Product Description

Tmote Connect software allows a Linksys NSLU2 Network Attached Storage device to function as a gateway appliance, connecting Tmote wireless sensor modules to a wired local area network. Each Tmote wireless module connected to a gateway appliance can be remotely administered through a concise web-based graphical user interface. Tmote Connect integrates quickly and conveniently with TinyOS and provides control over remotely connected Tmote wireless sensor modules.

Key Features

Tmote Connect Software includes:

- Bridging between Tmote wireless networks and Ethernet infrastructure.
- Support for up to 2 Tmote wireless modules per Tmote Connect gateway.
- Bi-directional connectivity for data transfers to and from Tmote wireless modules over TCP/IP sockets.
- Flash reprogramming of Tmote wireless modules remotely using standard in-system programming protocols.
- Integration with TinyOS development system and tools (Both TinyOS 1.x and 2.x).
- Web-based status interface – mote identification, reset, and performance counters.
- Operates in networks with and without DHCP support.
- Field upgradeable for new software features from Moteiv.

*Tmote Sky modules sold separately
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**DISCLAIMER:** Moteiv provides Tmote Connect software as a replacement for the default software shipped with the Linksys NSLU2 network attached storage unit. By purchasing Tmote Connect from Moteiv, the customer acknowledges that Tmote Connect software voids the Linksys/Cisco NSLU2 warranty. Moteiv, independently from Linksys/Cisco, provides support for Tmote Connect and a supplemental warranty. See page 14 for additional information.
Setup Information
This section describes how to integrate Tmote Connect into your local area network. Tmote Connect is designed to work both with DHCP and without DHCP. DHCP is preferred for all Tmote Connect installations; whereas non-DHCP operation may be suitable for small installations on private networks.

Package Contents
1. Linksys NSLU2 unit with Moteiv Tmote Connect software
2. Ethernet Cable (6ft length)
3. 110V AC to 5V DC power adapter
4. Tmote Connect datasheet (this document)

Optional Accessories available from Moteiv
1. Power-over-Ethernet 802.3af Adaptor Kit
2. Moteiv 1 meter USB A-A extension cables

Connecting Tmote Connect to your network
1. Make a note of the Tmote Connect hostname and MAC address found on the bottom of the enclosure. If the label displays a MAC address (00:04:5A:xx:yy:zz, 00:0F:66:xx:yy:zz, or 00:13:10:xx:yy:zz) then the resulting hostname is LKGxxyyzz. If the label displays a hostname in the form LKGxxyyzz, then the full MAC address is the combination of xx:yy:zz with one of the above MAC address prefixes (ie: 00:04:5A:xx:yy:zz).
2. Attach the Tmote Connect’s Ethernet port to your hub, switch, or Ethernet outlet with the included Ethernet cable
3. Connect your Tmote Sky modules to the USB ports
4. Attach the Tmote Connect’s power port to an electrical output with the included power cord
5. Tmote Connect will automatically power on when the power cord is connected
6. Tmote Connect will run a self test followed by a boot process. When it is ready to be accessed it will beep once.
7. If a Tmote Sky module is connected to the “Disk 1” port, then the Disk 1 LED will be lit; likewise, if a Tmote Sky module is connected to the “Disk 2” port, then the Disk 2 LED will be lit.

Installation on DHCP-enabled networks
If your DHCP server integrates the client hostname into the naming service (Dynamic DNS), the task of finding Tmote Connect on your network is easy – it is simply assigned the hostname LKGxxyyzz that you noted in step 1 of the installation. If your DHCP server does not communicate with the naming service (as is the case with many of the inexpensive consumer gateways) or uses a different naming scheme, you must access your DHCP server’s client data. Most DHCP servers, including devices from Linksys and other major manufacturers, provide a mapping table with the IP address and hostname of the connected Tmote Connect device using MAC Addresses.
An example mapping from a Linksys Router is shown below:

Finding Tmote Connect on your network (for Linux users ONLY)
If you do not have access to the DHCP client data, you can still find the IP address of your Tmote Connect provided you are on the same network. You can discover the IP address of any particular computer connected to the network using arping utility from ftp://ftp.habets.pp.se/pub/synscan/arping-2.05.tar.gz:

```
arping 00:04:5A:xx:yy:zz
arping 00:0F:66:xx:yy:zz
arping 00:13:10:xx:yy:zz
```

using the MAC address you recorded in step 1 of the installation.

**NOTE:** There are several, slightly varying versions of arping available. In particular, arping included as part of the iputils package does not support pinging using the MAC address. arping is only supported on Unix platforms.

Operation without DHCP
Tmote Connect ships with DHCP support enabled by default, but can operate without it even in moderate size networks. In the absence of DHCP, Tmote Connect emits a series of “double-beeps” to signal that no DHCP lease has been granted. It then attempts to claim address 192.168.1.77. If there is a conflict at that address (for example, another Tmote Connect has already claimed it), the appliance will scan consecutive addresses until it finds an available address and claim it. After the initial connection, you can assign a static IP address to your Tmote Connect, see section “Tmote Connect Upgrades and Management” on page 10.

USB Extension cables to attach Tmote sky to Tmote Connect
Moteiv sells 1 meter USB A-A extension cables. You can order these cables from http://www.moteiv.com or via email at info@moteiv.com.

Belkin (www.belkin.com) and DCables (www.dcables.com) provide USB A-A extension cables of varying lengths.
Accessing Tmote Connect

Tmote Connect can be accessed through a number of interactive or non-interactive interfaces. All of the administrative tasks are accessible through a webpage interface running on port 80. The examples shown throughout this document are based on an interaction with Tmote Connect running at IP address 192.168.4.104; a Telos rev. A is connected to USB port 1 and a Tmote Sky is connected to USB port 2.

Tmote Connect GUI

The Tmote Connect webpage displays the type and serial number of each mote connected to the gateway and information about the gateway itself: hostname, IP address, and MAC address. It also displays information about packets transmitted to or received from each mote and the serial forwarder and control port numbers. By convention, port 900X is the Serial Forwarder port and port 1000X is the control/status port for a mote connected to USB port X. The web interface allows the user to individually reset each mote without breaking established serial forwarder connections, restart the server programs, and to reboot Tmote Connect.
Programming Motes

The programming code depends on the nc (netcat) utility that’s widely available on UNIX system. Precompiled versions of netcat 1.10 for Linux and Cygwin systems can be downloaded from the Moteiv support page at http://www.moteiv.com/support.php. Moteiv programming using Tmote Connect has been fully integrated into the TinyOS build system as of early May 2005. Users running release of TinyOS 1.1.12 or earlier should download the programming rules that allow for programming using Tmote Connect from the above support page. TinyOS 1.1.13 includes native support for Tmote Connect.

Users working with the TinyOS CVS repository from SourceForge, simply run

    cvs update

in your ${TOSDIR}/../tools/make directory to download the new programming rules.

Once the programming rules have been installed within the TinyOS distribution, Tmote Connect is ready to be used. To compile and install an application onto a particular mote, run:

    make tmote reinstall,2 netbsl,192.168.4.104:10002

The above command will install the program configured for mote id 2 at Tmote Connect module at address 192.168.4.104 on USB port 2. The arguments to netbsl can take a form of the standard IP:PORT or can be shorthanded to XX.1 and XX.2. The value XX will be prefixed with the value of NETBSL_HOSTPORT_PREFIX, which defaults to "192.168.1." for a full ip address of 192.168.1.XX; the shorthand port numbers “1” and “2” map to ports 10001 and 10002 used to program each Tmote Connect USB port.

Accessing Mote Data

The data connection to motes is provided using the Serial Forwarder protocol used extensively throughout the TinyOS distribution. All TinyOS java applications retrieve the connection information from an environment variable called MOTECOM. In our example, to connect listen to packets generated by the Oscilloscope application, run

    MOTECOM=sf@192.168.4.104:9002 java net.tinyos.tools.Listen

With this syntax we can quickly switch between different Serial Forwarder servers. MOTECOM variable can be made persistent for a shell session (e.g. when all connections are made to the same Serial Forwarder server) by executing:

    export MOTECOM=sf@192.168.4.104:9002
Tmote Connect Advanced Operations

This section describes the Tmote Connect control protocol for expert users. The protocol has been engineered for simplicity and readability rather than compatibility with existing standards (like HTTP) or security. All protocol transactions take a form of

Command line
Optional data
Optional trailer

After issuing the command, the client reads the response from the socket until the server closes the connection. The examples below use `nc` (netcat) utility to show protocols in action. Currently, the following protocol actions are supported:

status
quit
msp430-bsl
baudrate
protocol
unfriendly_system_reboot

Status

Various status parameters of the Tmote Connect control server can be obtained by connecting to the Control port and issuing a single line with the word “status”. The server returns a sequence of key value pairs, each on a separate line. Keys are limited to be a single word, the value begins after the initial space and extends until the end of the line. For example, to access the status of the server at IP address 192.168.4.104 connected to the mote on port 2, we could execute the following command

```
echo status | nc 192.168.4.104 10002
```

Programming Protocol

Tmote Connect’s programming protocol is based on msp430-bsl application. The command can be issued in the form:

```
echo “msp430-bsl <command-line-switches>” | nc 192.168.4.104 10002
```

Command line switches specify the device type to be accessed and a sequence of actions to perform. When a program is being uploaded to the mote, the above command is to be immediately followed by the program image in the IHEX format. The end-of-file is signified via a blank line. The server responds with a sequence of diagnostic messages that one see as an output from msp430-bsl.
The programming protocol supports the following actions:

- `e, --masserase` Mass Erase (clear all flash memory)
- `E, --erasecheck` Erase Check by file
- `p, --program` Program file
- `r, --reset` Reset connected MSP430. Starts application. This is a normal device reset and will start the program that is specified in the reset vector.
- `v, --verify` Verify by file

Don't forget to specify "e" or "eE" when programming flash!
The platforms are supported:

- `--tmote` Moteiv Tmote Sky
- `--telosb` Moteiv Telos rev. B
- `--telos` Moteiv Telos rev. A

**NOTE:** The Tmote Connect software does not auto detect the platform for programming access, so you must specify `--tmote`, `--telosb`, or `--telos`. If the control server responds with "NAK received", the user specified an incorrect platform (e.g. `--telosb` instead of `--telos`, or the platform was omitted altogether).

Additional options are available. You can access the help screen by specifying `-h` on the command line.

For example, the following command programmatically resets a Tmote Sky mote:

```
echo "msp430-bsl --tmote -r" |nc 192.168.4.104 10002
```

**Resetting the control server**
The control server runs within a respawning daemon. Command "quit" will exit the current control server instance, and the respawning daemon will start a new instance.

**Protocol and Baud Rate**
Tmote Connect (as of firmware version 1.2.0 and later) supports dynamic setting of the serial protocol and baudrate. The specific protocol can be set with the "protocol" command. Valid options for "protocol" are:

- `auto`
- `tinynos1.x`
- `tinynos2.x`

When a mote is inserted or reprogrammed, Tmote Connect will automatically try to detect the protocol version running on the connected mote if the "auto" protocol setting is selected. If detection fails, Tmote Connect defaults to `tinynos1.x`. If a specific protocol is specified (such as `tinynos1.x`), the autodetection process will not occur.
The baudrate may also be selected through the command interface. The option specified to the
“baudrate” command is any valid baudrate. Specifying "0" (zero) as the baudrate will cause
Tmote Connect to autodetect the baudrate based on protocol—in this case, 57600 baud is used
for TinyOS 1.x motes and 115200 baud is used for TinyOS 2.x motes. If the baudrate is
explicitly set to a number other than zero using the “baudrate” command, Tmote Connect will
use the specified baudrate regardless of the selected protocol.

The default setting of Tmote Connect is auto protocol detection and auto baudrate selection.
Protocol and baudrate settings are lost when Tmote Connect is rebooted or shutdown.

NOTE: Tmote Connect does not gracefully transition clients when a new protocol is
chosen. If the protocol is changed from TinyOS 1.x to TinyOS 2.x, all TinyOS 1.x clients
will be forcibly disconnected from Tmote Connect.

Restarting Tmote Connect device

On rare occasions, there may be a need to restart the Tmote Connect device. For those rare
occasions, the control interface supports the “unfriendly_system_reboot” command. This
command takes no arguments, cannot be revoked or cancelled, and produces a single line
of output confirming that the reboot will take place. Once you issue this command, Tmote
Connect should be available within a minute.
Tmote Connect Upgrades and Management

This section describes how to manage and upgrade Tmote Connect software with new software provided by Moteiv. Tmote Connect offers a web-based management console. The gateway hardware and the management software was created by Linksys, all troubleshooting questions regarding the operation of Tmote Connect must be directed to Moteiv Support (support@moteiv.com). Linksys does not provide support services for the NSLU2 units loaded with Tmote Connect software.

Managing Tmote Connect

Tmote Connect management interface is located under linksys.cgi page in the top level directory. The top-level page describes the basic properties of the device.

![Tmote Connect Management Interface](image)

Server Name: LKG7DD7D4
Version: V2.3R29
IP Address: 192.168.1.77
Disk 1: Not Installed
Disk 2/Flash: Not Installed
The “Administration” tab is useful for administering Tmote Connect network properties. It is password protected; by default access is granted to user “admin” with password “admin”. The “Administration” tab offers the ability to switch between DHCP and fixed IP addresses, change the hostname and workgroup information, as well as access status information.

NOTE: By using Tmote Connect software on the Linksys NSLU2 device, the NSLU2 no longer acts as a network attached storage unit. Network attached storage functionality (such as disk status information, user and group management, and UPnP) are not supported by Tmote Connect software.

(continued on the next page)
Upgrading Tmote Connect

You can access Tmote Connect upgrade page by going to Administration>Advanced>Upgrade tab in the Linksys management interface. Do not press the “Check for upgrade” box. Instead, download software from [http://www.moteiv.com/](http://www.moteiv.com/) to your local drive, and install it using the upgrade utility. The typical installation takes under 5 minutes. After clicking the “Start Upgrade” button, do **not** power-off the unit while it is being upgraded.

The Linksys “Current Firmware Version” text may not change; however, the Tmote Connect software revision is displayed on the main status webpage of the Tmote Connect unit.
General Information

Known Limitations
Tmote Connect software does not support certain capabilities of the Linksys/Cisco NSLU2 unit. Below is a short list of unsupported capabilities:

- USB 2.0 High-speed devices
- USB hubs
- USB 802.11 wireless adapters
- USB storage
- File sharing protocols are not supported

Document History

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<th>Revision</th>
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<tr>
<td>1.0</td>
<td>2005/05/18</td>
<td>Initial Release</td>
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<tr>
<td>1.0.1</td>
<td>2005/12/28</td>
<td>Updated for Tmote Connect software version 1.0.2</td>
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<td></td>
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<td>Updated software description, principles of use, and contact information</td>
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<tr>
<td>1.2.0</td>
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<td>Added additional protocol support (TinyOS 1.x and TinyOS 2.x)</td>
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<td></td>
<td></td>
<td>Updated data for firmware 1.2.0+, updated pictures and disclaimer</td>
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Address Information

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