Chapter 7. Results

7.1 Results: GSM in the disaster area

The architecture proposed has the GSM core network in the disaster area and it is given again in Fig. 7.1. For each interface the communications protocol is depicted along with the throughput.

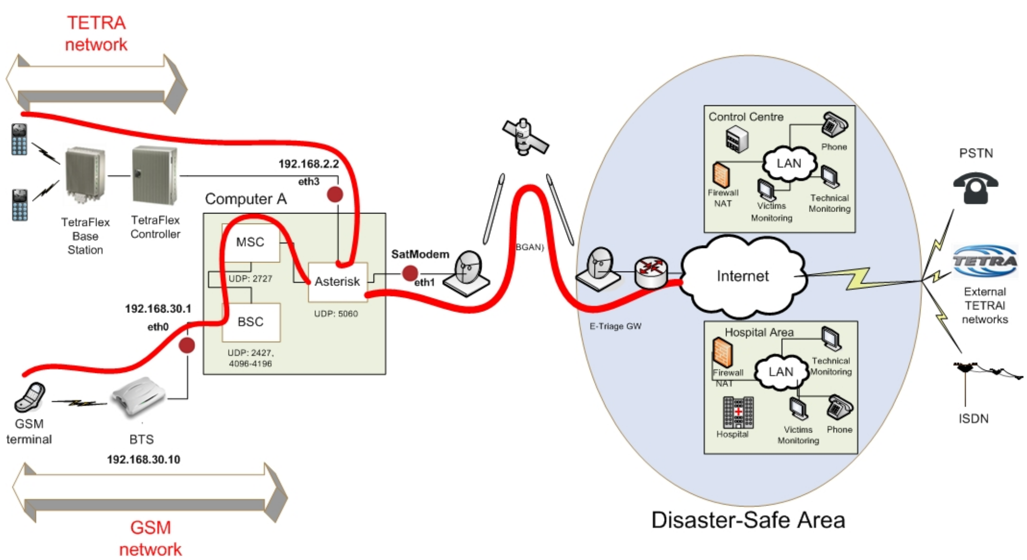

Figure 7.1. Architecture to be tested.

7.1.1 TETRA - commercial GSM

7.1.1.1 Communication protocol

The data communication protocol is given here:

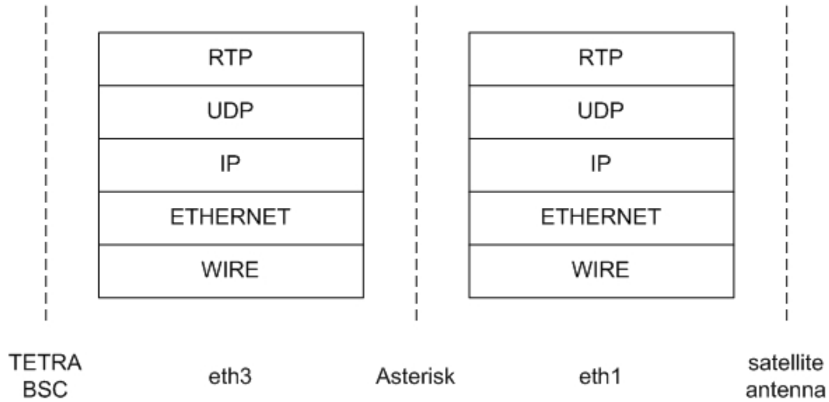

Figure 7.2. Data communication protocol.

7.1.1.2 Signalling communication protocol and signalling flow graph

The signalling communication protocol:

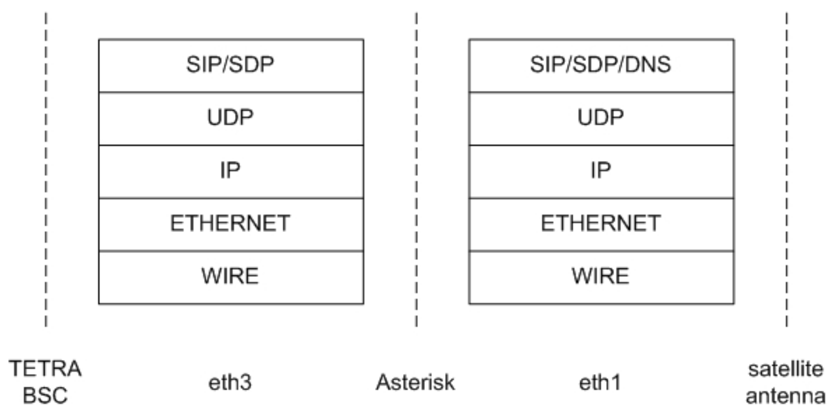

Figure 7.3. Signalling communication protocol.

And the signalling flow graphs for the TETRA interface (eth3) and the satellite interface (eth1).

eth3

```
|Time     | 192.168.2.1              192.168.2.2 |

|0,000    |         Request: INVITE sip          |SIP/SDP: Request: INVITE sip:015204079302@
```

```
   192.168.2.2, with session description
|         |(5060)   ------------------>  (5060)   |
|0,001    |         Status: 401 Unautho           |SIP: Status: 401 Unauthorized
|         |(5060)   <------------------  (5060)   |
|0,010    |         Request: ACK sip:01           |SIP: Request: ACK sip:015204079302@192.168.2.2
|         |(5060)   ------------------>  (5060)   |
|0,010    |         Request: INVITE sip           |SIP/SDP: Request: INVITE sip:015204079302@
 192.168.2.2, with session description
|         |(5060)   ------------------>  (5060)   |
|0,011    |         Status: 100 Trying            |SIP: Status: 100 Trying
|         |(5060)   <------------------  (5060)   |
|0,014    |         Status: 180 Ringing           |SIP: Status: 180 Ringing
|         |(5060)   <------------------  (5060)   |
|9,682    |         Status: 180 Ringing           |SIP: Status: 180 Ringing
|         |(5060)   <------------------  (5060)   |
|12,553   |         Status: 200 OK, wit           |SIP/SDP: Status: 200 OK, with session description
|         |(5060)   <------------------  (5060)   |
|12,560   |         Request: ACK sip:01           |SIP: Request: ACK sip:015204079302@192.168.2.2
|         |(5060)   ------------------>  (5060)   |
|14,998   |         Request: REGISTER s           |SIP: Request: REGISTER sip:192.168.2.2
|         |(5060)   ------------------>  (5060)   |
|14,999   |         Status: 401 Unautho           |SIP: Status: 401 Unauthorized    (0 bindings)
|         |(5060)   <------------------  (5060)   |
|15,009   |         Request: REGISTER s           |SIP: Request: REGISTER sip:192.168.2.2
|         |(5060)   ------------------>  (5060)   |
|15,022   |         Request: OPTIONS si           |SIP: Request: OPTIONS sip:tetra1@192.168.2.1:5060
|         |(5060)   <------------------  (5060)   |
|15,023   |         Status: 200 OK    (           |SIP: Status: 200 OK    (1 bindings)
|         |(5060)   <------------------  (5060)   |
|15,023   |         Status: 501 Not Imp           |SIP: Status: 501 Not Implemented
|         |(5060)   ------------------>  (5060)   |
|30,308   |         Request: BYE sip:01           |SIP: Request: BYE sip:015204079302@192.168.2.2
|         |(5060)   ------------------>  (5060)   |
|30,309   |         Status: 200 OK                |SIP: Status: 200 OK
|         |(5060)   <------------------  (5060)   |
```

eth1

```
|Time     | 192.168.0.6              217.10.79.9 |
|         |                          |
```

```
|0,000    |         Request: REGISTER s         |SIP: Request: REGISTER sip:sipgate.de
|         |(5060)   ------------------>  (5060)   |
|2,031    |         Status: 401 Unautho         |SIP: Status: 401 Unauthorized    (0 bindings)
|         |(5060)   <------------------  (5060)   |
|4,000    |         Request: REGISTER s         |SIP: Request: REGISTER sip:sipgate.de
|         |(5060)   ------------------>  (5060)   |
|5,951    |         Status: 401 Unautho         |SIP: Status: 401 Unauthorized    (0 bindings)
|         |(5060)   <------------------  (5060)   |
|6,454    |         Request: INVITE sip         |SIP/SDP: Request: INVITE sip:015204079302@
 sipgate.de, with session description
|         |(5060)   ------------------>  (5060)   |
|7,551    |         Status: 407 Proxy A         |SIP: Status: 407 Proxy Authentication Required
|         |(5060)   <------------------  (5060)   |
|7,552    |         Request: ACK sip:01         |SIP: Request: ACK sip:015204079302@sipgate.de
|         |(5060)   ------------------>  (5060)   |
|7,553    |         Request: INVITE sip         |SIP/SDP: Request: INVITE sip:015204079302@
 sipgate.de, with session description
|         |(5060)   ------------------>  (5060)   |
|8,000    |         Request: REGISTER s         |SIP: Request: REGISTER sip:sipgate.de
|         |(5060)   ------------------>  (5060)   |
|8,830    |         Request: OPTIONS si         |SIP: Request: OPTIONS sip:sipgate.de
|         |(5060)   ------------------>  (5060)   |
|9,232    |         Status: 100 Giving          |SIP: Status: 100 Giving a try
|         |(5060)   <------------------  (5060)   |
|9,472    |         Status: 401 Unautho         |SIP: Status: 401 Unauthorized    (0 bindings)
|         |(5060)   <------------------  (5060)   |
|9,801    |         Status: 200 OK              |SIP: Status: 200 OK
|         |(5060)   <------------------  (5060)   |
|10,671   |         Request: REGISTER s         |SIP: Request: REGISTER sip:sipgate.de
|         |(5060)   ------------------>  (5060)   |
|12,512   |         Status: 401 Unautho         |SIP: Status: 401 Unauthorized    (0 bindings)
|         |(5060)   <------------------  (5060)   |
|16,122   |         Status: 180 Ringing         |SIP: Status: 180 Ringing
|         |(5060)   <------------------  (5060)   |
|16,142   |         Status: 183 Session         |SIP/SDP: Status: 183 Session Progress, with
 session description
|         |(5060)   <------------------  (5060)   |
|17,672   |         Request: REGISTER s         |SIP: Request: REGISTER sip:sipgate.de
|         |(5060)   ------------------>  (5060)   |
|18,992   |         Status: 200 OK, wit         |SIP/SDP: Status: 200 OK, with session description
|         |(5060)   <------------------  (5060)   |
|18,993   |         Request: ACK sip:24         |SIP: Request: ACK sip:24004915204079302@217.10.69.6
```

```
|         |(5060)   ------------------>  (5060)   |
|19,871   |         Status: 401 Unautho           |SIP: Status: 401 Unauthorized    (0 bindings)
|         |(5060)   <------------------  (5060)   |
|20,042   |         Status: 200 OK, wit           |SIP/SDP: Status: 200 OK, with session description
|         |(5060)   <------------------  (5060)   |
|21,671   |         Request: REGISTER s           |SIP: Request: REGISTER sip:sipgate.de
|         |(5060)   ------------------>  (5060)   |
|22,671   |         Status: 401 Unautho           |SIP: Status: 401 Unauthorized    (0 bindings)
|         |(5060)   <------------------  (5060)   |
|25,671   |         Request: REGISTER s           |SIP: Request: REGISTER sip:sipgate.de
|         |(5060)   ------------------>  (5060)   |
|27,313   |         Status: 401 Unautho           |SIP: Status: 401 Unauthorized    (0 bindings)
|         |(5060)   <------------------  (5060)   |
|29,671   |         Request: REGISTER s           |SIP: Request: REGISTER sip:sipgate.de
|         |(5060)   ------------------>  (5060)   |
|30,833   |         Status: 401 Unautho           |SIP: Status: 401 Unauthorized    (0 bindings)
|         |(5060)   <------------------  (5060)   |
|32,435   |         Request: REGISTER s           |SIP: Request: REGISTER sip:sipgate.de
|         |(5060)   ------------------>  (5060)   |
|33,393   |         Status: 401 Unautho           |SIP: Status: 401 Unauthorized    (0 bindings)
|         |(5060)   <------------------  (5060)   |
|36,769   |         Request: BYE sip:24           |SIP: Request: BYE sip:24004915204079302@217.10.69.6
|         |(5060)   ------------------>  (5060)   |
|37,951   |         Status: 200 OK                |SIP: Status: 200 OK
|         |(5060)   <------------------  (5060)   |
|39,434   |         Request: REGISTER s           |SIP: Request: REGISTER sip:sipgate.de
|         |(5060)   ------------------>  (5060)   |
|41,472   |         Status: 401 Unautho           |SIP: Status: 401 Unauthorized    (0 bindings)
|         |(5060)   <------------------  (5060)   |
```

This flow graph has been included to get an idea of the actual signalling process that takes place within the interfaces. The flow graphs for the rest of the scenarios will be omitted as they don't provide new information.

7.1.1.3 Throughput

The throughput of the satellite link is given here too. Just out of curiosity, the throughput of the link between the TETRA BSC and Asterisk link is given for this test to show what was already said in chapter 5 when describing the TETRA equipment; the DAMM BSC releases a rate of 64 kbps.

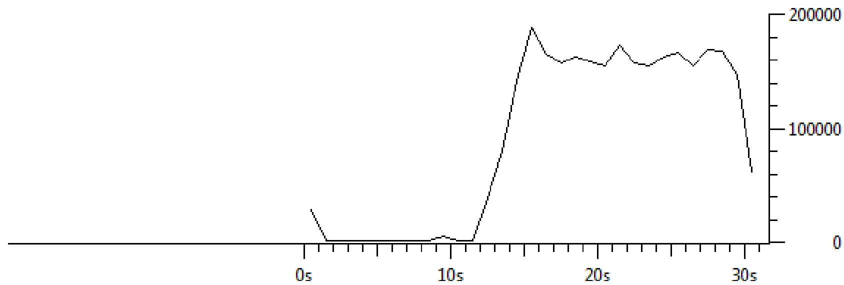

Figure 7.4. Throughput in the eth3 interface.

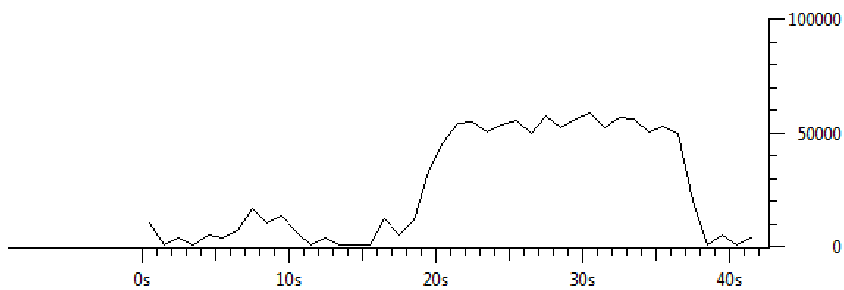

Figure 7.5. Throughput of the satellite link (eth1).

7.1.2 TETRA - land line

7.1.2.1 Communication protocol

For the case of a call from a TETRA terminal to a regular land line the stack protocol is depicted in Fig. 7.6.

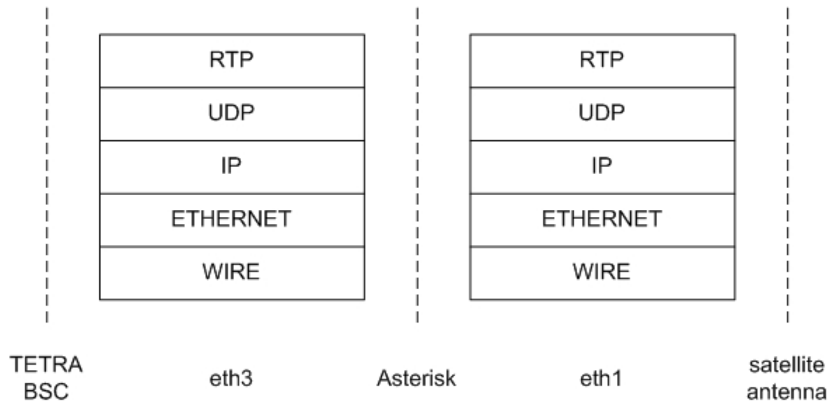

Figure 7.6. Data communication protocol.

7.1.2.2 Signalling communication protocol

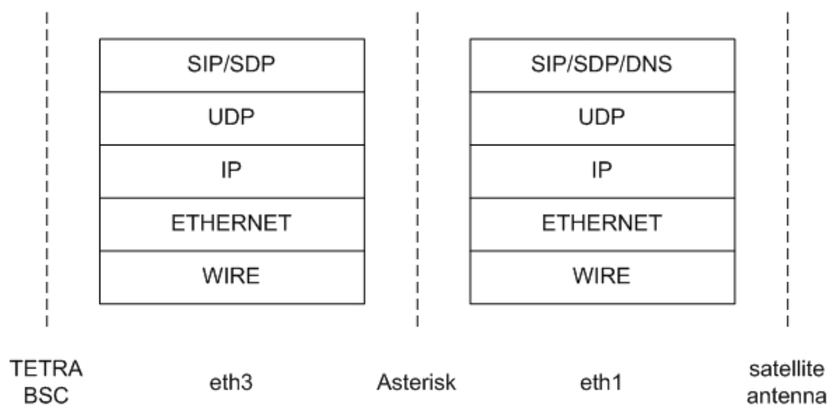

Figure 7.7. Signalling communication protocol.

7.1.2.3 Throughput

The throughput of the satellite link is given here too.

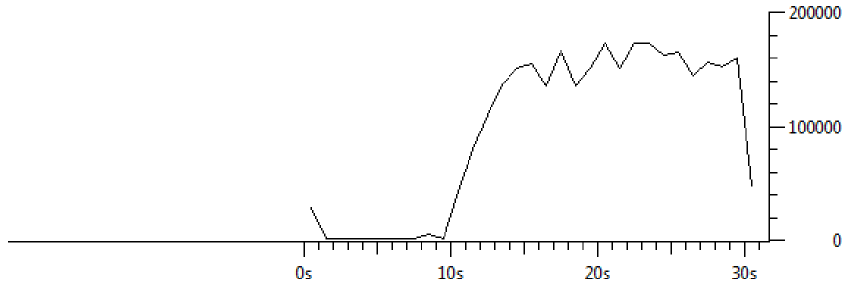

Figure 7.8. Throughput in the eth3 interface.

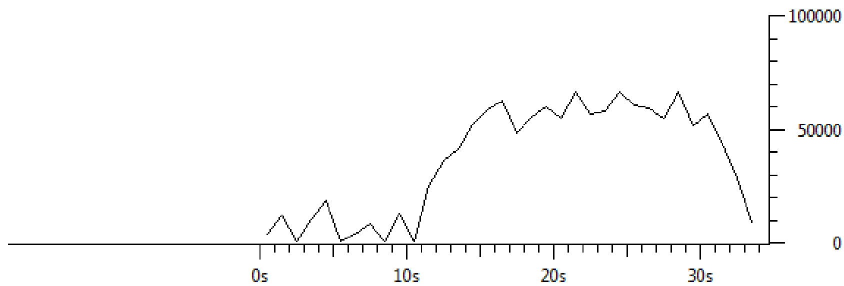

Figure 7.9. Throughput of the satellite link, eth1.

7.1.3 GSM - commercial GSM telephone

7.1.3.1 Communication protocol

Again, the data stack protocol is given here:

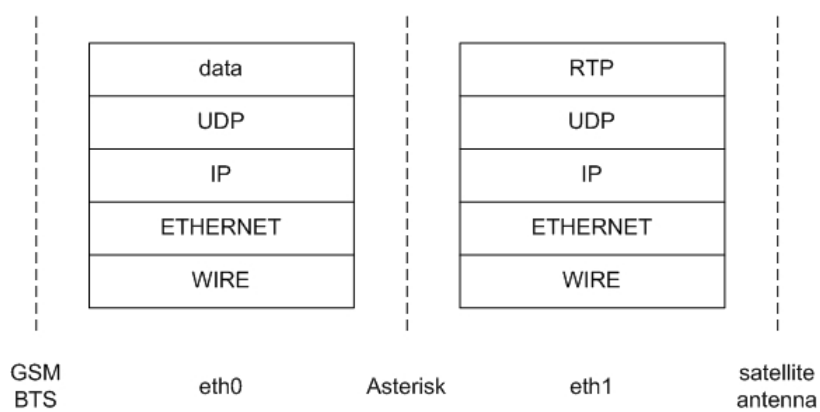

Figure 7.10. Data communication protocol.

7.1.2.2 Signalling communication protocol

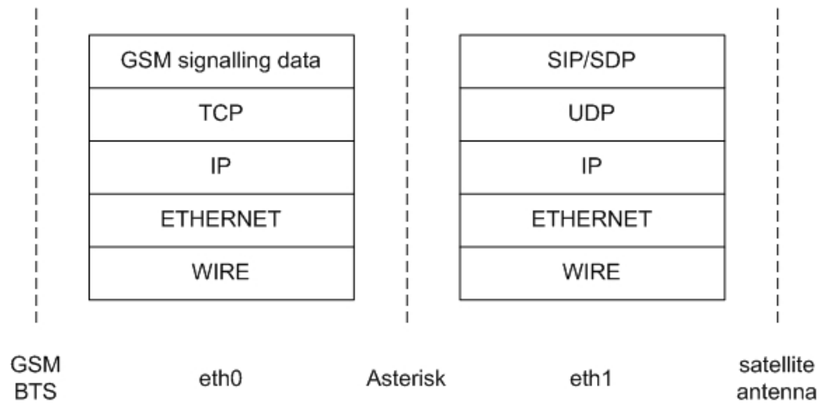

Figure 7.11. Signalling communication protocol.

7.1.2.3 Throughput

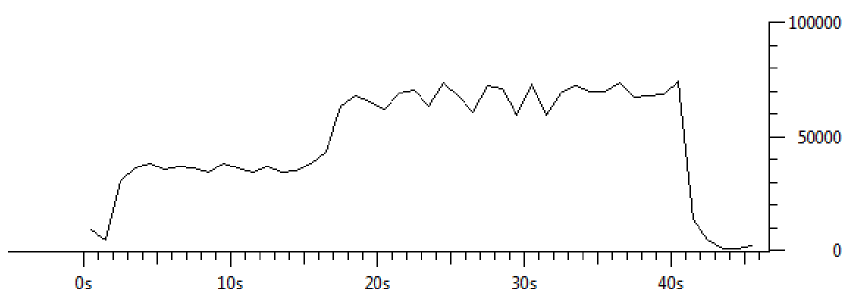

Figure 7.12. Throughput in the eth0 interface.

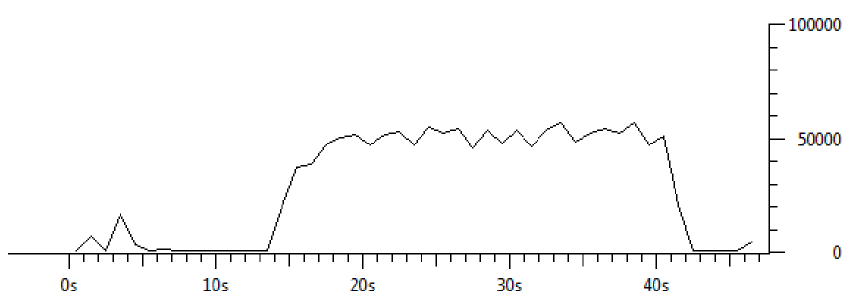

Figure 7.13. Throughput of the satellite link, eth1 interface.

7.1.4 GSM - land line

7.1.4.1 Communication protocol

The communication protocol for a GSM to land line call is depicted in Fig. 7.14.

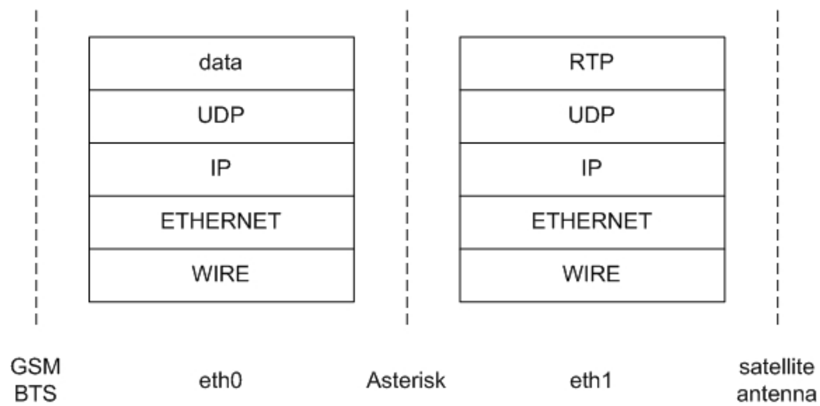

Figure 7.14. Data communication protocol.

7.1.4.2 Signalling communication protocol

The signalling protocol:

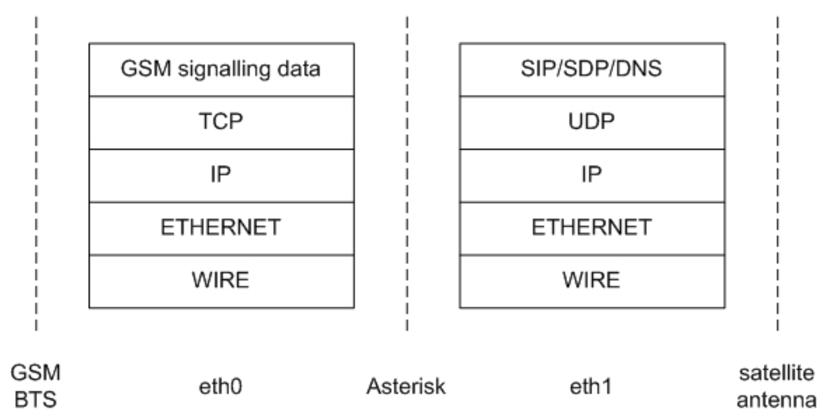

Figure 7.15. Signalling communication protocol.

7.1.4.3 Throughput

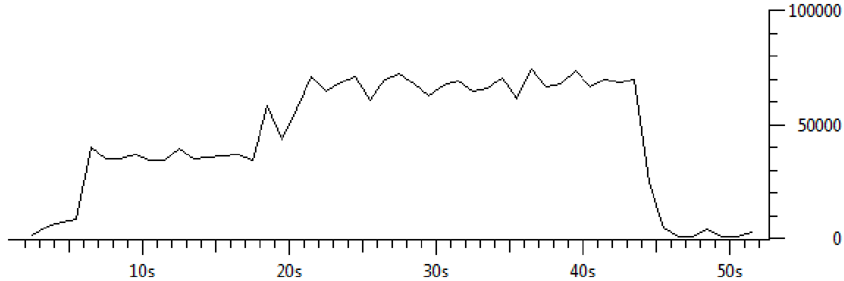

Figure 7.16. Throughput in the eth0 interface.

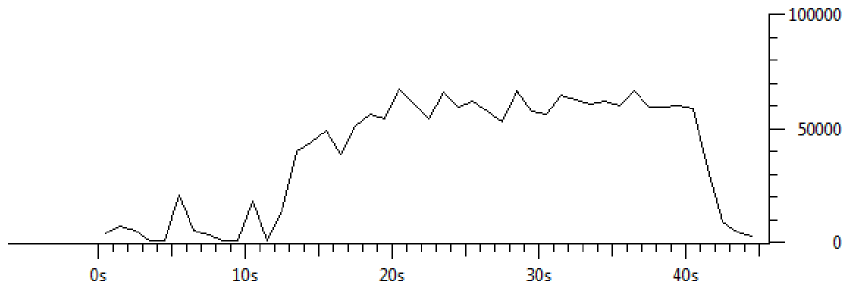

Figure 7.17. Throughput of the satellite link, eth1.

7.2 Results: GSM in the safe-disaster area

As for the case where the GSM core network is located within the safe-disaster area, explained in chapter 6, the scenario that has been tested is again depicted in Fig. 7.18.

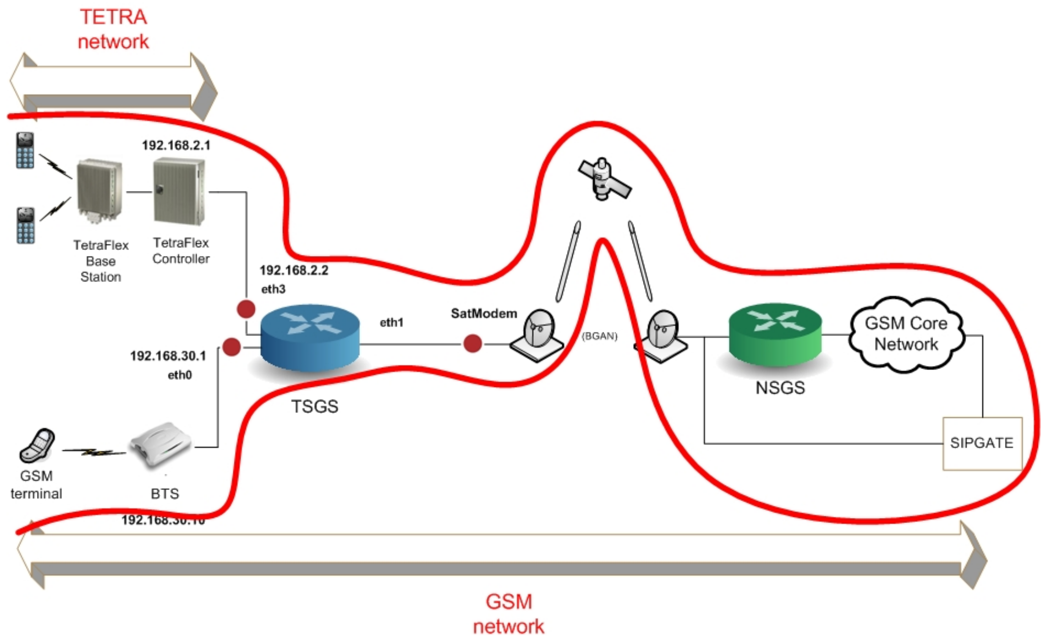

Figure 7.8. Architecture to be tested with the GSM core network in the safe-disaster area.

7.2.1 GSM - land line

7.2.1.1 Communication protocol

For a GSM to land line call the stack protocol can be seen in Fig. 7.19.

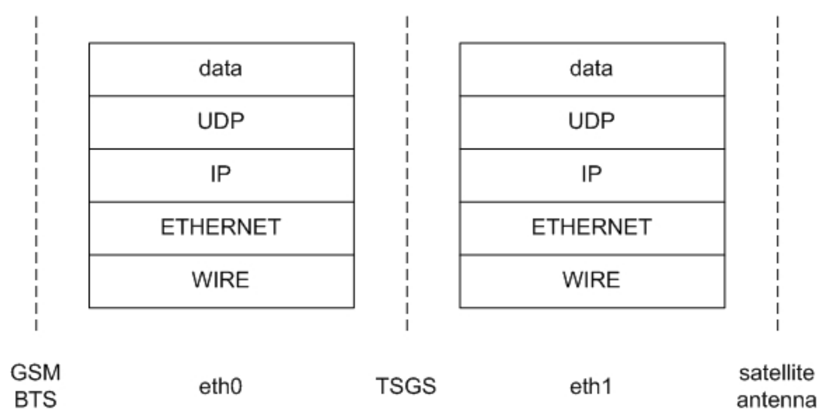

Figure 7.19. Data communication protocol.

7.2.1.2 Signalling communication protocol

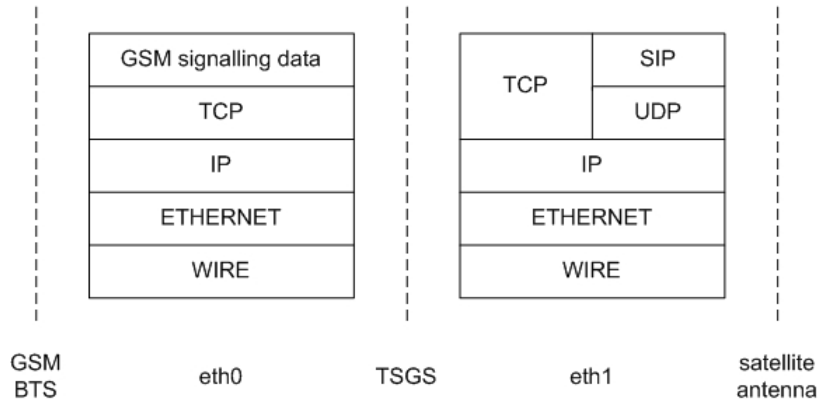

Figure 7.20. Signalling communication protocol.

7.2.1.3 Throughput

The throughput for both interfaces is given in Figs. 7.21 and 7.22.

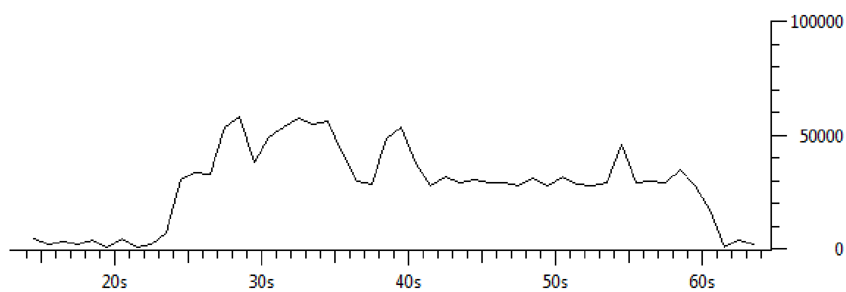

Figure 7.21. Throughput in the eth0 interface.

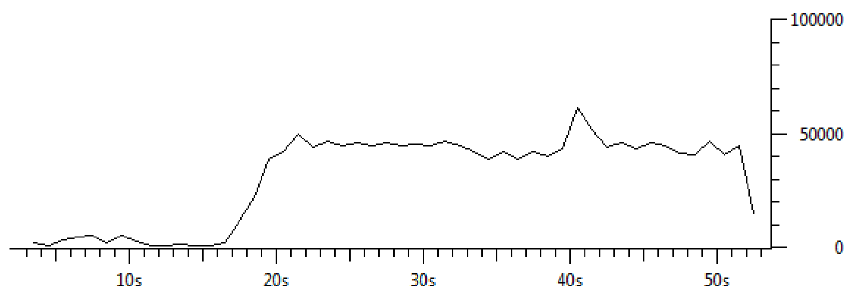

Figure 7.22. Throughput of the satellite link, eth1.

7.2.2 TETRA - land line

The last two tests correspond to TETRA calls. This one shows the TETRA to land line parameters.

7.2.2.1 Communication protocol

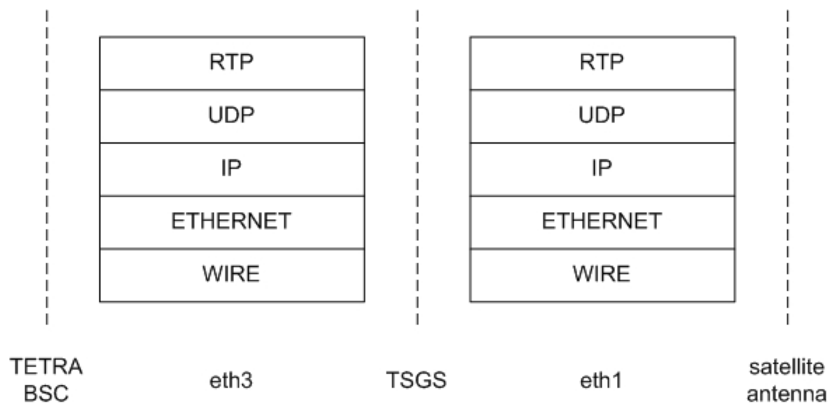

Figure 7.23. Data communication protocol.

7.2.2.2 Signalling communication protocol

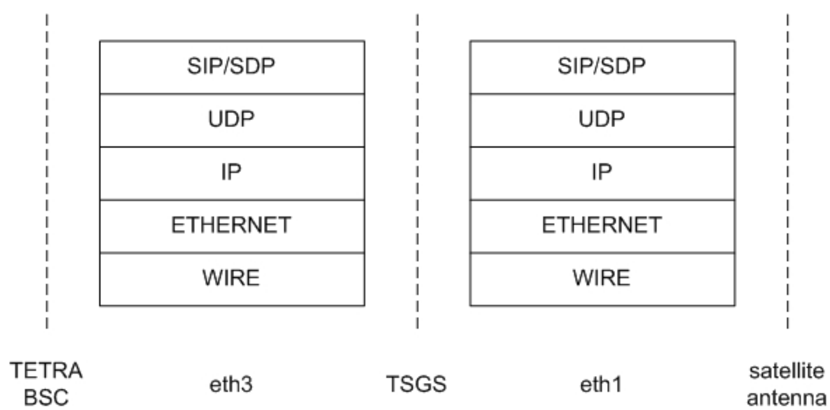

Figure 7.24. Signalling communication protocol.

7.2.2.3 Throughput

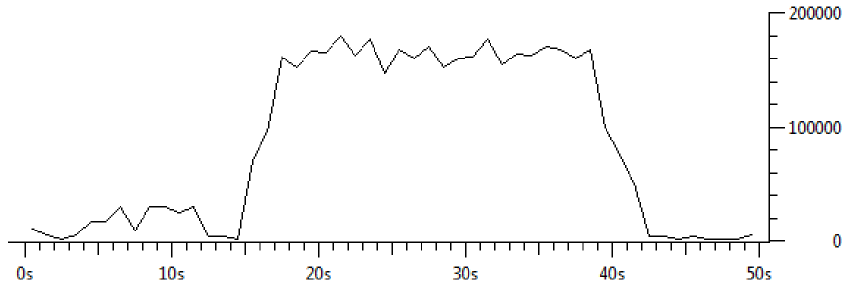

Figure 7.25. Throughput in the eth3 interface.

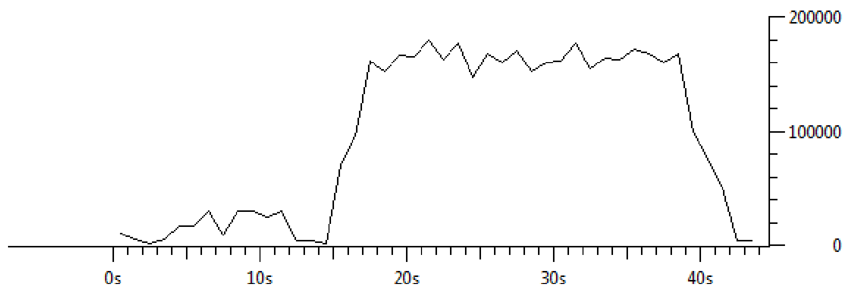

Figure 7.26. Throughput of the satellite link, eth1.

7.2.3 TETRA - commercial GSM

The last test goes about a TETRA to external GSM call.

7.2.3.1 Communication protocol

The data communication protocol is depicted in Fig. 7.27.

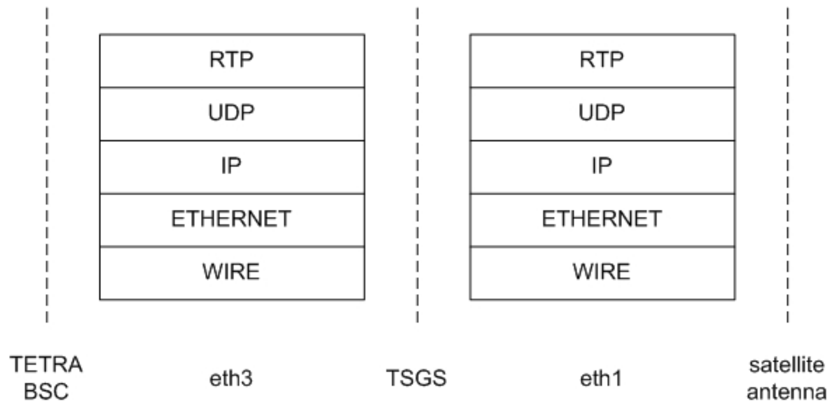

Figure 7.27. Data communication protocol.

7.2.3.2 Signalling communication protocol

As for the signalling stack, it is depicted in Fig. 7.28.

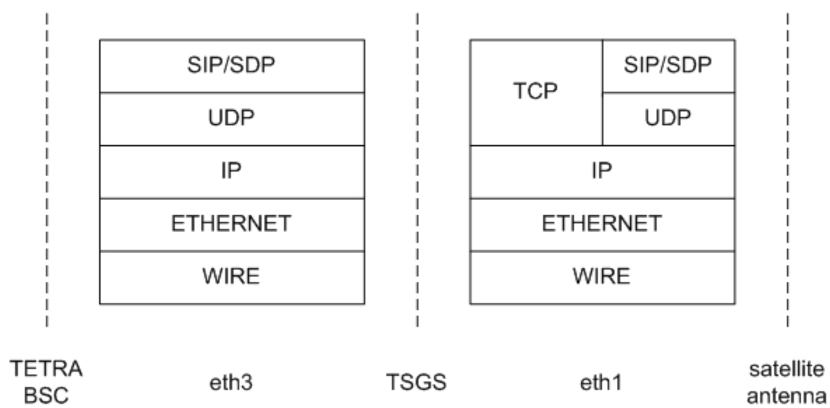

Figure 7.28. Signalling communication protocol.

7.2.3.3 Throughput

Finally, the throughput is given in Figs. 7.29 and 7.30.

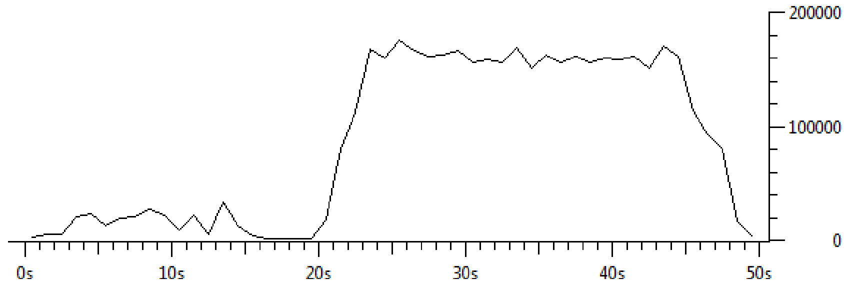

Figure 7.29. Throughput in the eth0 interface.

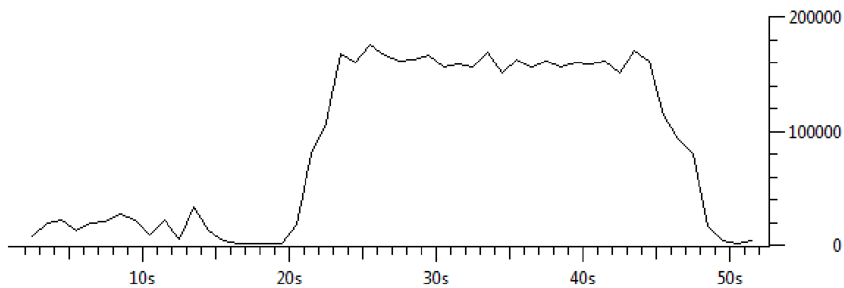

Figure 7.30. Throughput of the satellite link, eth1.

7.3 Conclusions

The results certainly show the feasibility of the integration of TETRA and GSM by means of a software process. In this sense, Asterisk plays a vital role since it allows the configuration in a simple, effective way. The integration of other technologies involved in the e-Triage Project, such as WLAN, are also configurable via Asterisk. In addition, it's been shown how the coexistence of both technologies is configurable via some configuration files and those have been given in Appendix C. Possible changes can be easily updated this way.

Delays also have play an important role, and thus have been analysed. It turns out that they are approximately equal for both TETRA and GSM. Paying attention to what was explained in chapter 3 as one of the most important advantages of TETRA over GSM, the shorter delays in the case of TETRA, this might seem surprising. However, getting back to figures 7.1 and 7.18, it can be seen that since all data is actually flowing through the Internet and a SIP server, the delays are conditional on IP delays. In other words, since the output of the TETRA equipment is directly IP-based instead of the ISI-based packets, and because all information is being sent via the Internet and a SIP provider, the delays for TETRA and GSM are virtually identical once data reaches the router at the CPCE.

Accordingly with this, the call set-up was approximately 9-10 seconds depending on the test (and not on the technology utilised, as the theoretical approach would suggest). The delay experienced once the call between two MSs was established was 900-1100 ms. This is more than an adequate result for emergency situations, although this value might vary depending on the location of each of the terminals involved in the communication (e.g. a call between two different continents).

All in all, it can be stated that TETRA and GSM integration and correct operation are fully achievable as this project proves.

7.4 Further research

As it has already been advanced, due to a lack of time tests have only be carried out for individual calls. TETRA group calls and conference calls are left to be tested as well. However, and even though it has not been carried out in this project, a description of how group calls could be achieved, with the usage of Asterisk, has been described.