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REPRINT
of an essay written by Mark Wood, DRCF
for The Working Group on Emergency Telecommunications:

"To what extent is the normal public cellular phone system of use in a disaster situation?"

As it happens, my 'day time job' is teaching Cellular phone systems at the Ericsson Technical Training Centre in Stockholm. I have access to very large volumes of information on this subject. However I know you don't have time to read all that so I now present a summary of my research into this question.

As I see it there are several issues:

- capacity of the system,
- subscription to the system,
- survival of the system,
- capacity.

The problem is as always, spectrum. These days it is usual for a government to allocate a frequency band for mobile telephony which is an international standard rather than a national one. In the past countries having their own national standards have come across big problems due to the small market for their mobile phones, and the relative expense of modifying mass produced models. South Africa for example have now scrapped their own allocation and cleared the GSM band of military users in order to benefit from the mass market equipment, which is cheaper, that the GSM system brings.

The GSM band has only 124 carrier channels. As one carrier carries 8 voice channels (known as traffic channels) this gives a capacity of 992 voice channels. Sadly, the situation is not as good as this because the government may allocate two or even three operators in the GSM band (for instance), so the operator has only 41 carriers to himself, a total of 320 traffic channels. The operator has several hundred thousand customers, of which about 5-10 per cent will be making or receiving calls at any one time.

This is made possible by the cellular concept.

Building a base station is rather expensive, so the operator tries to build as few as possible. This does not mean that he can do that in the traditional way, by building stations high on a hill with a big mast. The reason is..frequency re-use. In order to achieve the capacity needed, the frequencies used in the coverage area of the station (the cell) have to be re-used. How often this is done varies, but it can mean frequency re-use every 7th cell. Therefore any cell cannot use a frequency of a cell adjacent to it, or co-channel interference would be the result. If we take an allocation of 44 carriers for instance, this means only 5 carriers per cell, or only 40 voice channels at the very maximum. Normally the biggest cells at this time have a capacity of 32 traffic channels at most. This situation is about the same for all systems.

In a normal situation, about 5-10 per cent of users in a cell are making calls, this means that there can be only 600 or so actual users in my cell before it can be considered to be overloaded.

Because there is no way to increase the capacity of the cell by adding more carriers, the only response is a cell split. This means splitting the cell into three smaller ones. This is not as easy as it seems because then the co channel interference problems become complicated, and the situation can be worse not better.

The job of fixing this problem is done by highly skilled specialist called cell planners, who use sophisticated computer modelling tools to predict what will happen.

The bottom line is that the operator has to build more base stations, he has no alternative. This can take quite some time while negotiations with landlords are finalised before the builders and engineers can move in. It is slow and expensive.

This explain why cellular systems are nearly always loaded right up to their maximum capacity, which is why they are poorly suited to handling emergency overload situations such as the autobahn pile up.

However there are some things we can do about it if we find our system overloaded. When the base station finds that it is overloaded, it responds by telling the mobiles not to request service for a while, otherwise it will be fully busy listening to requests for service and have little time for setting up calls.

However on command from the Base Station Controller, the base station can command only MOBILES FROM EMERGENCY SERVICES to request access. Therefore emergency services would have service as priority over normal users in that cell. As far as I know, this is rarely done. The result would be a large loss of revenue for the operator not to mention angry customers who did not get service because they did not have the special numbers. It is a complicated issue which no one likes to talk about and perhaps it is one that WGET would like to take up in the future with the operators. Of course our mobile would have to have the right number for this to work.

Another strategy is, where it is possible, to try to get the phone to change network to that of an other operator. This is done by menu on the phone. Perhaps the other operator's base stations are less overloaded, anyway it is worth a try.

Overload problems can be made worse by some users such as journalists who once having seized a circuit, hold it all day if they have to keep the link to the studio. This is expensive but effective. However it will mean that traffic channel will not be released for other users for as long as it is held. Particularly vulnerable are rural base stations, which though having the same capacity as city ones, have much larger areas to cover. It could mean that a gaggle of journalists 10 or 20 KM away are saturating the whole cell and effectively reducing the capacity of the whole cell. In the city this is less so because the mobile phone is programmed to scan around for a working cell if the one it has tried is saturated and it is likely that one will be in range.

As a comparison, the maximum area of a cell is about 35KM radius from the base station. Remember only 600 users is considered to be a good figure for that cell! By contrast the city cell may be only 1KM radius, with another base station 2KM away. In an urban environment a drive away from the journalists of 1KM may fix the problem, but in a rural environment you may have a long drive to escape the congested cell. An external antenna may help your mobile to see another cell which is less congested.

Each operator has a different business strategy and he will tell his cell planners accordingly. This information is highly commercially sensitive, as knowledge of it can give a competitor an advantage. An operator will never reveal his cell plan to anyone so it is therefore near impossible to say what the service is like in any place in an overloaded situation. Not only that but the work of cell planning is continuous and highly dynamic, so a bad spot in one month may be the best the next month as either the capacity of the base stations is boosted, or new base stations are built.

Subscriptions:

When you switch your mobile phone on, it will try to scan around the band looking for 'broadcast channels' from the base stations in range. These give details about the network that is in range and the rules about using it. The mobile will then try to 'log on' to that network. The base station will set up a dedicated data channel from the mobile phone to the Base Station Controller, which will then decide if it will grant you service or not. This is where your problems start!

If you bought your subscription to this region or area, then the BSC will know you and after checking if you have paid your bill, and that your phone is not stolen etc. etc., will register you in its home location register. Now you can make calls and receive calls from land line users. This is when your green light on your phone comes on so reassuringly.

If you are not from this area, things are different. The BSC will inform a system called the Mobile Services switching Centre that you are a visitor to this system. This will try to contact your home base computer in the region where you are registered. It will ask your home base if you are allowed service and will only give service is you are. For this to happen, there has to be a 'roaming agreement' between the system you are now using and your operator at home. In fact most of the GSM operators in the world have such agreements with each other, but some of the cheaper operators do not (that is why they are cheaper). You should check when you subscribe, exactly who your operator has agreements with. naturally this will not work at all if the communications lines to your country of origin are down.

All of this assumes that the system you are using has such an international roaming system. In fact few systems other than GSM do so. What is more, many countries such as the USA do not have GSM and have decided never to have it but install incompatible systems of their own. This was the case of Japan for example.

This brings me to the next problem. If for some reason the phone you have bought will not work, then you will need to purchase a local model phone, and have a valid subscription for it. This will be very hard because if there are shops open, the local people will have beaten you to any remaining phones. If you have bought a phone, validation is done electronically and if systems are down it may take a few days to get you a subscription.

Survival:

Even if the base station itself survives the disaster intact, it cannot work alone and other services must also be working. The most serious problem is power. A typical base station has battery back up for max. 8 hours without mains power. If the mains is off in the area for longer than that, the operator can bring in a generator sometimes. Usually there is only one mobile generator per BSC, that is for several hundred base stations. If there is widespread disruption of the mains power, then he can't sustain them all. A typical base station consumes about 6KW of power, plus air conditioning systems.

The base station also need a working digital link to its parent base station controller (BSC). In most cases where the base station has survived a disaster, it is equipped with a microwave link directly to the BSC. But this is not always so. Often there is a landline to the local telephone exchange, followed by a long trip through the PTT's barer network over many multiplexors and repeaters before making the BSC. If any of that is not working.., well sorry.

There is also the BSC. This has diesel back up and is unlikely to be affected by mains failure. However the links to the outside are usually by landline, and the MSC may be some distance away. If the MSC is cut off, then calls between mobiles are possible but calls to landline phones are not.

Mobile operators are aware of these problems and so there are emergency recovery plans being drawn up. These feature 'cell on wheels' and even 'switch on wheels' solutions. However the biggest problems may in the end be with transmission and power to the site, and in any case it could take days to set up such a system.

Despite all of this, experience shows that the Cellular systems are quite good at surviving disasters and providing service as long as they are not overloaded.

Furthermore the overloading situation is worse in situations where phones are in private use rather than in business use. Business tends to be suspended in the acute phase of an emergency, whereas private matters become more acute. In the future more private users than business users will be on line, so the overloading problem will be more severe.

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