



# Preference list use and management

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## 1 Introduction

Eseye has pioneered multi-network SIM cards. Our market-leading AnyNet Secure™ product is a highly resilient solution that selects the most appropriate network for each installation. We have built upon our knowledge and design expertise to develop Multi-IMSI SIM cards, uniquely reprogrammable Over the Air (OTA) and offering the best possible worldwide coverage.

As experts in network selection, customers often ask us how a network is selected. Many people have experience with roaming handsets and smartphones, where the handset can roam onto more than one network. However, for these consumer grade applications many of the larger network operators steer SIMs to their preferred networks, which aren't always the most reliable or cost-effective. Indeed, it has been seen that the networks regularly 'bump' connections that are made through roaming partners with less favourable pricing. Eseye, with its 'quality first' approach always aims to ensure that the most appropriate network is selected, and uptime is maximized.

The Specifications for how the network is selected is defined rigorously by the 3GPP specifications, however there are options that the application can select, and many factors need to be considered when choosing the most suitable method, including:

- Device and modem firmware and specifications
- SIM card configuration
- Configuration of serving mobile and home networks
- Physical location/device antenna

## 2 3GPP Specification

Network selection methods are detailed in the 3GPP Specifications and these vary depending on the type of modem GSM, GPRS, 3G, UMTS. For further reading, the following documents provide detailed insight:

1. 3GPP TS 23.122 Functions related to Mobile Station (MS) in idle mode and group receive mode.
2. 3GPP TS 23.122 Non-Access-Stratum (NAS) functions related to Mobile Station (MS) in idle mode.
3. 3GPP TS 25.304 User Equipment (UE) procedures in idle mode and procedures for cell reselection in connected mode.
4. 3GPP TS 31.102 Characteristics of the Universal Subscriber Identity Module (USIM) application.

## 3 Network Selection Modes

There are two modes of network selection specified by the GSMA, and implemented in cellular modems: automatic and manual.

**Automatic mode** – this mode uses a list of networks in priority order. The highest priority network which is available and allowable is selected.

**Manual mode** – the user makes a manual selection and then the modem tries to obtain normal service on the serving network.

### 3.1 Automatic Network Selection Algorithm

This section describes how the priority of networks is determined.

For fastest re-connection time when roaming, the file 'LOCI' in the SIM card stores the details of most recently used network. The modem will read the LOCI file and attempt to connect to this network.

In the case that the network described in the LOCI file is unavailable, the modem will initially perform a network scan to identify networks currently available in the given location.

The SIM contains a number of lists that are used in network selection, which include:

- Home network list
- Operator preference list
- User preference list
- Forbidden networks

The following illustration describes the Automatic Network Selection procedure:



- Forbidden networks are removed before the network selection is made.
- If the home network is not available the last successful network is selected first.

It can be seen that the lists programmed into the SIM card heavily influence the choice of network that the modem will make.

### 3.2 Automatic Network Reselection

When a device is both roaming and in idle mode, the modem will periodically search for better networks; the default frequency for this is every 60 minutes.

Note: a device is not classified as being idle if it has an active GPRS data session even if no data is being sent.

Note 2: The act of scanning for networks that may be available, and re-running the steps shown above as the reselection procedure will render the modem unavailable for a period of time. This will affect the availability of the modem for MT calls, since during the scan period; the modem will not be available on the network. Systems which rely on placing MT calls to remote devices must include a retry mechanism to manage this.

### 3.3 Unsuccessful Registration

There are a number of error responses a network can give in reply to an attempt to register to the GSM. Some will cause the modem to add the rejecting network to the Forbidden List in the SIM card, until the SIM card is next power cycled.

### 3.4 Manual Network Selection

Where manual network selection is desired, the application will issue the Network Selection command (AT+COPS) to the modem. The specification document 3GPP TS 27.007 version 8.6.0 Release 8<sup>1</sup> describes the command, however it should be noted that modem manufacturers may implement this partially, and their individual data sheets should be consulted.

The AT+COPS command may first be used to determine which networks are available, and the modem should return these in the following order:

- Home Network
- Networks in preference lists in the SIM card
- Other Networks with RSSI<sup>2</sup> greater than – 85 dBm in a random order
- All other networks strongest signal first.

The application may use the AT+COPS command to select the required network.

The application software should anticipate that the network chosen may return 'no Service' .In this case, it should select an untried alternative network and re-attempt to connect.

For more details on manual network selection, ETS 300-921 may be consulted.<sup>3</sup>

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<sup>1</sup> [http://www.etsi.org/deliver/etsi\\_ts/127000\\_127099/127007/08.06.00\\_60/ts\\_127007v080600p.pdf](http://www.etsi.org/deliver/etsi_ts/127000_127099/127007/08.06.00_60/ts_127007v080600p.pdf)

<sup>2</sup> Received Signal Strength Indication

<sup>3</sup> [http://www.etsi.org/deliver/etsi\\_i\\_ets/300900\\_300999/300921/01\\_40\\_59/ets\\_300921e01o.pdf](http://www.etsi.org/deliver/etsi_i_ets/300900_300999/300921/01_40_59/ets_300921e01o.pdf)

## 4 Network Selection & Eseye

As has been seen, there are several options regarding network selection, and it is vital to consider the pros and cons of each when developing an M2M application.

Eseye can provide advice and assistance in selecting the correct configuration for your device based on manual, unmanaged or steered automatic network selection, as outlined below.

### 4.1 Manual Network Selection

With manual network selection, the embedded application overrides any steering in the modem, SIM or on the network, and attempts to register the device on the manually chosen network. Eseye Fully supports Manual Network Selection on all SIM cards we supply, but do not normally advise that it be used. The exception is in combination with automatic network selection, where Manual Network Selection can be used to clear a network from the Forbidden List in the SIM card if the network has been added as per section 3.3 above.

*The benefit of this approach is that the firmware in the device has full control over network steering. The down side is that when programming embedded devices it is difficult to predict every possible scenario, and it is possible that the firmware selects an unsuitable network, and the situation cannot be resolved remotely.*

### 4.2 Unmanaged Automatic Network Selection

Sometimes (inaccurately) referred to as 'best signal' or 'strongest signal' network selection. To allow fully unmanaged selection, the SIM provider does not load a preference list into the SIM card. Unmanaged automatic network selection is normally found in SIM cards where the provider has limited ability to manage the connectivity.

The first two stages in the specification for the Automatic Network Selection procedure are skipped, and the modem will order the available networks

- a) Randomly from networks where the signal level is  $> -85$  dBm.
- b) Networks with lower signal strengths in decreasing order.

*The benefit of this approach is that in countries where all networks have good coverage and provide all services, the estate will typically be spread evenly across all networks since the network selection is almost completely random. However there are a number of downsides for M2M applications most notably that each time the unit loses connection to the network, it is required to re-scan, (rather than quickly rejoin the network it had been using). Problems are typically seen where a network has variable quality service since this network will be picked regularly. More seriously, in countries where networks offer differentiated levels of service the connection may be made via a network that cannot support the desired features of the application and could potentially get stuck. This configuration option suits some customers, and can be supplied as an option but is not usually recommended by Eseye.*

### 4.3 Steered Automatic Network Selection

Eseye understands M2M, and through our active network management we deliver intelligent steering information to the modem to ensure better network selection. SIM cards are supplied with a pre-loaded preference list which, allows the modem to fully implement all the steps described in the GSMA standards. In this mode, Eseye can also manage the lists in the SIM card remotely after the SIM is fitted to equipment and deployed. Because Eseye has been fully involved in the design and commissioning of the SIM cards, we have access to the security keys, algorithms and network interfaces to reprogram the preference lists inside the SIM card over the air (OTA). Importantly this does not stop the device from joining any network but steers the modem towards networks that offer better performance by providing the data and weight of each available network.

*The benefit of this approach is that Eseye can use information which is not available to the modem to steer the connection around potential issues e.g. networks which are not providing GPRS, if GPRS is being used by the device; or backhaul connectivity issues on the mobile networks. This mode best enables Eseye to maintain connectivity to your device, regardless of what happens to the network. We would recommend this option as the best where the application writer wants a 'fit and forget' SIM card to provide reliable connectivity.*

## 5 Network Reporting

At Eseye we expertly manage network steering for our customers through a number of data feeds.

We achieve this primarily through the mobile interconnect's known status on networks in any particular country. We add intelligence such as live status feeds from our mobile network operator partners and as we have a large number of managed devices continuously reporting real-time network information to our steering manager. We are able to use this crowd model to understand and manage the real performance of networks all over the world.

## 6 Conclusion

Multi-network or 'roaming' SIMs can offer real benefits to customers needing highly available connectivity – however understanding how network selection takes place and ensuring that the most appropriate method is chosen can make the difference between a good product, and a great one. Eseye support customers using all these options.