Connected Device Design Guidelines and Common AT Commands

Tech Notes
by Curtis Govan

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About this paper: This paper was written by Curtis Govan, a mobile industry expert with 10 years of experience certifying mobile phones, PDAs, modules and integrated devices. In his current role as principal architect for Jasper Wireless, Curtis is primarily responsible for managing Jasper's device certification program. As such, he has worked with hundreds of device manufacturers and application software developers to help them design intelligent and efficient device applications. These are the notes he has shared with them.

1 Introduction

This document is intended for developers of GSM/GPRS/UMTS-based device applications.

Cellular connectivity of machines is fundamentally changing both our daily lives and whole industries. While the advantages of wireless connectivity over fixed line are significant, how these devices are designed requires additional sophistication in application logic. One objective of this document is provide guidance on how application logic can be applied to make best use of wireless connectivity.

It should be noted that this document is not intended as a guide for general application development. It is focused solely on how an application developer should take advantages of cellular connectivity.

This document assumes a certain level of understanding of GSM/GPRS/UMTS technology. Appendices are included for additional information on those topics, including references for more detailed information where needed.

2 General Information for Managing Modems

2.1 AT Commands

Most wireless devices include a wireless radio modem (also known as a module) sourced from a vendor such as Cinterion, Wavecom, Enfora, Telit and SIMCom. These modems are controlled by the application through a set of Attention (AT) Commands.

Standard AT Commands for controlling wireless modems are defined in the following specifications:

3GPP TS 27.007 (3rd Generation Partnership Project; Technical Specification Group Terminals; AT Command set for User Equipment (UE))

3GPP TS 27.005 (3rd Generation Partnership Project; Technical Specification Group Terminals; Use of Data Terminal Equipment - Data Circuit terminating; Equipment (DTE - DCE) interface for Short Message Service (SMS) and Cell Broadcast Service (CBS))

These documents contain the standard commands for managing modems. However, not all commands in these documents are mandatory. Thus, some modem makers may support only a subset of the standard AT Command set.

In addition, most modem vendors include proprietary AT Commands that provide additional capabilities beyond standard AT Commands. It is very important that developers be very familiar with the complete set of AT Commands applicable to the vendor and modem model in use.

2.2 Taking Advantage of Modem Error Reporting

AT+CMEE is the AT Command that enables the modem to report errors. It is important that error reporting is enabled as it allows for the application to take action based on the error result.

AT+CMEE=1 Enable numeric error codes (the error response includes a value to indicate the detail of the error in question. For example, error value 10 means no SIM inserted.

AT+CMEE=2 Enable verbose error code (the error response includes a text string describing the error situation. For example “SIM not inserted”.

2.3 Using Extended Error Reporting

Many modem vendors support extended error reporting so that additional information can be sent when an problem occurs. For example, if a PDP Context Activation fails, it may be possible to obtain additional information on the reason for the failure.

AT+CEER is used to provide this additional information associated with the last unsuccessful call setup, in-call modification, last call release, last short message, or last GPRS session.

When an error occurs and if the complete reason for the error is not obvious, the application should issue CEER to obtain additional information and act accordingly.

2.4 Enabling Unsolicited Result Codes

AT+CMEE instructs the modem regarding how to report errors in response to commands from the application. In addition, the modem may need to report information associated with certain events that are not triggered by commands from the application. For example, the modem may need to inform the application that a mobile-terminated short message has arrived. These reports are known as Unsolicited Result Codes (URCs).

It is important to enable URCs for any function that the application might use because the receipt of the URCs will allow the application to take best advantage of events that occur in the radio network.

General URCs are enabled by command AT+CMER.

Indicator URCs are enabled by command AT+CIND (AT^SIND is used by some modem vendors). Indicators include such information as when a battery charge level changes, when SMS memory becomes full, when service is available / unavailable, etc. The specific indicators available are defined by the modem vendor.

In addition, other URCs may be associated with specific functions and may need to be enabled specifically. For example, the application can be informed whenever a modem changes GSM registration status of whenever it finds itself in a new cell.

AT+CREG = 0 disable network registration unsolicited result code

AT+CREG = 1 enable network registration unsolicited result code to report changes in registration status

AT+CREG = 2 enable network registration and location information unsolicited result code to report changes of registration status or cell location.

It is recommended that URCs be enabled in general, and that indicator URCs be enabled (AT+CIND) for all indicators of interest to the application. Also, it's recommended that all URCs be enabled for any function that may be used by the application. For example, if the application needs to know when a short message is received, it should enable the appropriate URC by command AT+CNMI. (see 3GPP 27.005).

2.5 Utilizing Packet Domain Event Reporting (if available)

AT+CGEREP enables URCs for GPRS-related events. For example, the application can be informed if the modem has deactivated a PDO context, or if the network has forced a GPRS detach. Knowledge of such events allows the application to take appropriate action.

This command is not supported by all modem vendors.

2.6 Enabling SIM Application Toolkit

SIM cards provide an environment that can be used to run certain applications. The SIM Application Toolkit (SAT) is a capability of SIM cards to issue commands to the mobile device in accordance with applications running on the SIM. Some service providers, provide value-added capabilities that run on the SIM and utilize SAT. If such applications are to be used, the modem must be configured to enable SAT.

Not all modems support SAT. For those that do support it, some require that certain AT Commands be issued to enable SAT. This may be done by a single command that enables all SAT functions, or it may be done by individual commands for each SAT function. Any modem start-up script should include the necessary AT Commands to enable all SAT functions supported by the modem.

2.7 Auto-Retry Commands - DO NOT USE

Some modem vendors provide commands that keep retrying in the event of error or failure. For example, there are commands that may continuously retry GSM registration, or GPRS Attach or PDP Context activation. These tend to retry without due consideration of the reason for denial or failure.

There are situations where a subscriber may be legitimately prevented from registering on a network, activating a session or using some service. In such cases, constant retry will not succeed and will cause needless load on the network.

The application should retain control of how/when to retry a service and should do so in accordance with the guidelines in this document.

DO NOT use AT Commands that cause the modem to continuously retry.

3 Accessing the Network

3.1 Network Registration - General

Prior to establishing a GPRS session, a device / subscriber must first register with the network.

GPRS is enabled by a network overlay on top of a standard GSM network. A modem registers separately with the GSM network (i.e. registers with the MSC) and the GPRS network (i.e. registers with the SGSN, also known as GPRS Attach). Although it is possible to register only on the GPRS network (i.e. perform GPRS Attach without GSM registration), most modems are configured to register for GSM and GPRS.[1]

Some operators require that a device perform both GSM registration and GPRS Attach.

Do Not set the device to GPRS-only service. In other words, DO NOT issue command AT+CGCLASS = CG or command AT+CGCLASS = CC.

3.1.1 Network Selection – Automatic and Manual

As with a phone, any GSM device can select a network manually or automatically. This is controlled by command AT+COPS as follows:

AT+COPS? – List the network you are currently registered on

AT+COPS=? - List all available networks including the network that the SIM is currently registered on

AT+COPS=1,2,"MCC MNC" – Attempts to manually set the network. If unsuccessful, leaves the modem in manual selection

AT+COPS=4,2,"MCC MNC" - Attempts to manually set the network. If unsuccessful, puts modem back into automatic network selection

AT+COPS=0 - Puts modem into automatic network selection

(MCC = Mobile Country Code, MNC = Mobile Network Code)

Modems have network selection set to automatic by default (AT+COPS=0). The modem control script does not need to issue the AT+COPS command to avail of automatic network selection. Most operators require that network selection be automatic unless otherwise specified.

A modem that has automatic network selection will perform GSM registration automatically.

A modem with manual network selection will perform GSM registration only if the specified network is available.

Make sure your application gives the modem enough time to register. If you use a timer to determine GSM registration success, make sure that you allow at least five minutes. Lower values may be enough in most cases, but up to five minutes may be needed for some modems under certain circumstances.

[1] There is a function in GSM/GPRS called 'combined attach'. However, this is primarily a signaling mechanism over the air interface and means that the device requests registration on GSM and GPRS at the same time. Within the network, the user is considered registered for GSM and GPRS separately, even if the registration was instigated by use of combined attach.

3.1.2 Network Registration – Checking Status

AT+CREG command checks GSM registration status. Without GSM registration, you should not attempt to attach to GPRS or perform any dialing function. By default, a modem will attempt to automatically register with a network without your having to invoke any action.

Command: AT+CREG?

Results:

0,0 – not registered, MT is not currently searching a new operator to register to

0,1 – Registered, home network

0,2 – Searching

0,3 – Registration denied

0,5 – Registered, non-home network

Prior to performing GPRS attach, it is important to ensure that GSM registration has been successful. You can check this in the following ways:

Command: AT+CREG? (returns the current GSM registration status)

Command: AT+CREG = 1 (enables network registration unsolicited result code – provides registration status only)

Command: AT+CREG = 2 (enables network registration unsolicited result code – provides registration status only and service location area and cell)

Note that AT+CREG=1 or AT+CREG=2, if selected, should be used at the start of the modem manager script to enable the +CREG unsolicited response code.

3.2 Performing GPRS Attach

GPRS Attach should be performed after GSM registration. Make sure that GSM registration is successful before attempting GPRS Attach. GPRS Attach is performed using command AT+CGATT.

AT+CGATT=1 (GPRS Attach).

OK = successful result.

Other responses represent an error and should be handled as described below. In the case of error, in addition to understanding the error code (based on AT+CMEE=1 or 2), it is advisable to issue command AT+CEER to get further error detail and enable a more targeted response.

GPRS detach is the process of deregistering from the GPRS network (specifically the serving SGSN). It is executed as follows:

AT+CGATT=0 (GPRS detach).

Once a data session is over, execute GPRS Detach if the application does not expect to establish a further session for 2 hours or more, especially for mobile applications (e.g. devices in vehicles). By executing a GPRS detach, important network resources are conserved.

3.3 Establishing a Session

3.3.1 Defining the PDP Context

In GPRS, a data session is known as a PDP Context. This is a data path between the wireless device and a node in the network called a GGSN (Gateway GPRS Support Node). The GGSN is the gateway between the wireless network and the rest of the world, including the Internet and VPNs. A PDP Context must be established before data is sent. A PDP Context is not the same as a TCP or UDP socket.

A critical characteristic of a PDP Context is the Access Point Name (APN). The APN determines the GGSN to be used and other characteristics such as VPN use or fixed IP use. Your operator will provide you with the correct APN to use with your application.

First define the PDP Context using command AT+CGDCONT. For example:

AT+CGDCONT=1,"IP","apn1.globalm2m.net" - This will set the APN to what is specified. In this case, apn1.globalm2m.net. In addition, the command specifies this PDP Context definition as PDP Context Definition Number 1, and specifies that it is designed for IP traffic.

To query the definition of a PDP Context, use command:

AT+CGDCONT?

Example output: +CGDCONT: 1,"IP","apn1globalm2m.net","",0,0

3.3.2 Setting Up the Session

Command AT+CGACT is used to set up or tear down a PDP Context.

To activate a PDP Context:

AT+CGACT=1,1 (defines the state to be 1 – active, and the context ID, 1 in this case).

To deactivate a PDP Context:

AT+CGACT=0,1 (defines the state to be 0 – inactive, and the context ID, 1 in this case).

The CGACT command is very useful in determining why a PDP Context activation was not successful. If the result of CGACT is anything other than OK, then an error should be provided (assuming that AT+CMEE=1or 2 has been issued) and the application can respond accordingly. We also recommend that the application issue command AT+CEER to obtain more specific error information and act accordingly. (See below section on error handling.)

It is also possible to establish a PDP Context using command ATD as follows:

ATD*99***1 (the “1” in the string refers to the context ID, previously defined in command AT+CGDCONT)

Using ATD*99***1 to establish a PDP Context causes the modem to take whatever actions are necessary to set up the PDP Context – including GPRS Attach if not already done. While this may seem to be advantageous, it can be misleading because it does not allow for the result of each step to be understood individually. The separate use of AT+CGATT, followed by AT+CGACT is recommended. Alternatively, it is OK to use ATD*99***1 only if AT+CGATT has been already performed.

3.3.3 Maintaining a Session

By default, the network will keep a PDP Context open for 1-4 hours, typically, without data transfer. The time limit applies to most APNs, and can be assumed to be the case unless your operator stipulates otherwise.

However, in addition to the PDP Context idle-timeout, operators also maintain firewall timeouts for UDP ports and TCP sockets.

For some networks, timeouts may not apply in the case of VPN connections.

Therefore, if you use a VPN connection, all that is needed to keep a data path open is to transfer data every 14 hours at least.

If you do not use a VPN, then transfer data every 5 minutes at least for UDP and every 60 minutes at least for TCP.

3.3.4 Avoiding Too Many Short Sessions or Very Long Sessions with Little Data

It is important to strike a balance between many short sessions and excessively long sessions with long periods between data transfers. There is no single optimum session duration without transfer, because the right choice also depends on the amount of data in each transfer. The following general guidelines should be observed.

If data is to be passed more frequently than once every hour, maintain a single PDP Context session rather than a separate context for each burst of data.

If data is to be passed less frequently than once every eight hours, use a new PDP Context for each transmission.

3.4 Avoiding Aggressive Behavior

In the event of failure to connect to the networks, it is important that your application doesn't repeatedly attempt to gain access to the network. Instead, it should recognize that it has been denied and back-off from connecting accordingly. Below is an outline of some basic rules that should be applied, depending on the corresponding CMEE codes. As always, some of this information may vary depending on modem manufacturer.

Generic Failure Retry Logic - In the case where the application does not get identifiable and actionable error codes, the following logic is recommended (please consult network provider for retry guidelines)

GSM/GPRS Registration Failures

It is acceptable for an application to reboot the modem in case of GSM registration failure or in case of GPRS Attach failure due to transient reasons or due to no network available, but no more frequently than once every 5 minutes, and no more than 4 times in succession. Additional reboots may occur at 30 minutes, 60 minutes, then every 60 minutes; i.e. @ 1(initial attempt), 5, 10, 15, 20, 30, 60, 120, 180, …

SMS Failures

It is acceptable for an application to retry in case of SMS failures. Initial retries may be attempted no more frequently than once every 30 seconds, and no more than 4 times in succession. Additional retries may occur at 15 minutes, 30 minutes, then every 60 minutes; i.e. @ 1 sec (initial attempt), 30 sec, 60 sec, 90 sec, 120 sec, 15 min, 30 min, 60 min, 120 min, 180 min, …

PDP Context Activation Failures

It is acceptable for an application to retry in case of PDP Context Activation failures. Initial retries may be attempted no more frequently than once every minute, and no more than 4 times in succession. Additional retries may occur at 15 minutes, 30 minutes, then every 60 minutes; i.e. @ 1(initial attempt), 2, 3, 4, 5, 15, 30, 60, 120, 180, …

No Traffic/Server Down

When a device is unable to send/receive data to/from a server, it is recommended that the data connection is verified by attempting to reach a known good or public server. Alternatively, It is acceptable for an application to reset the data connection by deactivating and re-activating the PDP Context. However, resets may be attempted no more frequently than once every minute, and no more than 4 times in succession. Additional retries may occur at 15 minutes, 30 minutes, then every 60 minutes; i.e. @ 1(initial attempt), 2, 3, 4, 5, 15, 30, 60, 120, 180, …

3.5 Synchronous Actions

The device application or backend server shall not be designed such that network activities (GSM Registration, GPRS Registration, PDP Context Activation, and reception/transmission of data) are synchronized. In the event of server or network anomalies, such behavior can overstress network elements.

4 Managing Errors

For a complete List of CMEE Codes, see Appendix C – List of CMEE Codes and Recommended Actions

As discussed earlier, enabling unsolicited result codes (URC) and utilizing extended error reporting will allow you to more easily diagnose problems that may occur within your application when utilizing the wireless network. There is a standard list of results that you can expect and it is worth familiarizing yourself with some of the key results. However, it is important to note that in some cases the results will differ from modem to modem so it is always good to review the respective user guide.

Notable URCs include:

CMEE 132

Cause - Service option not supported

Reason - This cause code is used by the network when the device requests a service which is not supported by the network operator or the APN is invalid

Action - As per 3GPP specs, return to previous state. Additionally, device should not retry the attempt on the same operator unless prompted externally to do so (i.e. modem should not automatically retry). You should also check the APN to ensure it is correct.

CMEE 133

Cause - Requested service option not subscribed

Reason - This cause is sent when the device requests a service option for which it has no subscription. The difference between this and CMEE 132 is that the network may support the requested option, but the user is not subscribed to that option.

Action - As per 3GPP specs, return to previous state. Additionally, the device should not retry the attempt on the same operator unless prompted externally to do so (i.e. modem should not automatically retry).

CMEE 134

Cause - Service option temporarily out of order

Reason - This cause is sent when the MSC\SGSN cannot service the request because of temporary outage of one or more functions required for supporting the service.

Action – If a second network is available, attempt to connect via the alternate network. If no other network is available, per 3GPP specs, return to previous state. Additionally, retries may be attempted, but according to the generic retry logic noted above.

CMEE 149

Cause - User authentication failed

Reason - This cause code is used by the network to indicate that the requested service was rejected by the external packet data network due to a failed user authentication (e.g. rejected by Radius)

Action – As per 3GPP specs, This typically means that device is in PDP-inactive state. Additionally, retries may be attempted, but according to the generic retry logic noted above.

CMEE 148

Cause - unspecified GPRS error

Action – If a second network is available, attempt to connect via the alternate network.Additionally, retries may be attempted, but according to the generic retry logic noted above.

Please see Appendix C – List of CMEE Codes and Recommended Actions, for the most common errors and proposed actions.

In some error cases, it is appropriate to retry the action. In some error cases, it may be appropriate to reset the modems. However, any retry or reset scheme must have a robust back-off algorithm. Constant retries or resets can be a reason for a device/application to be rejected during operator certification

5 Timers

Many application developers use timers with the application to dictate control of the modem. In some cases, this is appropriate. However, in most cases, timers should be used in conjunction with error reports and extended error reports. Thus, if a timeout occurs, the application can understand not just the fact that the timeout occurred, but also the reason why. For example, if an application has a timer associated with establishing a PDP Context, and that timer expires, it is important to know that the PDP Context establishment failed, and why. Then the application can decide whether to retry or not.

It is advisable that timers be specific to individual tasks and not groups of tasks. For example, if the start-up script of an application includes a timer for measuring time from start to PDP-Context establishment, what happens at timeout? It is not obvious that the delay or failure was

due to GSM registration, GPRS Attach or PDP Context establishment. If timeouts are needed, it is better to have a timeout associated with each step.

6 Additional Guidelines

While the time it takes to execute an AT Command may vary, you should receive a response within 60 seconds.

An application should not reboot the modem if it is aware of blocking situations including illegal MS (authentication failure), illegal ME (failed IMEI check) or incorrect APN.

It is acceptable for an application to reboot the modem in case of GSM registration failure or in case of GPRS Attach failure due to transient reasons or due to no network available, but no more frequently than once every minute, and no more than 4 times in succession.

It is acceptable for an application to reboot the modem in case of PDP Context failure due to transient reasons or due to no network available, but no more frequently than once every minute, and no more than 4 times.

There is no way to determine the loss of GPRS coverage. You must instead verify coverage via GSM registration (AT+CREG?). This means that if you check GPRS (AT+CGATT?) it may show connected (0,5) even though it is not. This specifies loss of coverage only for GSM not GPRS.

If you receive an error message, then retry after the recommended timer interval and receive a new error with a different retry timer, use the timer associated with the most current error. Do not default to the first timer you received.

When a device is in a no coverage area, you will see “AT+CREG?” return “+CREG: 0,2” or “+CREG: 0,3” for GSM registration; meaning the device is searching or has been rejected on the current network or has limited service, respectively. For this condition, do not have the application reset the modem. You should continue to check AT+CREG? using some back-off logic to preserve battery power.

If you are repeatedly seeing a specific error, support may be required and/or it may be best to view the UI display for information about the problem. For example, repeated 132, 133, 134, 148 or 149 errors should follow the recommendations found above or display a message on the UI. As a general rule, you could implement some back-off logic or see if you can get GSM connection at all.

Diagnostic/Application logging is usually necessary when trying to discover the cause of the problem. When developing your application, especially during the early stages, it is best to output as much information as possible to an available log file.

7 Information on specific modems

Over the past several years, through working closely with the modem manufacturers to implement solutions around the world, a range of interesting characteristics regarding different modems have been discovered. Understanding these characteristics can make a big difference when designing an application. The following are some specific examples.

7.1 Cinterion (Formerly Siemens Wireless Modems):

Known Issues:

With both the TC63 and TC65, if the SIM sends the “Refresh - SIM Reset” Proactive Command, the device application must acknowledge the modem’s “SIM Application returns to main menu” URC (^SSTN:254) by sending an AT Command. Please refer to Cinterion for the appropriate specification on how to handle this situation.

For the MC55/56, use of AT^MONI is not recommended for real-time verification of the device’s registration status, as this command does not update as frequently as AT+CREG. In addition, if AT^MONI is used, it may interfere with other URCs, preventing notification of service-impacting information.

SIM Application Toolkit:

The MC55i, MC75i/TC63i/TC65i, AC65i/AC75i, HC25/HC28 and EGSx/BGSx have SAT enabled by default. The MC55/MC56 and MC75/TC65/TC63 must have SAT enabled specifically by the application script.

Activation Command:

AT^SSTA=1,0 (GSM alphabet)

AT^SSTA=1,1 (UCS2 alphabet)

7.2 Sierra Wireless (formerly Wavecom)

Known Issues:

Sierra Wireless Q24 series modems have an issue with their network selection algorithm when two networks are available but one has significantly lower, but acceptable, signal strength If the network with the lower signal strength is the target network, the modem will not connect to it.

This issue has been resolved. Please refer to Sierra Wireless for the software release information for correcting this issue.

SIM Application Toolkit:

Activation Commands:

AT+STSF=2,,,1

“AT+STSF=1”

For some SIM types, the Q24 and Q26 series modems require SAT activation to process the SIM OTA messages.

7.3 Telit

Known Issues:

Telit modems require that SIM Application Toolkit is activated to process SIM OTA messages.

Modem Recommendations

AT#SELINT=2 //use of most recent AT Command set

AT#STIA=2,10 or AT#STIA=1 // enable SAT – SIM Application Tool-Kit

AT#BND=3 // default bands to 850/1900 (applicable if used in North America)

AT#AUTOBND=1 // enable Quad band system selection

AT#PLMNMODE=1 // enable EONS (enhanced operator naming scheme)

AT&P0 // save profile

AT&W0 // save setting

Modem Web Pages;

GM862 Quad & Quad PY - http://www.telit.com/en/products/gsmgprs.php?p_id=12&p_ac=show&p=4

7.4 Enfora

Known Issues:

If the SIM sends the “Refresh - SIM Reset” Proactive Command, the modem fails to complete the refresh and is unable to register on the network. The workaround for this issue is to reset the modem.

SAT Activation commands do not accurately reflect the actual modem settings

Do NOT use the Enfora-specific command AT$AREG=2. This command causes extremely aggressive behavior; which will cause the device to FAIL some operator certifications.

SIM Application Toolkit:

SAT is activated by default on all Enfora modems.

7.5 Motorola

SIM Application Toolkit:

SAT is activated by default.

7.6 SIMCom

Known Issues:

When the modem is configured in Automatic Network Selection Mode, it fails to register when it moves from one country to another. This issue has been resolved. Please contact SIMCom for the release information.

SAT is supported, but, by design, the modem must be reset after the Refresh SIM Reset.

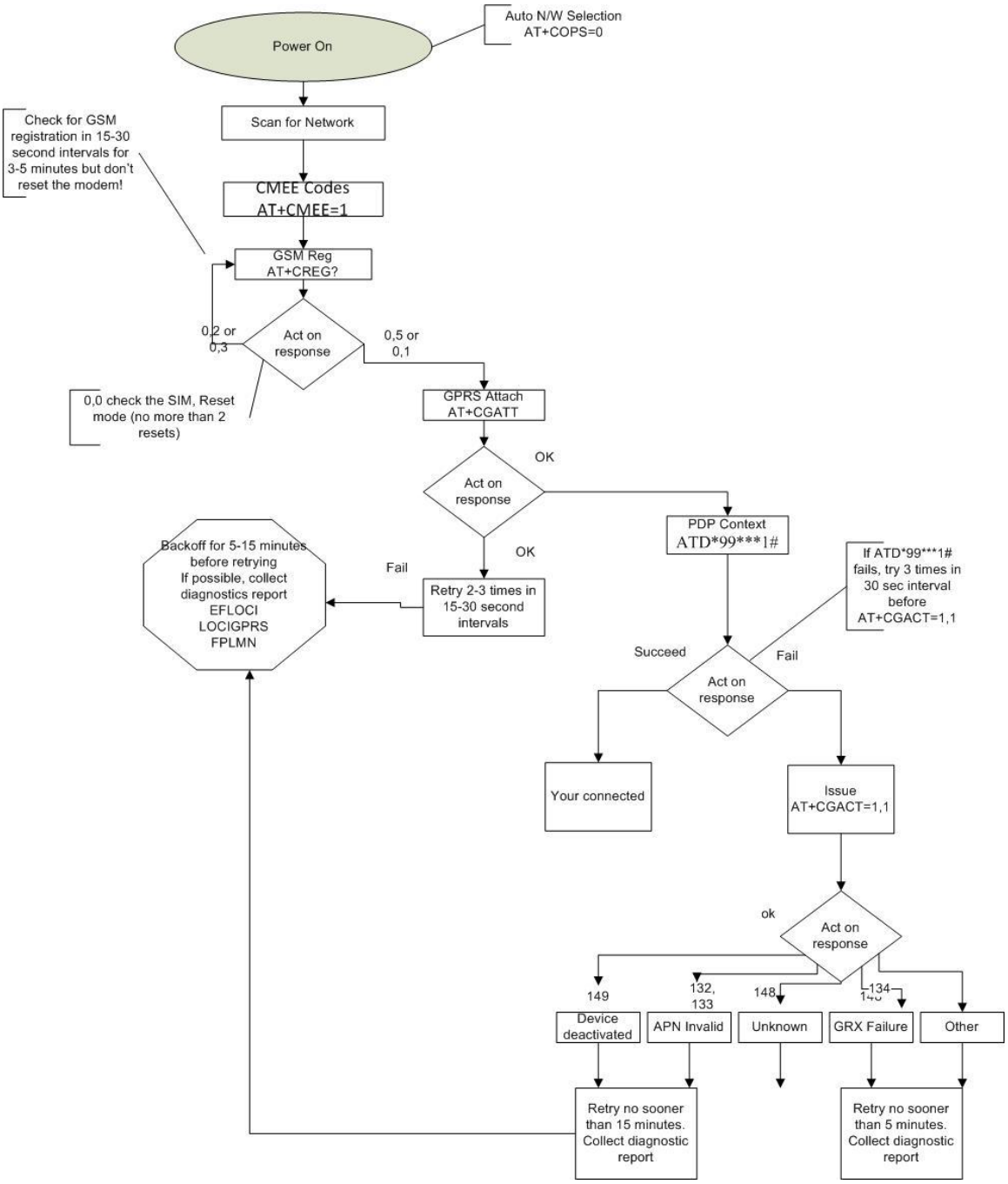
SIM Application Toolkit:

SAT is activated by default.

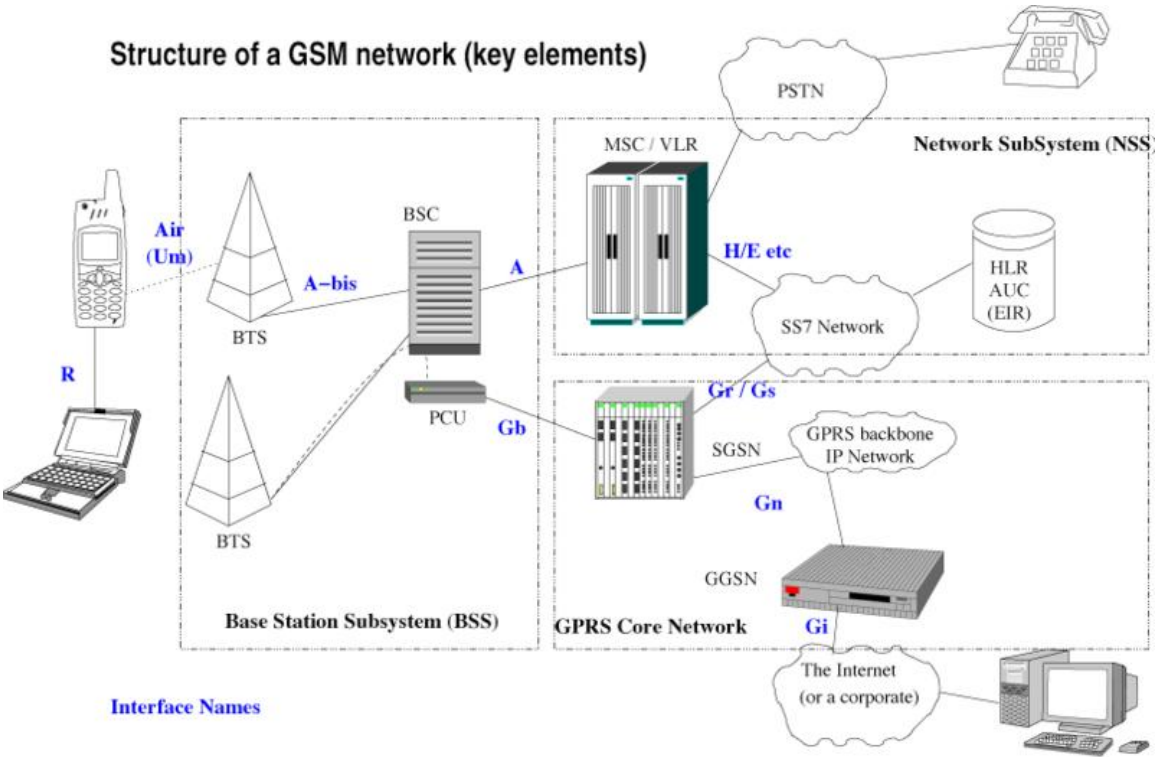
8 Example Device Logic

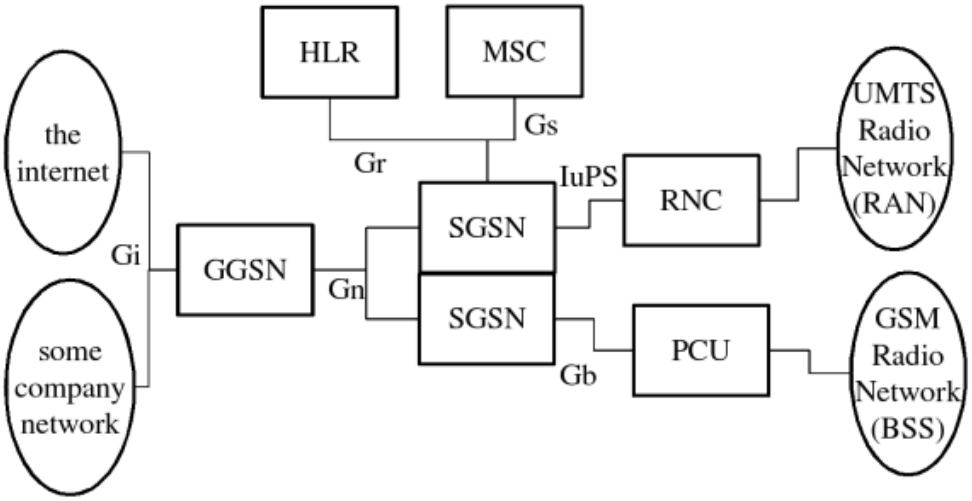
8.1 Default Connection Flow

- Device Powers on
- The Modem will begin scanning for available networks
- Via AT Command, turn on URC codes via AT+CMEE=1
- Validate GSM registration via AT+CREG?
- Issue a GPRS attach via AT+CGATT
- Attempt to establish a PDP Context via the device dial string using, ATD*99***1#.
- If unable to connect, issue a manual PDP Context via AT+CGACT=1,1 and obtain the error code
- Next steps depend on the error code received


Power On
Auto N/W Selection
AT+COPS=0
Scan for Network
Check for GSM registration in 15-30 second intervals for 3-5 minutes but don't reset the modem!
CMEE Codes
AT+CMEE=1
GSM Reg
AT+CREG?
Act on response
0,2 or 0,3
0,5 or 0,1
0,0 check the SIM, Reset mode (no more than 2 resets)
GPRS Attach
AT+CGATT
Act on response
OK
PDP Context
ATD*99***1#
Backoff for 5-15 minutes before retrying
If possible, collect diagnostics report
EFLOCI
LOCIGPRS
FPLMN
Fail
OK
Retry 2-3 times in 15-30 second intervals
If ATD*99***1# fails, try 3 times in 30 sec interval before AT+CGACT=1,1
Succeed
Fail
Act on response
Your connected
Issue
AT+CGACT=1,1
ok
Act on response
149
132, 133
148
134
Device deactivated
APN Invalid
Unknown
GRX Failure
Other
Retry no sooner than 15 minutes. Collect diagnostic report
Retry no sooner than 5 minutes. Collect diagnostic report

10 Appendix B – Core GSM/GPRS Architecture





11 Appendix C – List of CMEE Codes and Recommended Actions

Cause Codes Related to GSM Mobility Management				
MM Cause Code	**CMEE Result Code**	**Cause**	**Reason**	**Proposed action upon receipt**
2		IMSI unknown in HLR	This cause is sent to the MS if the MS is not known (registered) in the HLR. This cause code does not affect operation of the GPRS service, although it may be used by a GMM procedure.	as per 3GPP specs
3	103	illegal MS	This cause is sent to the MS when the network refuses service to the MS either because an identity of the MS is not acceptable to the network or because the MS does not pass the authentication check, i.e. the SRES received from the MS is different from that generated by the network.	as per 3GPP specs
4		IMSI unknown in VLR	This cause is sent to the MS when the given IMSI is not known at the VLR.	as per 3GPP specs
5		IMEI not accepted	This cause is sent to the MS if the network does not accept emergency call establishment using an IMEI.	as per 3GPP specs
6	106	Illegal ME	This cause is sent to the MS if the ME used is not acceptable to the network, e.g. blacklisted.	as per 3GPP specs
11	111	PLMN not allowed	This cause is sent to the MS if it requests location updating in a PLMN where the MS, by subscription or due to operator determined barring is not allowed to operate.	as per 3GPP specs
12	112	Location Area not allowed	This cause is sent to the MS if it requests location updating in a location area where the MS, by subscription, is not allowed to operate.	as per 3GPP specs
13	113	Roaming not allowed in this location area	This cause is sent to an MS which requests location updating in a location area of a PLMN which restricts roaming to that MS in that Location Area, by subscription.	as per 3GPP specs
17	615	Network failure	This cause is sent to the MS if the MSC cannot service an MS generated request because of PLMN failures, e.g. problems in MAP.	as per 3GPP specs. Additionally, retry retries may be attempted, but no more frequently than once every 60 secsaccording to the generic retry logic noted above.
22	42	Congestion	This cause is sent if the service request cannot be actioned because of congestion (e.g. no channel, facility busy/congested etc.)	as per 3GPP specs. Additionally, retry retries may be attempted, but no more frequently than once every 60 secsaccording to the generic retry logic noted above.
32	132	Service Option Not Supported.	This cause is sent when the MS requests a service/facility in the CM SERVICE REQUEST message which is not supported by the PLMN.	as per 3GPP specs. Additionally, device should not retry the attempt on the same PLMN unless prompted externally to do so (i.e. modem should not automatically retry).
33	133	Requested Service Option Not Subscribed	This cause is sent when the MS requests a service option for which it has no subscription.	as per 3GPP specs. Additionally, device should not retry the attempt unless prompted externally to do so (i.e. modem should not automatically retry).
34	134	Service option temporarily out of order	This cause is sent when the MSC cannot service the request because of temporary outage of one or more functions required for supporting the service.	as per 3GPP specs. Additionally, retry retries may be attempted, but no more frequently than once every 60 secsaccording to the generic retry logic noted

				above.
38		Call Cannot be identified	This cause is sent when the network cannot identify the call associated with a call re-establishment request.	as per 3GPP specs

Cause Codes Related to GPRS Mobility Management				
GMM Cause Code	**CMEE Result Code**	**Cause**	**Reason**	**Proposed action upon receipt**
7	107	GPRS Services Not Allowed	This cause is sent to the MS if it requests an IMSI attach for GPRS services, but is not allowed to operate GPRS services.	as per 3GPP specs
8		GPRS services and non-GPRS services not allowed	This cause is sent to the MS if it requests a combined IMSI attach for GPRS and non-GPRS services, but is not allowed to operate either of them.	as per 3GPP specs
9		MS identity cannot be derived by the network	This cause is sent to the MS when the network cannot derive the MS's identity from the P-TMSI in case of inter-SGSN routing area update.	as per 3GPP specs
10		Implicitly detached	This cause is sent to the MS either if the network has implicitly detached the MS, e.g. some while after the Mobile reachable timer has expired, or if the GMM context data related to the subscription dose not exist in the SGSN e.g. because of a SGSN restart.	as per 3GPP specs
14	111	GPRS services not allowed in this PLMN	This cause is sent to the MS which requests GPRS service in a PLMN which does not offer roaming for GPRS services to that MS.	as per 3GPP specs
16		MSC temporarily not reachable	This cause is sent to the MS if it requests a combined GPRS attach or routing are updating in a PLMN where the MSC is temporarily not reachable via the GPRS part of the GSM network.	as per 3GPP specs
	148	unspecified GPRS error		as per 3GPP specs. Additionally, retry retries may be attempted, but no more frequently than once every 60 secsaccording to the generic retry logic noted above

Cause Codes Related to Session Management				
SM Cause Code	**CMEE Result Code**	**Cause**	**Reason**	**Proposed action upon receipt**
25		LLC or SNDCP failure	This cause code is used by the MS indicate that a PDP Context is deactivated because of a LLC or SNDCP failure (e.g. if the SM receives a SNSM-STATUS.request message with cause "DM received " or " invalid XID response ", see 04.65 [78])	as per 3GPP specs. Additionally, retry retries may be attempted, but no more frequently than once every 60 secsaccording to the generic retry logic noted above
26		Insufficient resources	This cause code is used by the MS or by the network to indicate that a PDP Context activation request or PDP Context modification request cannot be accepted due to insufficient resources.	as per 3GPP specs. Additionally, retry retries may be attempted, but no more frequently than once every 60 secsaccording to the generic retry logic noted above.
27	134	Unknown or missing access point name	This cause code is used by the network to indicate that the requested service was rejected by the external packet data network because the access point name was not included although required or if the access point name could not be resolved.	as per 3GPP specs. Additionally, do not retry with same APN unless device is power cycled.
28		Unknown PDP address or PDP type	This cause code is used by the network to indicate that the requested service was rejected by the external packet data network because the PDP address or type could not be recognised.	as per 3GPP specs. Additionally, do not retry with same PDP address and/or type unless device is power cycled.
29	149	User authentication failed	This cause code is used by the network to indicate that the requested service was rejected by the external packet data network due to a failed user authentication (e.g. rejected by Radius)	as per 3GPP specs. Additionally, retry retries may be attempted, but no more frequently than once every 60 secsaccording to the generic retry logic noted above.
30		Activation rejected by GGSN	This cause code is used by the network to indicate that the requested service was rejected by the GGSN..	as per 3GPP specs. Additionally, retry retries may be attempted, but no more frequently than once every 60 secsaccording

				to the generic retry logic noted above.
31		Activation rejected, unspecified	This cause code is used by the network to indicate that the requested service was rejected due to unspecified reasons.	as per 3GPP specs. Additionally, retry retries may be attempted, but no more frequently than once every 60 secsaccording to the generic retry logic noted above.
32	132	Service option not supported	This cause code is used by the network when the MS requests a service which is not supported by the PLMN.	as per 3GPP specs. Additionally, device should not retry the attempt on the same PLMN unless prompted externally to do so (i.e. modem should not automatically retry).
33	133	Requested service option not subscribed	This cause is sent when the MS requests a service option for which it has no subscription.	as per 3GPP specs. Additionally, device should not retry the attempt on the same PLMN unless prompted externally to do so (i.e. modem should not automatically retry).
34	134	Service option temporarily out of order	This cause is sent when the MSC cannot service the request because of temporary outage of one or more functions required for supporting the service.	as per 3GPP specs. Additionally, retry retries may be attempted, but no more frequently than once every 60 secsaccording to the generic retry logic noted above.
35		NSAPI already used	This cause code is used by the network to indicate that the NSAPI requested by the MS in the PDP Context activation is already used by another active PDP Context of this MS.	as per 3GPP specs. Device may choose to use a different NSAPI, or retry after the context using the required NSAPI as been deactivated.
36		Regular PDP Context deactivation	This cause code is used to indicate a regular MS or network initiated PDP Context deactivation.	as per 3GPP specs.
37		QoS not accepted	This cause code is used by the MS if the new QoS cannot be accepted that were indicated by the network in the PDP Context Modification procedure.	N/A
38	615	Network Failure	This cause code is used by the network to indicate that the PDP Context deactivation is caused by an error situation in the network.	as per 3GPP specs. Additionally, retry retries may be attempted, but no more frequently than once every 60 secsaccording to the generic retry logic noted above.
39		Reactivation requested	This cause code is used by the network to request a PDP Context reactivation after a GGSN restart.	as per 3GPP specs. Additionally, the device may re-establish the PDP Context.
40		Feature not supported	This cause code is used by the MS to indicate that the PDP Context activation initiated by the network is not supported by the MS.	N/A

13 Appendix D – Glossary

13.1 Common Industry Terms/Technology

GSM (Global System for Mobile Communications). GSM is a cellular network, which means that radio spectrum is separated into individual coverage areas – cells, each served by a base station. Mobile devices connect to the network using the radio channels available in the local serving cell.

GSM networks operate in four different frequency ranges. Most GSM networks operate in the 900 MHz or 1800 MHz bands. Some countries in the Americas (including Canada and the United States) use the 850 MHz and 1900 MHz . For more information on GSM, see http://www.gsmworld.com

(see Appendix B for GSM diagram)

GPRS (General Packet Radio Service)- is a packet oriented mobile data Service available to users of GSM. It provides theoretical data rates of up to 170kbps. Data rates of up to 40kbps are experienced in real-world networks, depending upon device capabilities, network configurations and network load.

For more info on GRPS, see http://www.gsmworld.com

(see Appendix B for diagram)

AT Commands: (Attention Commands) – are used by a mobile application to control a wireless modem. The AT Command set consists of a series of short text strings which combine together to produce complete commands for operations such as dialing, hanging up, and changing the parameters of the connection. The command set for GSM modems is specified in 3GPP specifications TS 27.007 and TS 27.005 (for SMS-related commands). The standardized commands include some commands that are optional. Therefore, many wireless modem manufacturers support most, but not all standardized commands. In addition, most modem makers include additional vendor-specific AT Commands.

PDP (Packet Data Protocol) Context – is a GPRS data session. Through the establishment of a PDP Context, the device is assigned an IP address, which is a prerequisite for sending an receiving IP traffic.

The establishment of a PDP Context creates a data path from the mobile device to the local SGSN to the serving GGSN, which controls the required Access Point Name (APN).

In order to establish a PDP Context, the mobile device must first register with the serving SGSN. This process is known as GPRS Attach.

SIM - Subscriber Identity Modem (SIM) is part of a smart card ICC (Integrated Circuit Card), also known as SIM Cards, for mobile, telephony devices (such as computers) and mobile phones. SIM cards securely store the service-subscriber key (IMSI) used to identify a subscriber, plus a set of subscriber-specific and service provider-specific information. Most SIM cards are removable, and can allow a user to move a subscription from one device to another by moving the SIM. However, we expect to see new SIM form factors, based on non-removable chips specifically for M2M, in the near future.

SIM Application Toolkit (SAT) - SAT is a set of standardized capabilities within GSM that enable the SIM to initiate actions which can be used for various value added services. Without SAT, the SIM is a slave to the device and can only operate according to the needs of the device and its application. With SAT, the SIM can initiate instructions to the device or take proactive measures of its own (e.g. display a message on the device display or initiate an SMS).

SIMs can be programmed with applets that take advantage of SAT, thereby enabling value-added functions and services. Some operator's capabilities take advantage of SIM applets and SAT.

MSC - The Mobile Switching Center is the primary service delivery node for GSM, responsible for handling voice calls and SMS as well as other services. Most GPRS devices also have the capability of using services provided by the MSC (e.g. voice, SMS, USSD). For this reason, a GPRS device will normally first register on an MSC, known as GSM registration, before attaching to the local SGSN.

SGSN - A Serving GPRS Support Node is responsible for the delivery of data packets from and to the mobile stations within its geographical service area. Its tasks include packet routing and transfer, mobility management (attach/detach and location management), logical link management, and authentication and charging functions. The location register of the SGSN stores location information (e.g., current cell, current VLR) and user profiles (e.g., IMSI, IP address used in the packet data network) of all GPRS users registered with this SGSN.

GGSN – Gateway GPRS Support Node is a network node that acts as a gateway between a GPRS wireless data network and other networks such as the Internet or private networks. When a GPRS device establishes a PDP Context to a specific APN, the APN selected determines the GGSN to be used.

APN – Access Point Name is a URL that is used within the GPRS network to route to the correct GGSN and to indentify the services that should be provided to the user of the APN. For example, one APN might use a VPN connection, whiles another would not.

HLR - The Home Location Register is a central database that contains details of each mobile user, including information on the subscriber identities (IMSI, phone number) and the services to which the user has subscribed (e.g. APNs, fixed IP address, roaming restrictions).

SMS – Short Message Service is the ability to send messages of up to 160 characters to or from a mobile device (or multiples of 160 characters in the case of concatenated messages).

As an alternative to 160 text characters, messages can have up to 140 octets of binary data. In many cases SMS is used as a bearer for M2M data, especially where the data payload is small. The network solution for SMS includes automatic retry mechanisms.