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Design of an Intelligent System to Selectively Block Mobile Phone Communication within a Mobile Phone Restricted Area

Michael Agyare[1*], Jerry John Kponyo[2] and Francis Kwabena Oduro-Gyimah[3]

[1]Department of Telecommunication Engineering, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

[2]Department of Electrical/Electronic Engineering, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

[3]Department of Telecommunications Engineering, Ghana Technology University College, Accra, Ghana

E-mail: fiuezo@gmail.com

Abstract: In this paper we present a selective mobile phone communication blocking system for mobile phone restricted areas. Since existing systems are looking at selective blocking for calls, we extend the scope to cover other communication services; that is for data connection, SMS and emergency call services. This was implemented using fuzzy inference system toolbox and the mamdani inference type was used. The results in this paper show that when the system is implemented mobile phone communication services can be prioritized to suit privileged users within the mobile phone restricted area.

Keywords: Fuzzy logic; Membership functions; Mobile phone jammer; Emergency call

I. INTRODUCTION

On account of the developing enthusiasm of telecommunication services, mobile phones have advanced toward ending up as part of practically every human life. Mobile phones have transformed into a basic particular instrument in our regular day-to-day existences. This empowers clients to make calls, text and use other multimedia messaging applications. It is extraordinary to have the capacity to call or contact anybody whenever. However, there are a couple of spots where mobile phone exercises confined. These spots are houses of worship, libraries, mosques, banks, motion picture theatres and every other place where silence is required. It ends up noticeably irritating and upsetting when a mobile phone rings or somebody gets a call amid parties (tuning in to a sermon or lecturing, asking at the mosque), official gatherings and social affairs that requests hush consideration and core interest. An engaged region where phones are limited is in schools particularly senior secondary schools (motel) and exams corridors of tertiary establishments (preparing universities, Polytechnics and colleges).
With this as an issue, mobile phone jammers are utilized to keep phone clients from making and accepting calls inside that specific limited range. Therefore, the elementary determination of the mobile jammers is to block communications between a mobile phone and base stations [1]. This discourages mobile phone utilization in the confined range. Since there are distinctive, frequency bands that the mobile phone system use. The jammers would need to jam mobiles by crossing over those bands successfully [2], such as GSM, WCDMA and DCS [3]. Unfortunately, the use of mobile phone jammers would probably meddle with or bother public mobile services, and in turn have serious consequences on the users such as [4]:

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- Jeopardising the quality of the service (QoS).
- May affect the contact to emergency services.
- Bring about inconvenience and loss of business for mobile service provider.

A major benefit of a mobile phone jammer [5];

- It helps save trade secrets by blocking signals so employees are not able to send information to others in the form of pictures.

II. PROBLEM STATEMENT

The use of a mobile phone jammer has some limitations. Once activated no mobile phone can be able to function within the restricted area. For that reason, in the case of emergencies no mobile phone can either make or receive phone calls or perform emergence calls (police, fire and ambulance services). Therefore, there is a need for a system, which can allow certain mobile phones to exclusively make communication within the restricted area. The system should selectively block communication within the restricted area. The system should allow all mobile phones within the restricted to perform emergency calls (police, fire and ambulance services).

III. SCENARIOS TO EXPLAIN THE SIGNIFICANCE OF THE PROPOSED SOLUTION

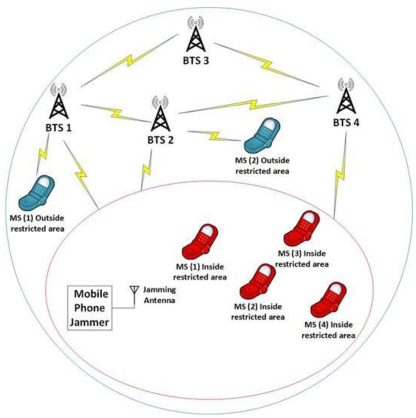

Figure 1: A mobile phone jammer blocking signal from the base station to the mobile phone.

The mobile phones labelled in red have been denied communication service by the jammer and the blue are those outside the restricted area. The restricted area is labelled with a red oval and the entire geographical area is labelled with a blue circle. The BTS's represent the operators' base transceiver stations. In this scenario, mobile phones in the restricted are completely cut-off from the operators' BTS by the mobile phone jammer. Therefore, in emergency contact situations (fire, police and ambulance services) communication cannot be established to the restricted area (Figure 1).

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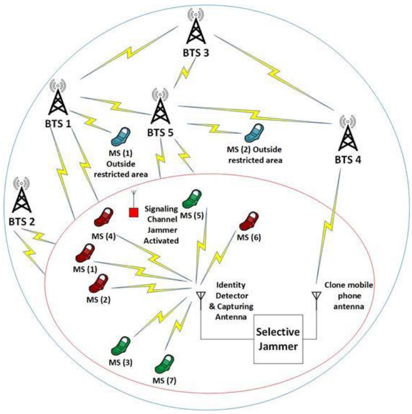

Figure 2: Selective blocking system performing selective blocking in the restricted area.

Figure 2 shows a scenario where mobile phones connected to the proposed system (selective jammer) are selectively blocked. The mobile phones labelled in red are those connected to the proposed system but have been denied a communication service, the green labelled are the once who have been granted communication service and the blue are those outside the restricted area. The restricted area is labelled with a red oval and the entire geographical area is labelled with a blue circle. The BTS's represent the operators' base stations. With the proposed system connected to a mobile phone, when the mobile phone wants to perform a communication service, the proposed system would check its database of eligible mobile phones allowed in the restricted. If a mobile phone is found as eligible then that mobile phones would be allowed else would be blocked. All allowed mobile phones would be connected to the operators' network through the proposed system. The signalling channel jammer can be used to attenuate the operator's control channel, which will in turn prevent a connection between the operator and the mobile phones. This will effective allow all mobile phones in the restricted area to connect to our system.

IV. RELATED WORKS

Over the past, few years' different types of mobile phone jammers have been manufactured for the commercial market. However, the evolution of the generation of communication networks has developed the interest of researchers to come up with different ways of jamming communications in a network for security reasons. In 2008, a group of students designed an intelligent jamming system, which can block only the controller channels in Global system for mobile communication (GSM) and digital cellular network (DCS) and to operate only if the jammer senses an active mobile in the restricted area [6]. In 2013, another group designed a jammer, which works at GSM 900MHz and GSM 1800MHz simultaneously and thus jams the four well-known network carriers (MTN, GLO, Etisalat and Zain) in Nigeria [7].
A group in 2002 developed a real time interception system for the GSM protocol [8]. In the paper, they exhibited three new capture attempt frameworks for security purposes. The first one (detector) powers all idle Mobile phones close-by to generate action, which can be utilized to actuate a caution of mobile phones presence. The second one screens information exchange between mobile phones and BS.
The third system syndicates the previous two systems to improve obstructive performance. These interceptors monitor GSM transactions and, if necessary, block non privileged calls. In a paper presented on new GSM/UMTS jamming, a pseudo base station was built to attempt connecting with mobile devices [9]. While the devices are trying to connect, the system will get the unique identity, such as IMSI and IMEI, and further check these identities in the repository. The system will selectively block the communication of these mobile terminals [10].
The above works can all block phone calls in a certain way. In relation to the problem statement of this paper, selective jamming approach described in [3] and [4], is a good approach in discriminating among mobile phones in a restricted area. However, these approaches do not exploit other mobile phone communication services such as data connection, SMS and emergency calls. Because of that, full communication control is not accomplished. The working of the system was implemented using the mamdani fuzzy inference system.

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V. PROPOSED SYSTEM

The system model looks at connecting mobile phones in the restricted area to the true operator's network. The system acts as a filter, which determines what service (call, SMS, data and emergency calls) a mobile is allowed to enjoy in the restricted area. Within the identity and decision making unit is a register containing the eligibility of mobile phones to the service that they can enjoy in the restricted. If a mobile phone which is connected to the system wants to enjoy a service, the system will check its identity storage to find out if that mobile phone is permitted to enjoy the requested service or not. If permitted then the mobile phone will be allowed, if not then it will be reject. When a mobile phone request for a service and is permitted, the system would connect the mobile phone to the operator's network (Figure 3).

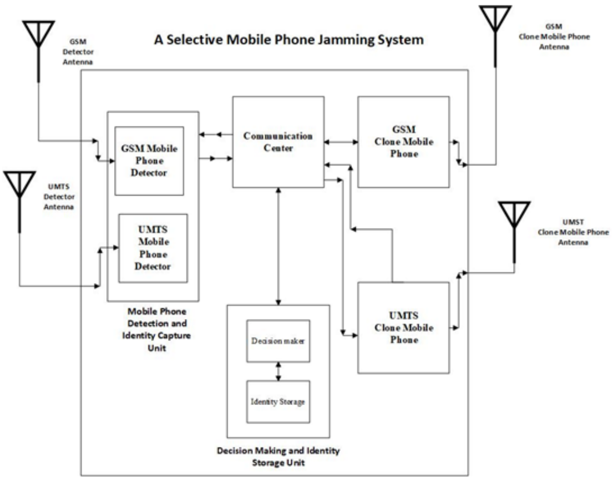

Figure 3: System model.

VI. METHODOLOGY

Fuzzy inference is the method of expressing the mapping from a given input to an output using fuzzy logic [9]. The mapping at that point gives a premise from which decisions can be made. The procedure of fuzzy inference involves : membership functions, fuzzy logic operators, and if-then rules. There are two types of fuzzy inference systems that can be applied in the Fuzzy Logic Toolbox: Mamdani-type and Sugeno-type. These two types of inference systems vary slightly in the way outputs are determined.
In this work, the mamdani-type inference characterized for the Fuzzy Logic Toolbox. The following were the steps through which the output of the inference system was computed;

1. Determining a set of fuzzy rules.
2. Fuzzifying the inputs using the input membership functions.
3. Joining the fuzzified inputs according to the fuzzy rules to establish a rule strength.
4. Verdict the consequence of the rule by joining the rule strength and the output membership function.
5. Joining the consequences to get an output distribution.
6. Defuzzifying the output distribution.

6.1 Simulation Parameters

6.1.1 Input variable:

a) Triangular membership function: Triangular function: defined by a lower limit a, an upper limit b, and a value m, where $a < m < b$.

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$$\mu A(X) = \begin{cases} 0 & x \le a \\ \dfrac{x-a}{m-a} & a < X \le m \\ \dfrac{b-x}{b-m} & m < X \le b \\ 0 & x \ge b \end{cases}$$ …..Equation 1

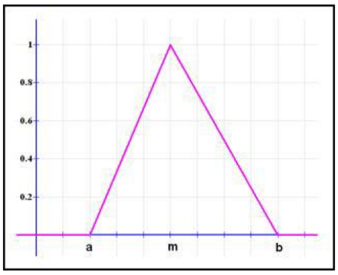

Figure 4: A graphical representation of the lower limit a, the upper limit b, and the value m.

The above labelled in Figure 4 defines a triangular membership function. A triangle has three vertex, two vertexes which can form the base of the triangle and an apex point or vertex. In Figure 4 point base a and b form the lower and upper limit of the triangular membership function. The lower and upper limits defines span base of the triangular membership function. The vertical axis defines the height of the triangle with a minimum height of zero and a maximum height of one. For in this work maximum height is preferred to attain sufficient results. The apex holds the value m of the triangular membership function.

The value m holds the value of the numbers tagged to the various IMSI number. Illustrated in Figure 5 is an example from equation (1) where a=3 and b=8. This defines the lower and upper limits respectively of the triangular membership function. The height of the triangle is 1. The value of triangular function is m=6. Therefore, m=6 can represent an IMSI number tagged number 6.

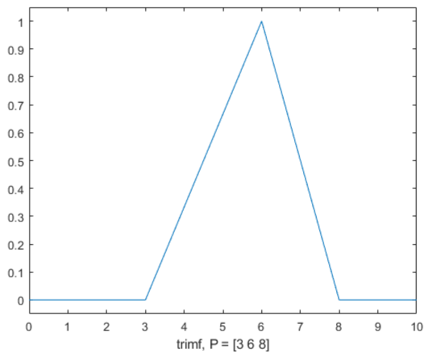

Figure 5: A graphical example of a triangular membership function with defined values.

6.1.2 Output variable:

a) **Z-shaped membership function:** The parameters a and b locate the extremes of the sloped portion of the curve is given by f(x,a,b). In this work, the Z-Shaped Membership Function is used to define a decision state

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of “not allowed” where there is a fall in the curve from one to zero on the horizontal axis. This can be seen in the example illustrated in Figure 6.

$$f(x;a,b)=\begin{cases} 1 & x \le a \\ 1-2\left(\dfrac{x-a}{b-a}\right)^2 & a \le X \le \dfrac{a+b}{2} \\ 2\left(\dfrac{x-b}{b-a}\right) & \dfrac{a+b}{2} \le X \le b \\ 0 & x \ge b \end{cases}$$ ….Equation 2

When a=3 and b=7 is inserted into the above equation (2) and x defined by a range of values 1 to 10, Figure 6 shows the results in a graphical form. The lowest point of the curve is defined as b and the highest point as a. It can be seen that curve falls from 1 to 0 which can signify a fall (not allowed) in decision making. Against the vertical axis, the curve falls from one to zero. Therefore, this membership function can be used to defined a decision making state of “not allowed” in this work.

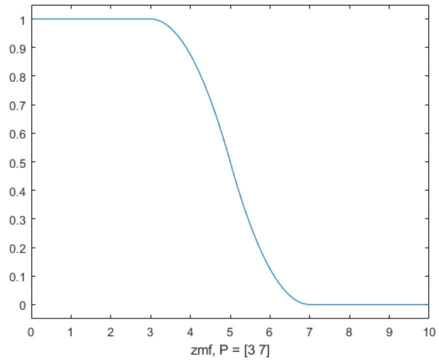

Figure 6: A graphical example of a Z-shaped membership function with defined values.

b) **S-shaped membership function:** This spline-based curve is a mapping on the vector x, and is named because of its S-shape. The parameters a and b locate the extremes of the sloped portion of the curve, as given by f(x,a,b). The S-Shaped Membership Function is used to define a decision state of “allowed” where there is a rise in the curve from zero to one on the horizontal axis. This can be seen in the example illustrated in Figure 7. When a=1 and b=8 is inserted into the above equation (3) and x defined by a range of values 1 to 10, Figure 7 shows the results in a graphical form. The lowest point of the curve is defined as a and the highest point as b. It can be seen that the curve rises from 0 to 1 which can signify a rise (allowed) in decision making. Against the vertical axis, the curve rises from zero to one. Therefore, this membership function can be used to define a decision making state of “allowed”.

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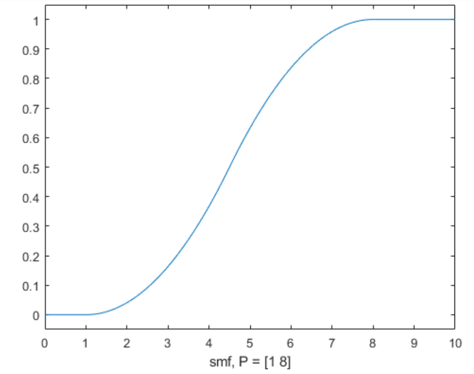

Figure 7: A graphical example of an S-shaped membership function with defined values.

VII. PSEUDO CODE

Step 1: Detect available mobile phones
Step 2: Acquire available mobile phones identities
Step 3: If a mobile phone request for service
Check registry
Step 4: If mobile phone is privileged
Grant request
Else
Decline request
Step 6: End

VIII. SIMULATION PREPARATION AND RESULTS

No	MS Identities	Call	SMS	Data	Emergency Call
1	010544123654	√	√	√	√
2	010244566523	√	√	√	√
3	010245361081	√	√	√	√
4	010544841176	√	√	√	√
5	010244371059	√	√	√	√
6	010244228290	√	√	√	√
7	020502546312	√	√	√	√
8	020502546312	√	√	√	√
9	020209396613	√	√	√	√
10	020200298244	-	√	√	√
11	030279476718	-	√	√	√
12	030572365814	-	√	√	√
13	030572365814	-	√	-	√
14	030572351256	-	√	-	√
15	060262552312	-	√	-	√
16	060266954712	-	√	-	√
17	060566302136	-	-	-	√
18	060568523691	-	-	-	√

19	070230012365	-	-	-	-
20	070231235220	-	-	-	-
21	070238100124	-	-	-	-

Table 1: Decision table of services for eligible mobile stations.

Table 1 shows the eligibility of mobile stations per the services they are allowed to enjoy. The symbol " √ " represents "allow" and "–"represent "not allowed". In the Call column, MS1 to MS9 have been checked as "allowed" and the rest "not allowed". In the SMS column, MS1 to MS16 are allowed and the rest not allowed. In the Data column, MS1 to MS12 are allowed, the rest not allowed. In the Emergency Call column, all MS are allowed.

No	MS Identities	Call	SMS	Data	Emergency Call
1	010544123658	√	√	√	√
2	010244566522	√	√	√	√
3	010245361086	√	√	√	√
4	010544841177	√	√	√	√
5	010244371059	√	√	√	√
6	010244228293	√	√	√	√
7	020502546316	-	√	√	√
8	020507563157	-	√	√	√
9	020209396619	-	√	-	√
10	020200298240	-	√	-	√
11	030572365810	-	√	-	√
12	030279201315	-	-	-	√
13	030572365810	-	-	-	√
14	030572351216	-	-	-	√
15	060262552372	-	-	-	√

Table 2: Decision table of services for eligible user equipment.

Table 2 shows the eligibility of users' equipment per the services they are allowed to enjoy. The symbol " √ " represents "allowed" and "–"represent "not allowed". In the Call column UE1 to UE6 have been checked as "allow" and the rest "not allowed". In the SMS column UE1 to UE11 are allowed and the rest not allowed. In the Data column UE1 to UE8 are allowed, the rest not allowed. In the Emergency Call column all UE are allowed.

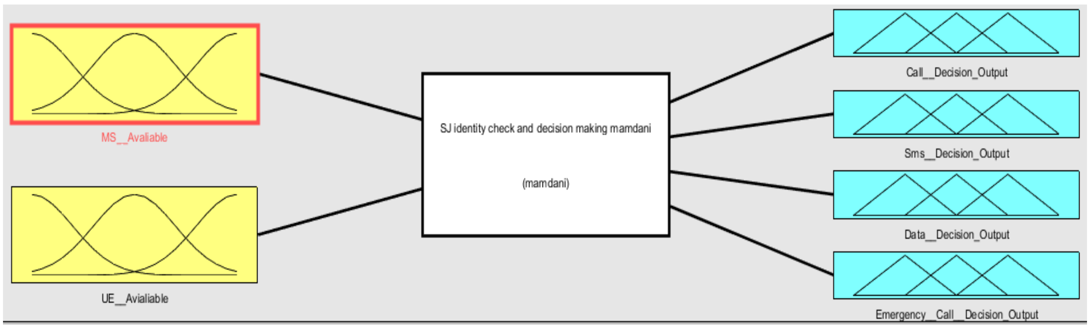

Figure 8: Mamdani-style fuzzy inference system for the selective blocking system.

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Figure 8 shows a Mamdani-style Fuzzy Inference System for the Selective Blocking System with two inputs and four outputs. In the fuzzification process, the first approach is to fuzzify the input variables and defuzzify the output variables. The process involves the transformation of the real or crisp valued variables MS Available and UE Available into the fuzzy sets. The MS Available and UE Available represent MS and UE identities from Tables 1 and 2. The conversion into fuzzy values was made possible by the triangular membership function.

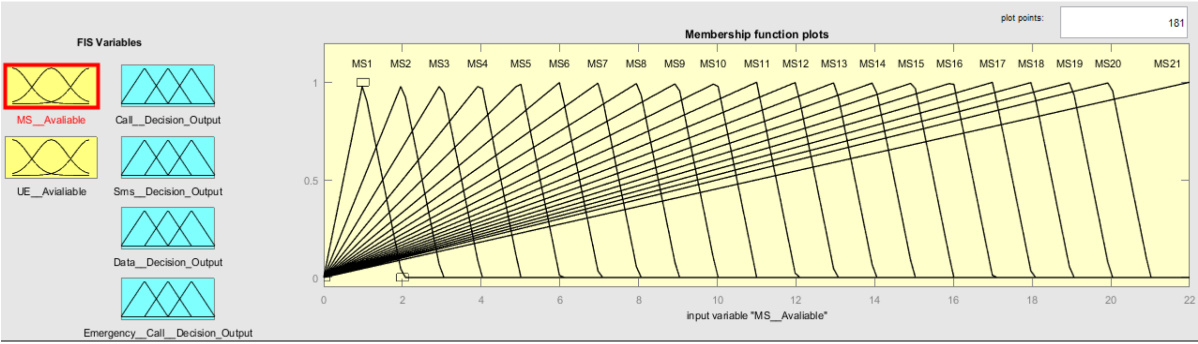

Figure 9: Triangular membership function for input variable MS available.

Figure 9 shows input converted MS identities (MS Available) into fuzzy values (triangular membership function).

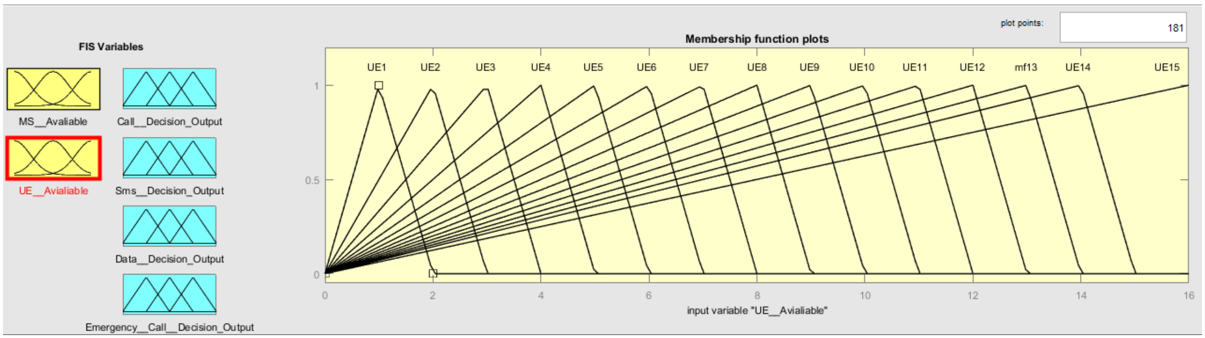

Figure 10: Triangular membership function for input variable UE available.

Figure 10 shows second input converted UE identities (MS Available) into fuzzy values (triangular membership function).

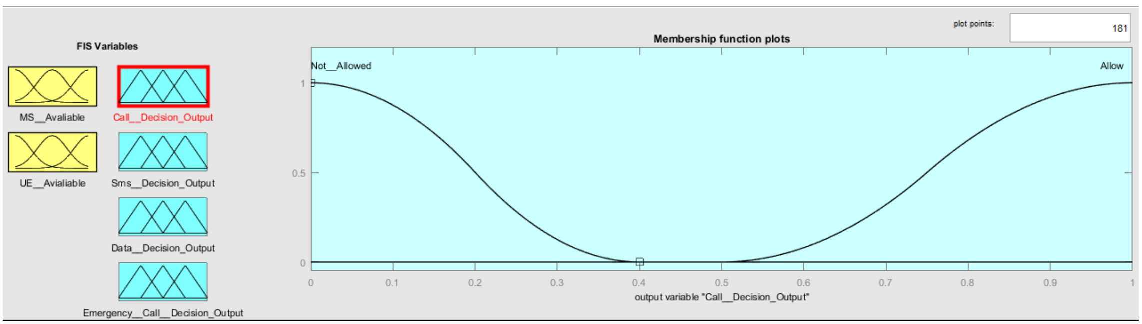

Figure 11: Z-shaped and S-shaped membership functions for output variable call decision.

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Figure 11 shows the Z-shaped and S-shaped membership functions for Output Variable Call Decision. The Z-shaped and S-shaped membership functions were used to classify the defuzzified range of values between 0 and 1 into “Allow” and “Not Allowed”. Therefore, the range of values from 0 to 0.4 is classified as “Not Allowed” and between 0.5 to 1 is classified as “Allowed”.

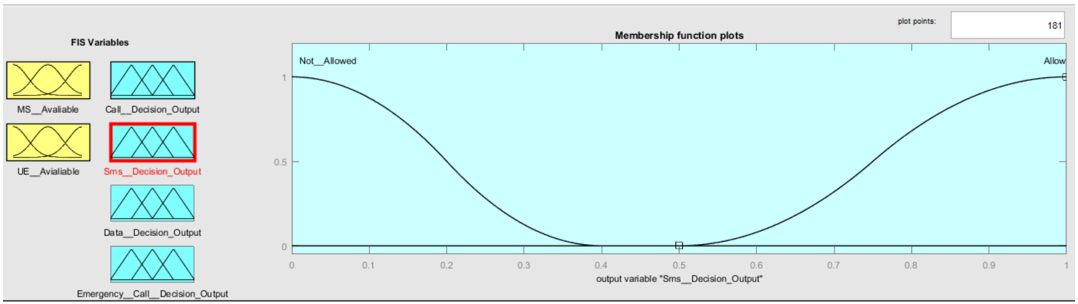

Figure 12: Z-shaped and S-shaped membership functions for output variable SMS decision.

Figure 12 shows Z-shaped and S-shaped membership functions for Output Variable SMS Decision. The Z-shaped and S-shaped membership functions were used to classify the defuzzified range of values between 0 and 1 into “Allowed” and “Not Allowed”. Therefore, the range of values from 0 to 0.4 is classified as “Not Allowed” and between 0.5 to 1 is classified as “Allowed”.

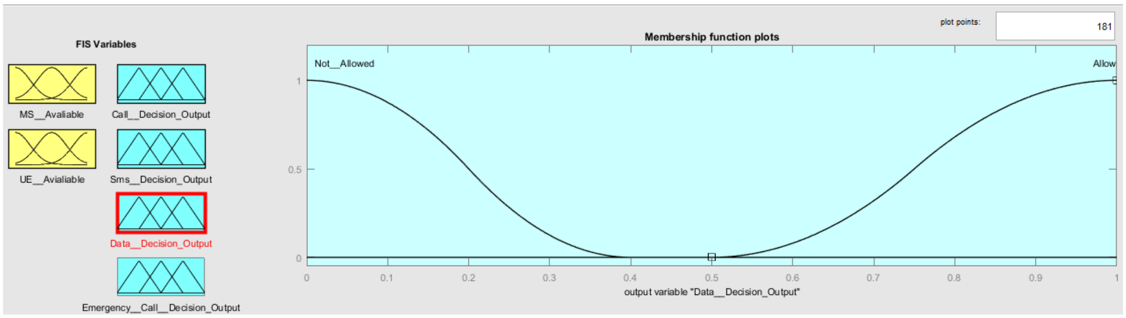

Figure 13: Z-shaped and S-shaped membership functions for output variable data decision.

Figure 13 shows Z-shaped and S-shaped membership functions for Output Variable Data Decision. The Z-shaped and S-shaped membership functions were used to classify the defuzzified range of values between 0 and 1 into “Allow” and “Not Allowed”. Therefore, the range of values from 0 to 0.4 is classified as “Not Allowed” and between 0.5 to 1 is classified as “Allowed”.

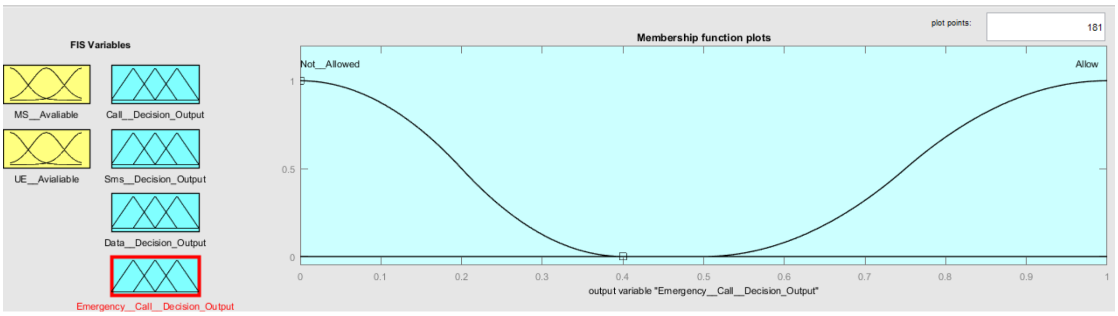

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Figure 14: Z-shaped and S-shaped membership functions for output variable emergency call decision.

Figure 14 shows Z-shaped and S-shaped membership functions for Output Variable Emergency Call Decision. The Z-shaped and S-shaped membership functions were used to classify the defuzzified range of values between 0 and 1 into “Allowed” and “Not Allowed”. Therefore, the range of values from 0 to 0.4 is classified as “Not Allowed” and between 0.5 to 1 is classified as “Allow”.

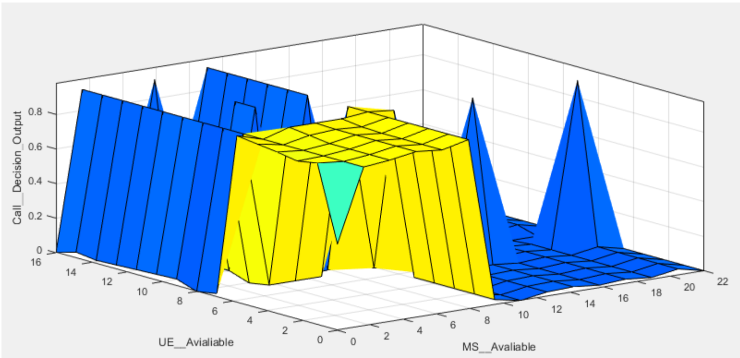

Figure 15: Surface view plot with MS and UE available as inputs and call decision as output.

Figure 15 shows the surface view plot with MS and UE available as inputs and call decision as output. The yellow section of the plot shows the MS and UE identities which are allowed to perform call and the blue section shows the MS and UE identities which are not allowed. The classification range for “allow” and “not allowed” in Figure 11 compared to this surface tells that the decision for call table in Tables 1 and 2 have been satisfied. That is MS1 to MS9 and UE1 to UE6 are allowed for calls and any other blocked. The light green section shows the starting point to the first decision point of the MS available and UE available inputs.

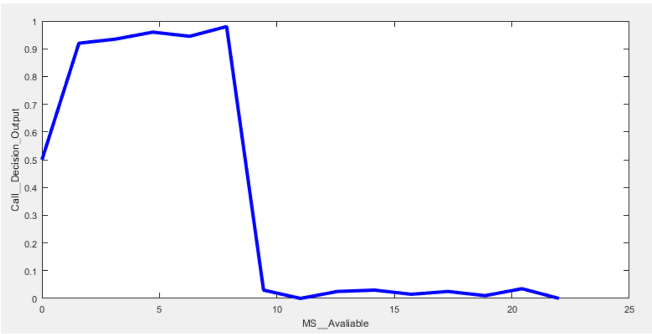

Figure 16: Output call decision verses input MS available.

Figure 16 shows the Output for call decision verses input MS Available. The classification range for “allowed” and “not allowed” in Figure 11 compared to Figure 16 shows that MS1 to MS9 have been allowed for calls as expected. MS10 to MS21 are blocked.

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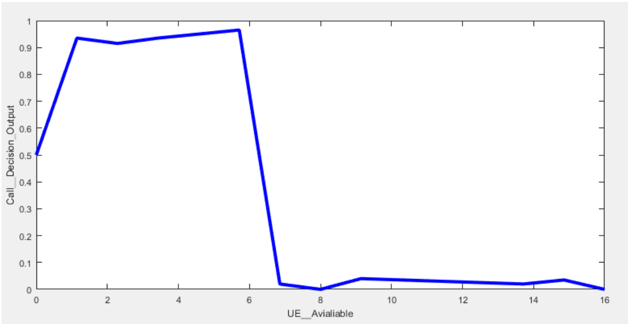

Figure 17: Output call decision verses input UE available.

Figure 17 shows the output for call decision verses input UE Available. The classification range for "allowed" and "not allowed" in Figure 11 compared to Figure 17 shows that UE1 to UE6 have been allowed for calls as expected. UE7 to UE15 are blocked.

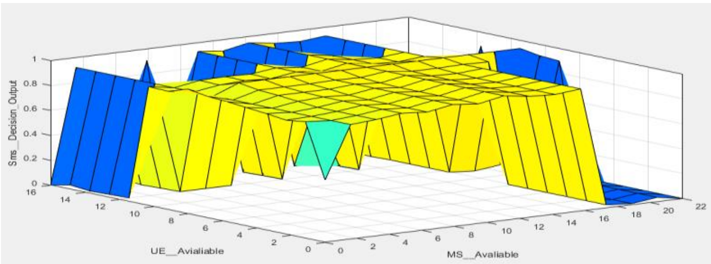

Figure 18: Surface view plot with MS and UE available as inputs and SMS decision as output.

Figure 18 shows the surface view plot with MS and UE available as inputs and SMS decision as output. The yellow section of the plot shows the MS and UE identities that are allowed to perform SMS and the blue section shows the MS and UE identities that are not allowed. The classification range for "allowed" and "not allowed" in Figure 12 compared to this surface tells that the decision for SMS in Tables 1 and 2 have been satisfied. That is, MS1 to MS16 and UE1 to UE11 are allowed for SMS and any other blocked. The light green section shows the starting point to the first decision point of the MS available and UE available inputs.

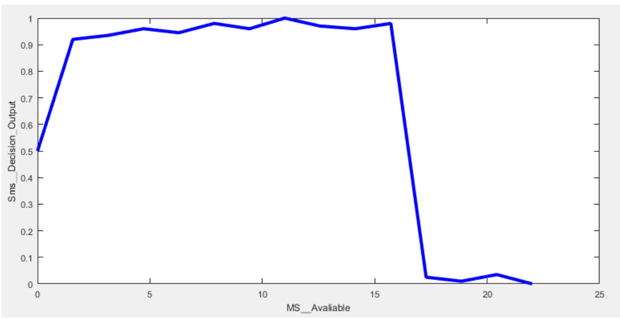

Figure 19: Output SMS decision verses input MS available.

Figure 19 shows the output for SMS decision verses input MS available. The classification range for "allowed" and "not allowed" in Figure 12 compared to Figure 19 shows that MS1 to MS16 have been allowed for SMS as expected. MS17 to MS21 are blocked.

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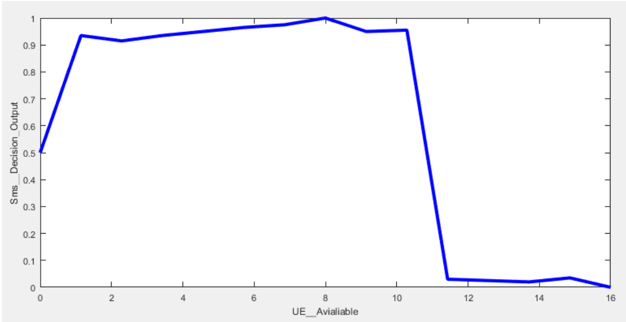

Figure 20: Output SMS decision verses input UE available.

Figure 20 shows the Output for SMS Decision verses Input UE Available. The classification range for “allow” and “not allowed” in Figure 12 compared to Figure 20 shows that UE1 to UE11 have been allowed for SMS as expected. UE12 to UE15 are blocked.

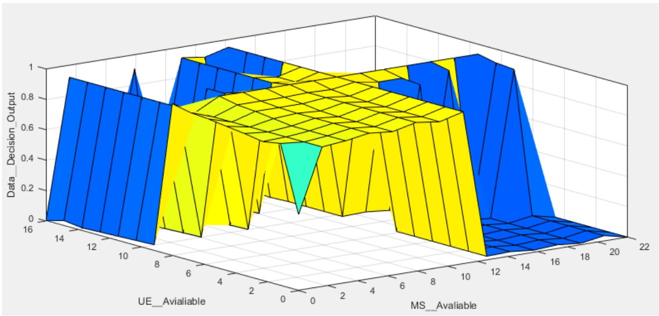

Figure 21: Surface view plot with MS and UE available as inputs and data decision as output.

Figure 21 shows the surface view plot with MS and UE available as inputs and data decision as output. The yellow section of the plot shows the MS and UE identities that are allowed to perform data connection and the blue section shows the MS and UE identities that are not allowed. The classification range for “allowed” and “not allowed” in fig. 15 compared to this surface tells that the decision for data connection in Tables 1 and 2 have been satisfied. That is MS1 to MS12 and UE1 to UE8 are allowed for data connection and any other blocked. The light green section shows the starting point to the first decision point of the MS available and UE available inputs.

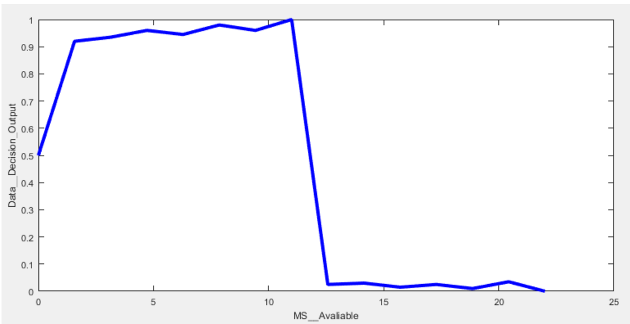

Figure 22: Output data decision verses input MS available.

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Figure 22 shows the output for data decision verses input MS Available. The classification range for "allowed" and "not allowed" in Figure 13 compared to Figure 22 shows that MS1 to MS12 have been allowed for data connection as expected. MS13 to MS21 are blocked.

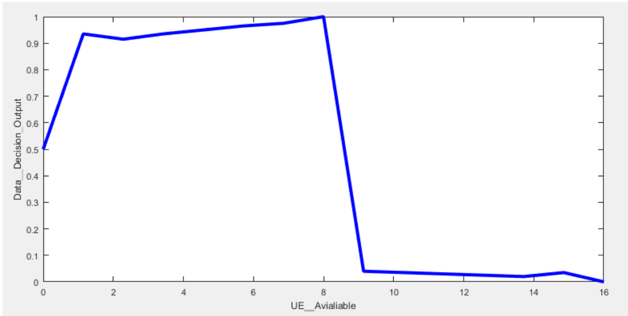

Figure 23: Output data decision verses input UE available.

Figure 23 shows the output for data decision verses input UE Available. The classification range for "allowed" and "not allowed" in Figure 13 compared to Figure 23 shows that UE1 to UE8 have been allowed for data connection as expected. UE9 to UE15 are blocked.

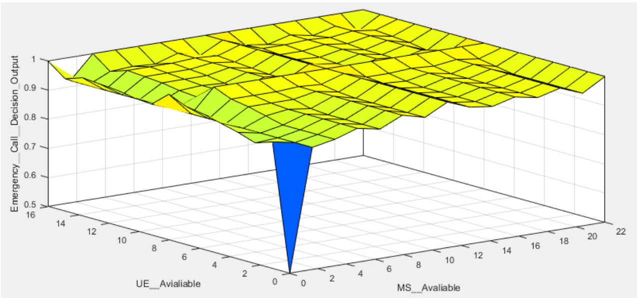

Figure 24: Surface view plot with MS and UE available as inputs and emergency call decision as output.

Figure 24 shows the surface view plot with MS and UE Available as inputs and emergency call decision as output. The yellow section of the plot shows the MS and UE identities that are allowed to perform emergency call, and the blue section shows the starting point to the first decision point of the MS Available and UE Available inputs. The classification range for "allowed" and "not allowed" in Figure 14 compared to this surface tells that the decision for emergency call in Table 1. That is all MS and all UE are allowed for emergency calls.

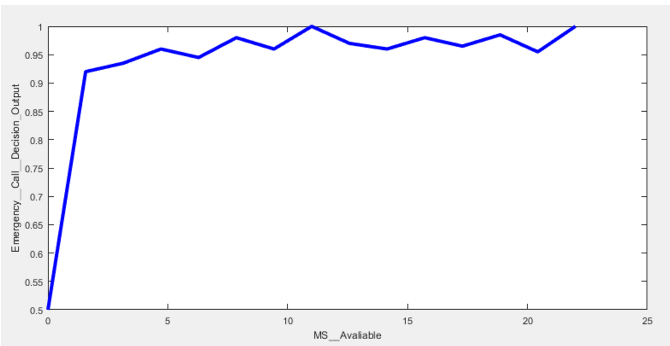

Figure 25: Output emergency call decision verses input MS available.

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Figure 25 shows the output emergency call decision verses input MS Available. The classification range for “allowed” and “not allowed” in Figure 14 compared to Figure 25 shows that all MS have been allowed for emergency calls as expected.

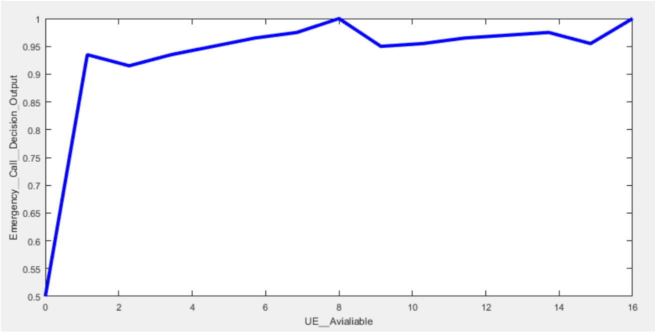

Figure 26: Output emergency call decision verses input UE available.

Figure 26 shows the emergency call decision verses input UE Available. The classification range for “allowed” and “not allowed” in Figure 14 compared to Figure 26 shows that all UE have been allowed for emergency calls as expected.

IX. CONCLUSION AND FUTURE WORK

The results shows that when the system is implemented selectively block of mobile phone communication can be accomplished in a mobile phone restricted area. Communication services can be prioritized to suit privileged users and allow all mobile phone users to emergency calls in the restricted area. Advance works on this study should develop a prototype.

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