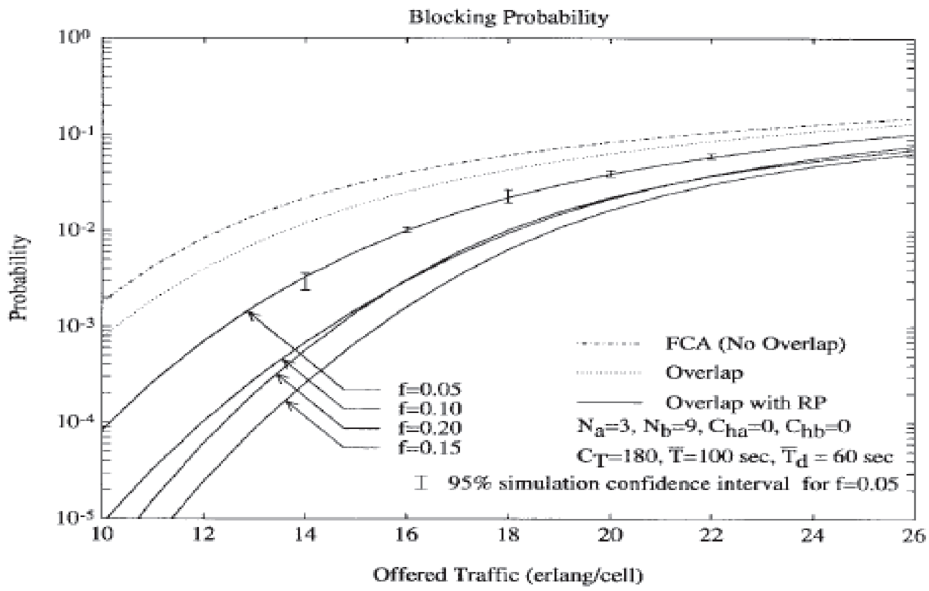


Figure 15: Performance comparison of overall blocking probability between FCA, coverage overlap, and coverage overlap with reuse partitioning

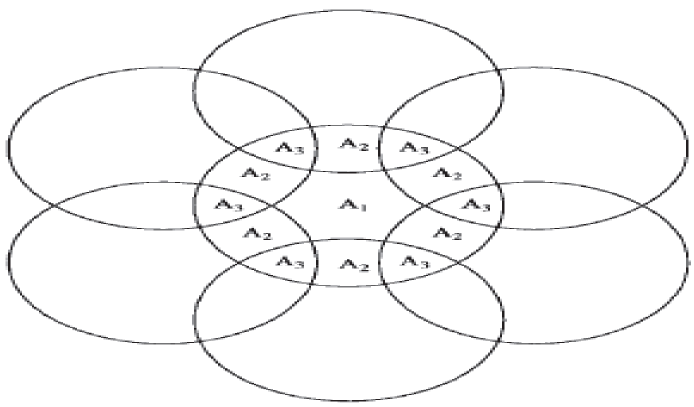


Figure 16: Three kinds of regions in the coverage of a base

Figures 17 to 19 show the component availability, MTTR and failure rate respectively. It can be seen that the availability of CDU, Antenna system and DRU is weak and definitely it's because of long MTTR of these components compared to others. By a brief view of the charts in this section it can be found the components which have low MTTR, it also can be found that A.C Power has high failure rate because it has very low MTTR. The common conclusion in this section is that MTTR play very important role to increase the availability of the networked system. If an alarm or fault raise from the CDU's the repair time is not as low as A.C Power as in Figure 18. This will cause low availability of CDU compared to A.C power even though the failure rate of A.C Power is much higher than DRUs.

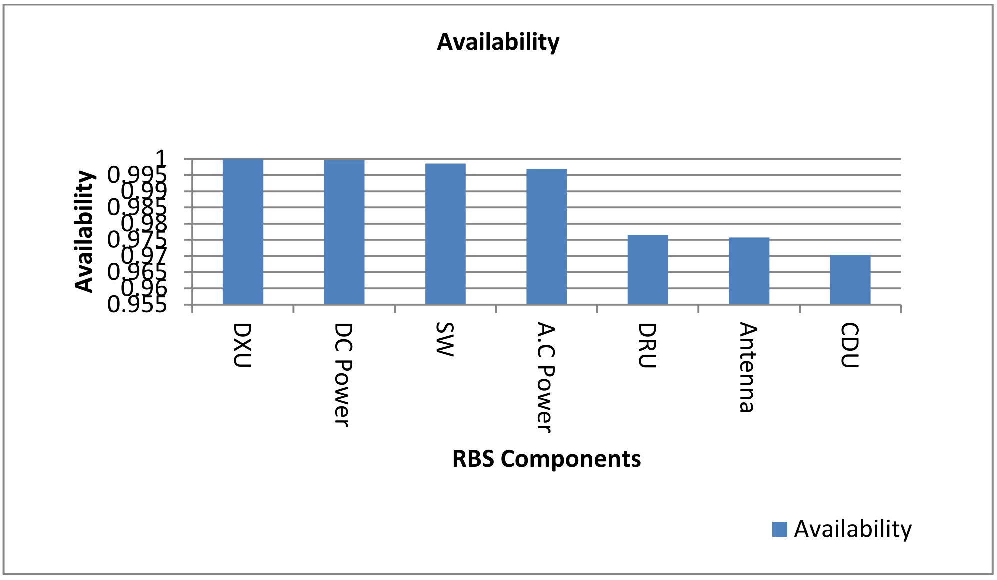


Figure 17: Components of availability

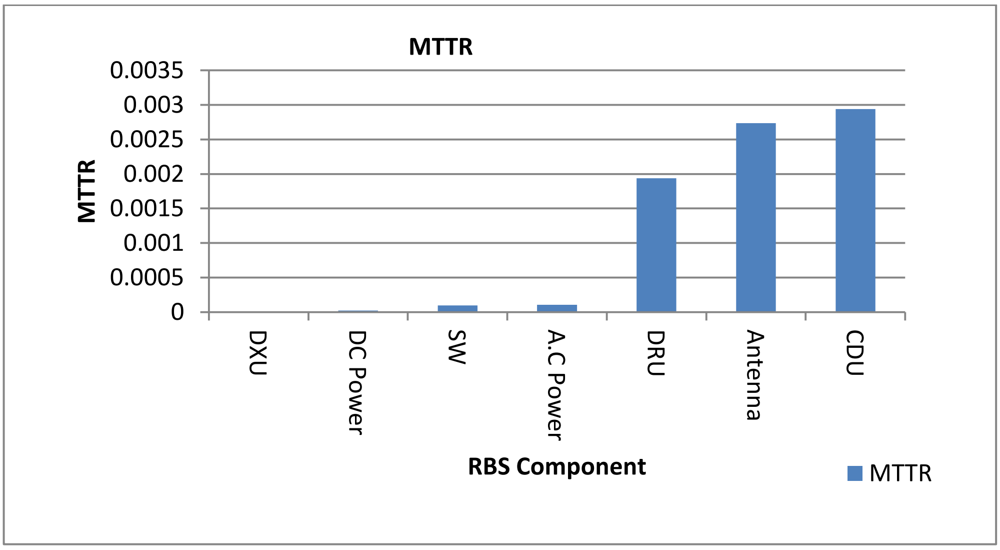


Figure 18: Components of MTTR

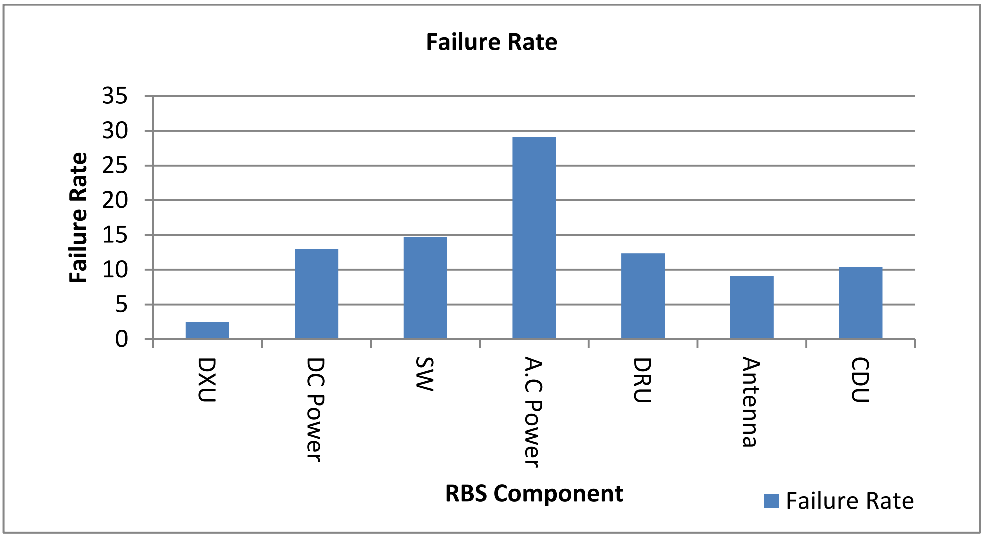


Figure 19: Components of failure rate

Having several HOP to connect RBS to BSC also will increase failure rate and decrease availability as shown in Figure 20.

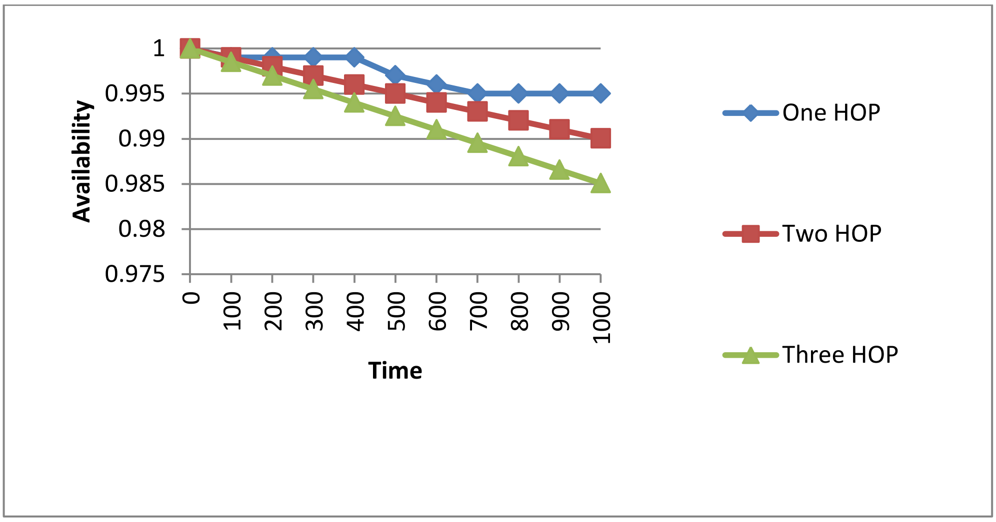


Figure 20: Availability vs. Time of Different Microwave HOP's

Figure 21 shows the availability of signal in Ainkawa area. The figure shows that initially 60% of the study area has low availability index and coverage service there may be not survivable. 25% of the area covered by overlapping of two cells the rest 15 % of studied area is overlapping of three, four and five cells which raise availability to standard levels. Results show that the overlapping is a major and vital parameter to be considered in GSM design.

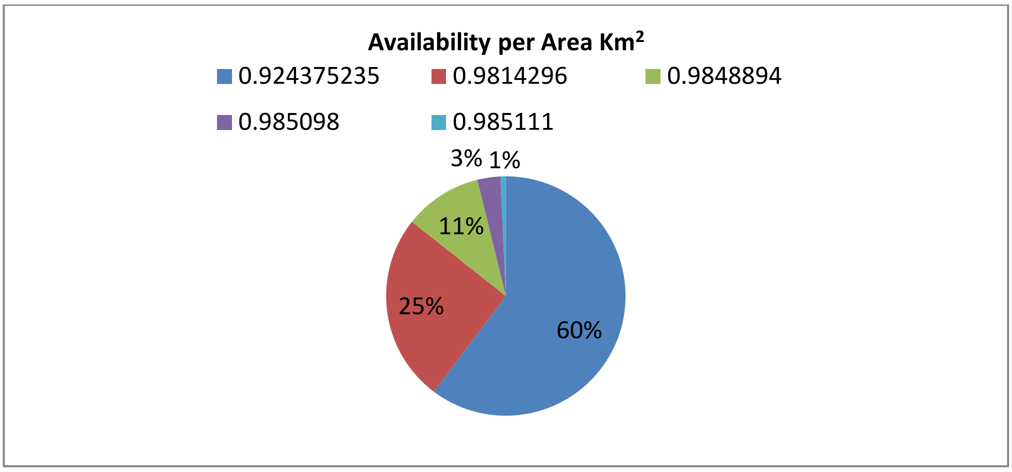


Figure 21: Availability index of Ainkawa region

4. Conclusion and Suggestions for Future Work

Availability and reliability measurement of existing GSM network for KOREK TELECOM, using statistical data over nearly one year (274 days) by using principle of availability and reliability rules results the following conclusions and recommendations:

1. The availability of GSM coverage depends on how much cell in cellular systems have overlapped; on the other hand the availability of the network in cell coverage area is increased by increasing the number of cells which cover the same area.
2. Different radio base station components have different availability and failure rates.
3. Using parallel redundancy and standby systems will improve Mean Time to Restore (MTTR) of the components and will improve availability.
4. The main problem can be concluded after analysing the statistics of different components of RBS; which is high value of MTTR of CDU's, Antenna System and DRU's; which cause the lowest availability value compared to the other components.
5. Increasing the number of Microwaves HOPs, decrease the overall availability and reliability of the cellular system. In this research, the availability model is done with a focus on the modeling. From theoretical point of view, it is important to conduct optimization, which is not included in this research due to mathematical complication and the limited time.

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