

Migrating M2M Applications to IP-based 2.5G and 3G Cellular Networks

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White Paper

Migrating M2M Applications to IP-based 2.5 and 3G Cellular Networks

Executive Summary

The Internet is a dynamic and unpredictable network environment. Internet-enabling an application that was not intended to communicate over the Internet is not necessarily a simple task. It depends on the time and level of engineering and financial resources available to the developer, on the amount of computing resources (processing power and memory) in the host device, and which protocols the device will use to communicate over the network. Internet-enabling a new product requires careful thought and planning, and a good understanding of the Internet protocols.

There are five main alternatives for connecting a device to a wireless IP network:

1. Buy or develop a TCP/IP software stack, or download shareware from the Internet, and integrate the protocol stack into the host application;
2. Buy a microcontroller that includes a TCP/IP stack and runs the application;
3. Buy a wireless modem with an embedded TCP/IP stack;
4. Buy a standard wireless modem and using an Internet adapter; and
5. Buy an Internet controller chip that offloads the Internet tasks from the MCU.

M2M applications can benefit from using the Internet, which can reduce the costs of infrastructure, operations and communications. Because the Internet is a complex, dynamic, and inconsistently implemented medium that is constantly evolving, an IP connectivity solution must be as dynamic as the Internet. It must be adaptable, simple to use and maintain, yet sophisticated enough to deal with the Internet's inherent inconsistency. The bottom line is that IP connectivity solutions must be reliable and robust.

Connect One's iChip is such a product. It eliminates the time, cost and complexity of connecting devices to the Internet. It is a complete hardware and software solution whose cost of acquisition equals its cost of implementation and ownership. It is the most versatile and risk-free solution on the market when compared to the TCP/IP-enabled wireless modems, software stacks, shareware, and other chip solutions that are currently available. iChip offers much more than just TCP/IP. By offering more value than these other solutions, it is the most cost-effective solution on the market.

Because iChip's reliability has been proven in the field by hundreds of thousands of deployed devices, Connect One's robust solutions give the customer the highest level of comfort. Thanks to Connect One's Internet expertise, customers can confidently and economically migrate their M2M applications to 2.5G and 3G cellular networks.

In this White Paper, we will explore the nature of the Internet and IP-based cellular networks, and relate them to how Internet protocols can be used to the maximum benefit for M2M applications. Because of the global success of GSM (with 72% cellular market share), we will use the GPRS network (which is built over the GSM infrastructure) as an example of an IP-based network that an M2M application must support. We will review the features of Connect One's iChip and discuss how iChip eliminates the time, cost and complexity of connecting devices running M2M applications to the Internet via IP-based 2.5G and 3G cellular networks.

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Introduction

We are now in the third generation of computing, the so-called Post-PC generation. This third generation involves remote access over the Internet to non-PC devices such as industrial controllers, utility meters, vending machines, financial terminals, vehicles, and much more. A generic name for this computing is M2M, or machine-to-machine, communication.

We are also in the third generation of cellular communications. Connectivity of non-PC devices to Internet Protocol (IP)-enabled networks is rapidly becoming popular as the infrastructure grows for new IP-based cellular networks, such as the 2.5G (second-and-a-half generation) GPRS (General Packet Radio Service) network, and the 3G (third-generation) CDMA2000 network. Both networks use IP as the basic communication protocol. As usage of these cellular infrastructures becomes more popular, existing and new applications and hardware must be Internet-enabled in order to use a network.

The scope of this document is to explain the functionality of Connect One's iChip Internet Controller for enabling non-PC devices to use a 2.5G cellular network such as GPRS (General Packet Radio Service) or a 3G network such as CDMA2000 for machine-to-machine (M2M) applications.

2G (second generation) is the current generation of mobile phones, and includes such standards as GSM, TDMA and CDMA, which primarily transmit voice over a circuit-switched network. Data service is possible, such as SMS over GSM.

2.5G is a bridge between 2G and 3G. The term 2.5G ("second and a half generation") describes systems that provide faster services than 2G, but not quite as fast or advanced as newer 3G systems. 2.5G provides some of the benefits of 3G (i.e. it is packet-switched) and uses some of the existing 2G infrastructure. GPRS is an example of a 2.5G cellular standard.

3G is the next (third) generation of mobile telephony that will require a different infrastructure than 2G. It is packet-switched (faster and more efficient) rather than circuit-switched (slower and less efficient), and can transmit both voice (telephone calls) and non-voice data (such as email, video, and other large files). Examples of 3G standards include:

- **CDMA2000:** CDMA2000 is an upgrade to the original CDMA (Code Division Multiple Access) network and is an evolving standard with several phased implementations. *CDMA2000 1x* has the capability of using up to three separate 1.25 MHz channels for data transmission. *CDMA2000 1xRTT* uses one 1.25 MHz carrier for data transmission and supports packet speeds up to 144 kbps. *CDMA2000 1xEV-DO* (Evolution-Data Only) supports data rates up to 2.4 Mbps in a voice-only network, while *CDMA2000 1xEV-DV* (Evolution-Data and Voice), supports circuit and packet data rates up to 3-5 Mbps and fully integrates with 1xRTT voice networks.

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- **EDGE (*Enhanced Data Rates for GSM Evolution*):** EDGE uses the same TDMA (Time Division Multiple Access) frame structure, logic channel and 200 kHz carrier bandwidth as today's GSM networks, which allows existing cell plans to remain intact. EDGE provides a short-term upgrade path for GSM operators and directly competes with CDMA2000.
- **UMTS (*Universal Mobile Telecommunications System*):** Also called 3GSM, UMTS uses an alternative, incompatible form of CDMA2000, called W-CDMA (Wideband Code Division Multiple Access), as the underlying standard. A pair of 5 MHz channels is used to support data transfer rates up to 2 Mbps. The migration for GSM operators to UMTS is simple but costly. Most of the infrastructure may remain the same, but it is very expensive to obtain new spectrum licenses and to overlay UMTS at existing towers.

Since 2.5G and 3G networks are packet-based, they are most appropriate for using the Internet Protocol (IP) for data transmission. As such, they require the application and hardware (wireless modems and servers) to support the TCP/IP protocol stack. In order to use the IP-based network, at a minimum, a wireless modem must support PPP (point-to-point protocol) and the Internet Protocol.

Therefore, applications that will migrate to GPRS or CDMA2000 *must* be programmed or rewritten to include support for IP, PPP, TCP and/or UDP protocols. It may also be advisable to include support for "upper layer" application protocols above the TCP and UDP layers in the OSI seven-layer networking model.

A number of alternatives exist for IP-enabling an M2M application. Software libraries and shareware have long been available for developers who wish to add the TCP/IP protocol stack to their application as a "do-it-yourself" solution. Processor manufacturers are bundling TCP/IP stacks with their silicon. Wireless modem manufacturers have started to bundle support for TCP/IP in their modems. Internet controllers and Internet adapters enable customers to use their current application and hardware with minimum redesign and reprogramming and maximum flexibility.

In this paper, we will explain the various protocols used by the Internet and the structure of an IP-based cellular network, using GPRS as an example. We will show that Connect One's iChip is a robust and flexible solution that offers much more than just TCP/IP connectivity for applications that will use 2.5G and 3G networks.

Machine-to-Machine Messaging

The first generation of computing started in the 1950s with business computing, and was followed in the 1980s by the second generation of personal computing. The third generation of computing is dawning for machine-to-machine communication, commonly known as M2M. A huge market exists for Internet-based messaging among devices that are not PCs, as illustrated in this forecast for 2005.

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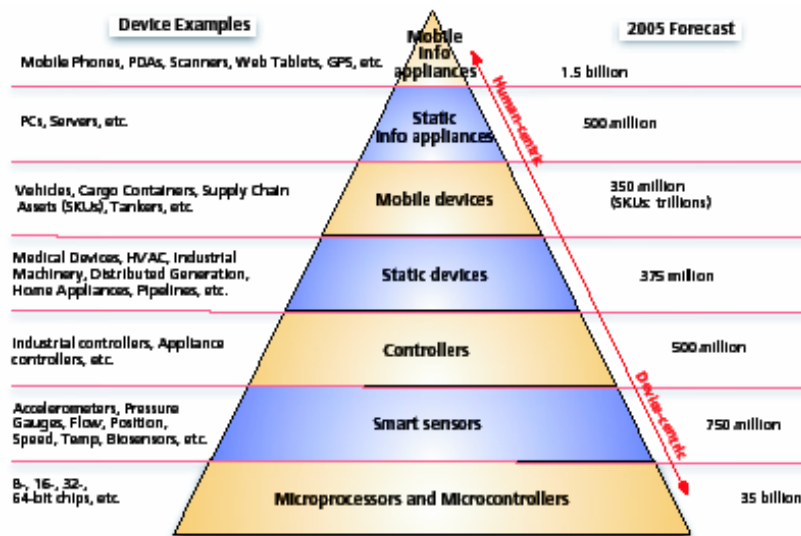


Figure 1: Projected 2005 Installed Base of Non-PC Devices
(Reprinted courtesy of Harbor Research)

Included in the category of communicating non-PC devices are home appliances, personal electronics, vehicles, financial terminals, machines, utility meters, medical devices, mobile terminals, transportable assets, information appliances, industrial controllers, security systems, building controls, telemetry devices and many other products with embedded microcontrollers. There are literally billions of these devices installed worldwide. Of course, not every device needs to communicate. But where there is a *real business need*, such as improving productivity or lowering the cost of service, communication or infrastructure, the Internet--as the global communication backbone--is the perfect medium for M2M communication.

The projected demand for M2M Internet connectivity is expected to explode between 2005 and 2010, as the following graph indicates:

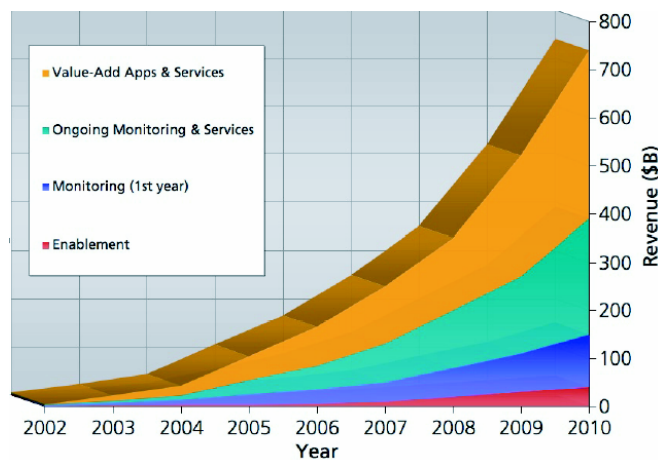


Figure 2: Projected Demand for M2M Internet Connectivity
(Reprinted courtesy of Harbor Research)

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About the GPRS Network

The most common methods used for data transfer are circuit switching and packet switching. In circuit-switched networks, a dedicated circuit is established across a sequence of links and then an entire channel is allocated to a single user for the duration of a call. With packet-switched transmission, the data is disassembled into small parts called packets that are then sent in sequence to the receiver, which reassembles the packets. This ensures that many different users can share the same link at the same time. The link is used only when there is data to be sent. When there is no data to send, the link may be used by another user.

The General Packet Radio Service (GPRS) network is a packet-switched data network. It uses the Internet Protocol to provide content and data services that are “always-on”, meaning that they are always accessible to the user. Since it uses the same protocols as the Internet, the GPRS network basically is a sub-network of the Internet, with GPRS-enabled devices functioning as mobile or fixed hosts. A GPRS node can be directly addressable, since potentially it can have its own IP address.

The GPRS network is built over the GSM (General System for Mobile communications) network infrastructure, which has a circuit-switched architecture and transmits data at 14.4 kbps. GSM technology is used by more than 72% of cellular users worldwide. In 2004, there were more than one billion GSM subscribers worldwide. GPRS is considered to be 2.5G, because it is packet-switched like 3G networks, but uses some of the existing 2G GSM infrastructure, but is several times slower than other 3G technologies. Because GPRS is backward-compatible with GSM, it eases the migration path for a GSM operator, who can gradually upgrade the infrastructure to GPRS as the market expands.

GPRS provides quick session setup and fast data transmission speeds--up to a theoretical maximum speed of 172.2 kbps when using all eight timeslots simultaneously. GPRS base stations and support nodes use the Internet Protocol for relaying messages. This requires that GPRS-enabled devices support PPP and IP.

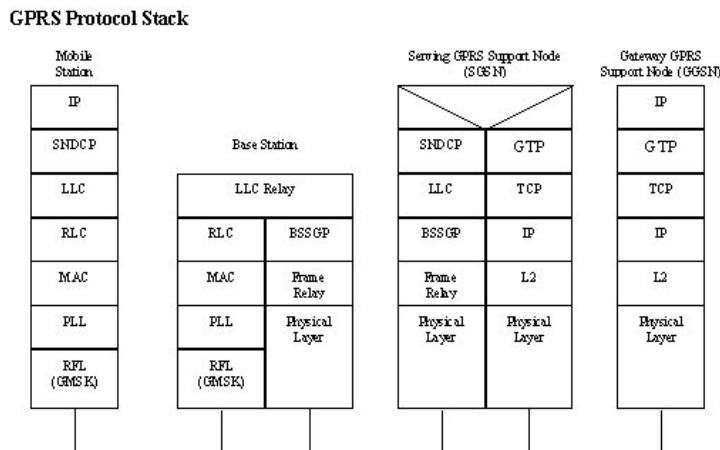


Figure 3: GPRS Protocol Stack

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In order to use the GPRS network, the user must:

- Subscribe to a wireless operator's GPRS service
- Have an IP-enabled GPRS terminal
- Configure the terminal for the GPRS network
- Know the IP address of the recipient
- Add support for TCP/IP into the application

The Internet and Internet Protocols

The Internet is a loosely organized, international collaboration of autonomous, interconnected networks that use TCP/IP as the protocol for host-to-host, peer-to-peer, and peer-to-host communication. Internet connectivity requires conformity with Internet standards by service providers who furnish access to the Internet, hardware manufacturers and software developers.

Because the Internet is based on open standards (as opposed to proprietary protocols), it offers the opportunity of a ubiquitous, low-cost medium for communication. With TCP/IP as the basic communication protocol, any company can develop a product that can interoperate and "talk" with products developed by other companies using TCP/IP. Thus, the Internet is the ideal medium for networking M2M applications. Since 2.5G and 3G networks use IP, wireless operators are basically Internet Service Providers (ISPs), providing IP connectivity for their wireless customers.

The Internet offers many methods to send and receive data, images, audio, video, and other files. The Open Systems Interconnection Reference Model classifies communication protocols, applications and physical media into seven layers, built one on top of the other. The model helps in understanding networks and in developing products that can communicate with each other. On the basic Transport layer of the OSI Reference Model, one can open TCP and UDP sockets between two points. On the Presentation Layer are the protocols that define ways of sending and receiving data according to certain IETF (Internet Engineering Task Force) standards known as RFCs (Requests for Comment). These standards include the FTP file transfer protocol; email protocols such as SMTP and POP3; Web protocols such as HTTP; and command protocols such as TELNET.

Using Internet Protocols in M2M Applications

Circuit-switched data transmission, such as SMS messaging over the GSM network, may be fine for transmitting small amounts of data or for monitoring of simple applications. But if there is a large amount of data, or a remote control application, the GPRS or CDMA2000 network is an ideal medium. A number of Internet protocols are available to choose from, each one suitable for different applications, depending on the amount of data, latency issues, and preferred delivery method.

The Internet offers the possibility to choose from a wide range of communication protocols that are suited for various applications. The basic protocol suite is referred to as the TCP/IP stack, because Internet communication is based on the Transmission Control Protocol (TCP), which is in turn based on the Internet Protocol (IP) that

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operates over the PPP protocol. These protocols together are known as the TCP/IP stack in a software application.

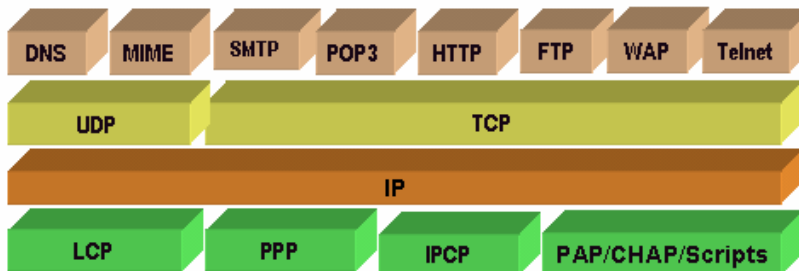


Figure 4: Internet Protocol stack for modem communication

The Challenge: Choosing an IP-Enabling solution

There are a number of issues associated with choosing an IP-enabling solution:

- Hardware design time
- Material cost
- Cost for development tools
- Application modification or development time
- Software development or acquisition cost
- Licensing fees or royalties (if applicable)
- Selecting the right protocol for your application
- Internet programming competence
- Mingling the Internet communication tasks with the host application
- Time-to-market
- Protocol maintenance

There also are a number of risks:

- Technological risk: Will the solution perform reliably under most conditions?
- Marketing risk: Will the solution come to market on time?
- Financial risk: Will the solution come in on budget?

There are five alternatives to implement Internet connectivity in the application, each of which carries a different level of risk:

1. Buy, develop or download a software stack, and program your application with the necessary Internet commands and configuration parameters;
2. Buy a microcontroller that includes TCP/IP protocols and runs the application;
3. Buy an TCP/IP-enabled wireless modem and add Internet commands and configuration parameters to the application;
4. Buy a standard wireless modem and add a wireless Internet adapter; and
5. Buy an Internet controller chip that offloads Internet tasks from the MCU.

Let's take a look at each of these alternatives.

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Develop, Buy or Download a Software Stack

An M2M device developer may be tempted to add the TCP/IP protocol stack to the application, especially if the application uses a 32-bit processor. However, there are technological, marketing, and financial risks associated with this option. If the developer's organization does not have embedded Internet programming expertise, this "do-it-yourself" solution may incur the risks of time and cost overrun, and the possibility that the solution may not function reliably in every network. This could add to the total cost of implementing the Internet-enabling solution.

If the design does not use a 32-bit processor, the host CPU may be underpowered to run the Internet protocols and the application simultaneously if there is a lot of data to send or if the processor is slow. It may be necessary to add additional memory to store the Internet protocols and add more buffers if the device does not have adequate memory resources and if more than sockets will be used. This may require a total hardware redesign of the product that needs to be TCP/IP-enabled. In any case, it is not recommended to mingle the application with the TCP/IP tasks, since the dynamic nature of the Internet requires frequent updating of the Internet protocols and configuration parameters.

Downloading shareware is particularly risky, because the developer will have to fine-tune and support the TCP/IP stack all by himself. There is no guarantee that the stack is a field-proven solution that will work in every network. Developing a software stack also is risky, since this is probably not the developer's expertise. In both these cases, the developer is reinventing the wheel. Buying a software stack is the least risky of these choices, but the developer will have to maintain the protocols by himself in order to provide the fastest support to his customers.

A reliable software solution requires that:

- The hardware must be designed and application programmed according to the planned use of the Internet protocols, and
- The Internet connectivity applications, protocols, and configuration parameters must be updateable and maintained continuously.

Microcontrollers with Bundled TCP/IP Protocols

Several manufacturers offer microcontrollers (MCUs) that include TCP/IP protocols and are designed to run the application simultaneously. Bundled solutions may be adequate for some MCUs and Internet connectivity tasks, but mingling the Internet protocols and application may degrade CPU performance. This depends on the microcontroller's processing power and speed, the amount of data to be transmitted, the protocols to be used, and if they are fully implemented. Because of limitations on internal chip memory and available processing power, the Internet protocols that the customer needs might not be supported or RFC-compliant. This may require the customer to incur additional application development time and cost. Since most MCUs have limited internal memory, it may be necessary to increase the target board's memory. Finally, because an MCU vendor's expertise is in silicon, not in TCP/IP, the amount and quality of support for the TCP/IP stack may be limited.

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TCP/IP-Enabled Wireless Modems

Most major manufacturers of wireless modems today offer modems with some implementation of TCP/IP. These modems still require the developer to add TCP/IP commands and configuration parameters to his application. In any case, the user must carefully evaluate the capability of the modem to perform the required TCP/IP tasks.

Some wireless modems enable the developer to write his application on the modem processor. This may be fine if the application is a new one, or if the user knows how to program his application in the language used by the modem (for example, Java in Siemens' TC45 or C in Sony Ericsson's GR47/48 and GT47/48). But if the application already exists, it does not make sense to rewrite the application on the modem. Also, if the developer does not have Internet programming expertise, this is a time-consuming and inefficient choice. Most wireless modems have a limited amount of memory and therefore include a minimal implementation of the TCP/IP stack. They also do not offer the user much flexibility or control over the connection. Therefore they require a great deal of development work in order to assure reliable connectivity.

Although TCP/IP-enabled modems are a relatively risk-free alternative, there are many limitations and questions to ask the modem vendor:

- Does the modem manufacturer have expertise in TCP/IP connectivity?
- The manufacturer's expertise is in designing and manufacturing modems, not in developing robust, reliable IP connectivity solutions.
- Does the modem support all the Internet protocols and features that are needed?
- Not all modems support TCP and UDP sockets. Most modems do not include listening sockets that permit a device to act as a server. Most modems do not support any upper layer protocols above TCP and UDP. Not all modems are compliant with industry-standard RFCs, because the entire protocol stack may not fit into the modem's available memory. Not all modems include PING to prevent the modem from timing out and to poll remote IP addresses.
- Can the modem open more than one socket at a time?
- This is important in applications that require multi-tasking, such as meter reading, where parameters must be checked or changed on-the-fly and data must be downloaded or uploaded in the same session. Most modems cannot do this.
- Can the TCP/IP stack firmware be updated?
- Internet protocol implementation is constantly changing from ISP to ISP and from server to server. New standards and security methods are constantly evolving. Updateable firmware is a must. Remote updateability is advisable.
- Does the modem's CPU have adequate processing power to run the TCP/IP stack and perform communication tasks simultaneously?

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- Transmission time may increase and packets may be lost due to timeouts if the modem has an underpowered CPU. This may be a serious issue if the modem processor runs the device application and Internet protocols simultaneously.

- Are the modem's buffers large enough to handle the incoming and outgoing data without losing packets?
 - *Applications with a lot of data to transmit may not be appropriate for all modems. Slow networks may also require large buffers on the modem.*
- Can the modem check if it's offline and automatically reconnect to the network?
 - *Most modems don't have a mechanism to promptly detect if they are offline and may be disconnected for a long time until they report an error.*
- Can I use the modem in plug-and-play mode so that I do not have to modify the hardware or application of devices that are already deployed in the field?
 - *Most modems with embedded TCP/IP do not include a plug-and-play mode. Therefore, it may be impossible to retrofit deployed devices without modifying the application and/or hardware.*
- Can I move from one modem to another without modifying my application?
 - *Not necessarily. Each modem manufacturer does its own proprietary implementation of the TCP/IP stack. So, if one wants to move from one modem vendor to another, or even use different modems from the same vendor, you may need to modify the application for it to work with the new TCP/IP stack.*
- Can the modem access a device that has a dynamic IP address and sits behind a firewall or NAT (Network Address Translator)?
 - *Not necessarily. Devices usually do not receive public IP addresses or fixed IP addresses. Instead they receive dynamic addresses that change per session. Also, wireless networks use firewalls and NATs to prohibit access from outside the network. Unless the modem includes a method (like a registration server) to discover and connect to the dynamic IP address of a device on a protected network, the device cannot be accessed from outside the network or subnet.*
- Do I (the user) have the resources (time, staff and knowledge) to program and maintain my application for reliable, stable TCP/IP connectivity regardless of where my products are deployed?
 - *Regardless of whether the modem contains some implementation of the TCP/IP protocol stack, you still must program and maintain the IP connectivity tasks in your application in order to use an IP-based cellular network. Will the modem and your application work reliably in all environments, and with all wireless operators? Do you really want to become an Internet expert?*
- Can I expect the modem manufacturer or distributor to support me if I have trouble with the TCP/IP connection?

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- The modem manufacturer or distributor may not have the expertise or incentive to provide support for every customer and every cellular network.

Standard Wireless Modems and Internet Adapters

An alternative to buying an IP-enabled wireless modem is to use a standard wireless modem with an Internet adapter, which provides the IP connectivity. In this case, the customer can choose the most suitable wireless modem from the many modem manufacturers. This solution is practical where the customer does not want to change his current modem or application, or if the functionality available on IP-enabled modems does not meet his requirements. Since this solution is more expensive than an IP-enabled modem, the Internet adapter must offer higher functionality.

Internet Controllers

Just as there are controller chips that offload certain functions from a host processor, such as VGA, DMA, and interrupt controllers, an Internet controller offloads Internet communication tasks from the host processor. The role of the Internet controller is to mediate the connection between the host and the Internet via the physical medium.

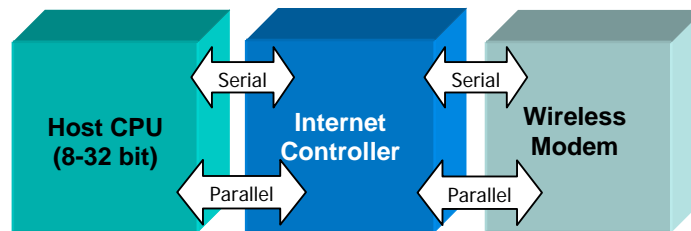


Figure 5: Internet Controller block diagram

An Internet controller enables the developer to modify his existing design with minimal changes to the hardware and minimal or no change to the application. He can use the existing processor, memory, and application, and just add a few commands to set the Internet configuration parameters and to activate Internet communications.

The iChip Internet Controller

The iChip Internet Controller is a family of robust and versatile IP communication co-processors that is designed to operate in unpredictable network environments. iChip has been operating reliably in hundreds of thousands of devices since 1999, and is functioning in more than 50 countries with hundreds of ISPs and wireless operators. There are several iChip sub-families. For details on the various iChips, please see the “iChip Family Comparison Chart” at the end of this White Paper.



Figure 6: iChip
CO110PC (LQFP48)



Figure 7: iChip
CO210AG/CO710AG (121-ball uBGA)

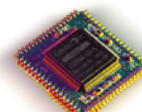


Figure 8: iChip
CO561AD/CO661AL (PLCC68)

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iChip offloads Internet connectivity tasks from a host processor, enabling it to exclusively and efficiently run the device application. iChip enables the customer to utilize his current application and operating system, and to focus on his expertise, which is the device itself. It eliminates the possibility of having to update the operating system, CPU, and memory in case the customer wishes to add new Internet functionality or protocol support to his application in the future. It eliminates the need for a major rewrite of the application.

iChip works with *any* host processor, *any* (or no) host operating system, and *any* wireless modem that supports the industry-standard Hayes AT command set. Its function is to echo modem commands back to the host processor and to manage the modem connection between the host processor and the IP-based network. Connect One developed its own Internet protocol stack and RTOS to run the Internet protocols on iChip. The result is a flexible, dependable, highly optimized, and efficient TCP/IP communication controller that is a “drop-in” IP networking solution for any current or future requirement and offers much more than just basic TCP/IP connectivity.

iChip includes on-board, updateable flash memory that stores the protocols that are used for accessing the Internet, including PPP, IP, TCP, UDP, SMTP, POP3, MIME, HTTP, WAP, FTP and TELNET. In addition, iChip’s flash memory stores the parameters that are required for configuring the cellular modem to dial the wireless operator’s access number and to log onto the cellular network. The firmware in all iChips can be remotely updated over the Internet, except for CO110PC, which is locally updateable. *This is particularly important, considering the unstable nature of IP-based networks and the ever-changing firmware version in many cellular modems.*

iChip supports a wide range of cellular modems. Customers can move from one modem model or manufacturer to another with very little effort, since iChip is portable and has a consistent user interface. Migrating to 2.5G or 3G is effortless, since iChip’s firmware is constantly being enhanced to support new networks, modems, and connectivity features. iChip includes many features designed to enhance cellular network reliability. For example, it includes automatic IP registration, so that devices with dynamic IP addresses can be accessed from outside the network or subnet. It also includes a “connectivity watchdog” that monitors the cellular connection and will automatically reconnect to the network in case of disconnection. It makes sure that sessions are properly terminated. It also permits sending AT commands to the modem during an Internet session, without interrupting the session.

The AT+i Command Set

The logical interface between the iChip Internet controller and the host processor is the unique AT+i™ command set developed and pioneered by Connect One. AT+i permits IP-enabling an application with minimal or no effort, because commands are intuitive and written in simple ASCII text. Just a few lines of code need to be added to the application. AT commands written for existing applications transparently pass through iChip to the modem. Commands for accessing the Internet written with the “AT+i” prefix instruct iChip to put the modem into Internet mode. The AT+i protocol is expandable, facilitating new IP protocol support and functionality on-the-fly.

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A key feature of the AT+i protocol is a plug-and-play operating mode called SerialNET, which is perfect for retrofitting installed legacy devices with TCP/IP capability. With SerialNET mode, the host does not need to be AT or AT+i aware. Absolutely *no* modifications are required on the host application. SerialNET is a two-way mode. The host processor can stream data to iChip, which packetizes it and sends it via TCP or UDP to a remote IP address. Alternatively, iChip de-packetizes data coming from a remote system and streams it to the host. iChip includes ample buffering to ensure that no data is lost when connecting or terminating active sockets.

It's easy to add GPRS commands to the application with the AT+i protocol. Just set iChip for blind dialing, define the modem type, enter the Modem Initialization String (MIS), and suppress the ATZ option (if required by the wireless modem). Then set the APN (Access Point Name), which allows the subscriber to connect to the wireless network. Then set the ISP configuration parameters as for any dial-up modem.

iConnector Internet Adapter

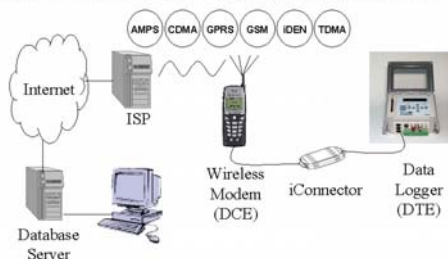


Figure 9: iConnector

iConnector is a plug-and-play adapter that IP-enables deployed devices or to devices that cannot be redesigned. It eliminates the need for any modification to the host device hardware or application. iConnector includes iChip and works seamlessly with any device that has an RS-232 serial port and any wireless modem that supports the Hayes AT command set.

iConnector is perfect for devices that do not currently include support for the AT command set (such as programmable logic controllers) or devices that do not currently include any remote communication. When operating in SerialNET mode, iConnector provides RS-232 emulation to the host device as it connects to a remote IP address. iConnector attaches to the host serial port via a male or female DB-9 connector, and connects to the wireless terminal or data-enabled phone via a male DB-9 connector. iConnector may be powered through pin 9 of the DB-9 connector to the host device, or via an external power source. Models are available for operation in the commercial or extended temperature ranges.

iConnector Female-Male Configuration



iConnector Male-Male Configuration

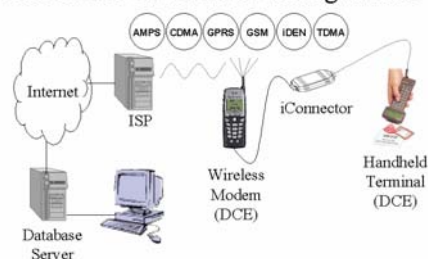


Figure 10: iConnector Configuration Alternatives

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iChip's IP Connectivity Features

Following are some of the many iChip functions that enable flexible and reliable connectivity to IP networks. Complete information on these features can be read in the AT+i Programmer's Manual at www.connectone.com/html/manuals.asp.

Function	Benefit
TCP/UDP Sockets	Ten simultaneous active TCP or UDP sockets enable many concurrent tasks.
Listening Sockets	Two simultaneous TCP listening sockets enable iChip to act as a server. Up to 10 active sockets in backlog.
SerialNET Mode	Plug-and-play mode for IP-enabling any RS232 device without modifying the host application or hardware.
Textual Email Send	Send standard ASCII text emails.
Binary Email Send	Send standard MIME-encoded attachments. No limit on number or size of binary attachments.
Email Receive	Retrieve entire message with or without headers, leave message on server or delete from server.
Web Server ¹	Includes two internal Web sites: one used by the application and one to configure and update iChip firmware. Web/WAP sites can be created by standard Web authoring tools, and can be uploaded to iChip via iChip's Web site packing tool. Web sites are password-protected by MD-5 encryption.
RAS Server	Dialing into iChip enables remote client to connect over PPP, browse iChip's Web site and open sockets to exchange data with iChip.
FTP Client	Enables transfer of large files and accessing/modifying directories and files on remote FTP servers.
TELNET Client	Open a TELNET session, send a line or a data stream, flush the socket's outbound data, or receive data.
Remote Firmware and Parameter Updates ¹	Use sockets, email or the Web to update firmware and parameter settings. Remote iChip parameter updates are password-protected using MD-5 encryption.
Dialer Scheduling	Schedule the number of redial attempts and time interval between each attempt.
Status Reporting	iChip provides detailed status reports.
PING	Assures the "always-online" connection and informs whether a remote device is online.
Hardware and Software Flow Control	Balances data flow over host-to-iChip and iChip-to-modem connections.
Ring Response Server	Enables iChip with a dynamic IP address to wake-up upon receiving a call and to dial a predetermined access number and to notify its IP address.
Network Time	Gets network time from standard time servers. Important for stamping time and day on outgoing emails, for scheduling according to the correct time of day, and for synchronizing host clocks across the Internet.

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Function	Benefit
Automatic IP Registration	Overcomes the problem of dynamic IP addresses. When going online, iChip automatically reports its host name, port number and dynamic IP address to a socket server, mailbox or Web registration page. Once registered, clients may query the servers in order to retrieve iChip's current IP address.
Always On-line Mode	iChip includes a "connectivity watchdog" that monitors the cellular network connection and automatically reconnects if necessary.
Automatic Reconnect	In case of a lost carrier, iChip establishes a new PPP link. iChip immediately goes online after a power-up cycle and can register its IP address. After going online, iChip's Web server can be configured to activate automatically.
Interlaced AT Commands	AT commands can be sent to the modem during an Internet session, without interrupting the session. iChip will wait for the modem to reply before restoring online mode.
Remote AT+i Commands	Send AT+i commands to an iChip from a remote device across the Internet. Enables remote configuration.

Note 1: Available on all chips except CO110PC.

iChip-Compatible GPRS Modems and Handsets

Connect One's customers are using iChip and iConnector with wireless modems from all the major manufacturers of GPRS modems and handsets. A partial listing of iChip-compatible GPRS modems, terminals, and handsets, as of this date, includes:

Cellon CMS-91	Siemens MC35i/MC35iT
Falcom A3Di (includes iChip)	Siemens MC45
Falcom F35i (includes iChip)	Siemens S45
Motorola P7389i	Siemens M50
Motorola G18	Siemens 3618/6618
Motorola G20	Sony Ericsson GM47/GM48
Nokia M30	Sony Ericsson T160
Nokia 6310i	Wavecom Fastrack M1203
Novatel G201	Wavecom Fastrack M1206
Novatel G301	Wavecom Integra
Sagem X8200 F195	Wavecom Q2403A/B
Siemens MC35/MC35T	Wavecom WMOi3-2

iChip-Compatible CDMA2000 Modems and Handsets

Connect One's customers are using iChip and iConnector with these CDMA2000 modems, terminals, and handsets:

AnyData DT2000	Wavecom Q2338
Hyundai HX-510B	Wavecom Q2358C

iChip Family Comparison Chart

	CO110PC	CO210AG	CO561AD	CO661AL	CO710AG
Positioning	Minimal features, lowest-cost solution, designed to optimize performance of 2.5G and 3G (GPRS and CDMA2000) cellular modems, with locally updated firmware. <i>Supports TCP/UDP sockets (plus SMTP & FTP client, or SerialNET¹ optionally).</i>	Full-featured, 3.3-volt designs. Lower-cost version of CO710 (pin-compatible), with locally updated firmware. <i>Supports upper layer protocols, TCP/UDP sockets, and SerialNET¹.</i>	Full-featured, 5-volt designs requiring remotely updateable firmware. <i>Supports upper layer protocols, TCP/UDP sockets, and SerialNET¹.</i>	Full-featured, 3.3-volt designs, requiring remotely updateable firmware, lower power consumption, higher bandwidth. <i>Supports upper layer protocols, TCP/UDP sockets, and SerialNET¹.</i>	Full-featured, 3.3-volt designs, requiring remotely updateable firmware, small size, high performance, low power consumption, highest bandwidth. <i>Supports upper layer protocols, TCP/UDP sockets, and SerialNET¹.</i>
Communication Platforms	Dial-up/Wireless Modem	Dial-up/Wireless Modem, 802.11b WLAN, 10 & 10/100BaseT LAN	CO561AD-S: Dial-up/Wireless Modem CO561AD-L: 10BaseT LAN CO561AD-D: Dial-up, Wireless and LAN	CO661AL-S: Dial-up/Wireless Modem CO661AL-L: 10 & 10/100BaseT LAN CO661AL-D: Dial-up, Wireless and LAN	Dial-up/Wireless Modem, 802.11b WLAN, 10 & 10/100BaseT LAN
Internet Protocol Support	PPP, IP, TCP, UDP, IPCP, DNS, PING, HTTP client (optional SMTP client, FTP client, and SerialNET)	PPP, IP, TCP, UDP, ICMP, IPCP, ARP, DNS, PING, DHCP, MIME, SMTP, POP3, HTTP, WAP, FTP, TELNET, SerialNET	PPP, IP, TCP, UDP, ICMP, IPCP, ARP, DNS, PING, DHCP, MIME, SMTP, POP3, HTTP, WAP, FTP, TELNET, SerialNET	PPP, IP, TCP, UDP, ICMP, IPCP, ARP, DNS, PING, DHCP, MIME, SMTP, POP3, HTTP, WAP, FTP, TELNET, SerialNET	PPP, IP, TCP, UDP, ICMP, IPCP, ARP, DNS, PING, DHCP, MIME, SMTP, POP3, HTTP, WAP, FTP, TELNET, SerialNET
Package	LQFP 48-pins	121-ball Micro BGA (uBGA)	PLCC 68-pins	PLCC 68-pins	121-ball Micro BGA (uBGA)
Size	7 x 7 mm (0.275 x 0.275 in.)	10 x 10 mm (0.393 x 0.393 in)	25.2 x 25.2 mm (0.995 x 0.995 in.)	25.2 x 25.2 mm (0.995 x 0.995 in.)	10 x 10 mm (0.393 x 0.393 in)
Processor	ARM7TDMI	ARM7TDMI	186	ARM7TDMI	ARM7TDMI
Flash Memory	128KB	512KB	512KB	512KB	1024KB

	CO110PC	CO210AG	CO561AD	CO661AL	CO710AG
SRAM	64KB	256KB	128KB	128KB	256KB
Clock Speed	Up to 60 MHz	Up to 66.6666 MHz	18.432 MHz	18.432 MHz	Up to 66.6666 MHz
Voltage	I/O: 3.3v (5v tolerant) Core: 1.8v	I/O: 3.3v Core: 1.8v	3.3v and 5v	3.3v (5v tolerant)	I/O: 3.3v Core: 1.8v
Power Current (Operating Mode) ²	30mA from VDDcore (typ.) 600uA from VDDi/o (typ.)	10mA from VDDcore 50mA from VDDi/o	3.3-volts: 70 mA (typ.), 80 mA (max.) 5-volts: 160 mA (typ.), 220 mA (max.)	30 mA	10mA from VDDcore 50mA from VDDi/o
Power Current (Power Save Mode) ²	Not Available	2.4mA from VDDcore 18mA from VDDi/o	Not Available	10 mA	2.4mA from VDDcore 18mA from VDDi/o
Power Current (Sleep Mode) ³	10uA from VDDcore (typ.) 500uA from VDDcore (max.)	Not Available	Not Available	<1 mA	Not Available
Temperature Range	Industrial (-40°C to 85°C)	Industrial (-40°C to 85°C)	Commercial (0°C to 70°C)	CO661AL-x/20PC-3: Commercial CO661AL-x/20PX-3: Extended (not rated)	Industrial (-40°C to 85°C)
Serial host interface speed	230.4k bits/sec	230.4k bits/sec	115.2k bits/sec	230.4k bits/sec	230.4k bits/sec

Note 1: SerialNET provides serial-to-IP bridging

Note 2: Based on 33.333MHz clock for CO710AG and CO210AG

Note 3: Based on 85°C (185°F)

Specifications are subject to change without notice.

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About Connect One

Connect One was established in 1996 with the goal of simplifying the task of connecting non-PC devices to the Internet. To implement this vision, Connect One includes a team of experts in embedded systems, networking, Internet connectivity and data communications protocols, whose expertise is in interfacing data communication protocols with Internet protocols. By enabling devices to tap into the Internet's ubiquitous global infrastructure, Connect One makes it possible for manufacturers, system integrators, wireless operators, and end-users to eliminate the time, cost and complexity of connecting their devices to the Internet.

Unlike other companies in the embedded Internet sphere, Connect One's expertise derives from its experience on the device side. Having spent almost all of its initial four years in development of an Internet fax appliance, Connect One understands the complexity of connecting a device to a myriad of Internet Server Providers, wireless operators, and telephone systems worldwide. The company has applied this knowledge on the system and embedded level, embodied in the most robust, flexible and economical Internet chips and plug-and-play, stand-alone products available today.

Connect One's products have been designed into products and operate with systems that typically have limited internal resources (e.g. processing power and memory). Typical products include point-of-sales (POS) terminals, fleet management terminals, fax machines, security systems, medical devices, data loggers, programmable logic controllers, HVAC systems, environmental monitors, vending machines, and utility meters.

Connect One's technology provides these and other devices with a wide range of benefits, such as remote diagnostics, maintenance, firmware downloads, data collection, remote monitoring and management. The benefit to manufacturers and consumers is that products that are Internet-enabled offer enhanced functionality, longer product lives, reduced infrastructure, and lower operating costs.

The company's products are distributed worldwide by leading distributors of electronic components and wireless modems. Connect One is privately owned, with offices in Phoenix, AZ and Kfar Saba, Israel. For further information, please visit the company's Web site at <http://www.connectone.com> or send an email to info@connectone.com. iChip, Internet Controller, AT+i, SerialNET, iConnector, Instant Internet, and Connect One are trademarks of Connect One Ltd.