HumPRO™ Series Transceiver Addressing Modes

Reference Guide RG-00105

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Introduction

The HumPRO™ Series transceiver module is designed for the reliable transfer of digital data. It offers powerful addressing modes that enable the creation of many different types of networks. This reference guide discusses the different addressing modes, where each is useful and how to configure them.

The HumPRO™ has three addressing modes and a compatibility mode for each one. The compatibility mode enables the HumPRO™ to communicate with the older 250 Series transceiver. This guide is divided up by each addressing mode. Compatibility operation for each mode is discussed at the end.

The three addressing modes are DSN, User and Extended User. Each mode offers different communications schemes, but all use source and destination addressing. The source address is for the transmitting unit, the destination address is the intended receiver.

Device Serial Number (DSN) Addressing Mode

DSN addressing mode is the simplest mode and supports point-to-point communications. Each module is programmed at the factory with a unique 4-byte serial number that cannot be changed. These bytes are found in the non-volatile read only MYDSN registers (MYDSN[3-0]). DSN addressing mode uses these bytes as an address. The transmitting unit's DSN is used as the source address and the intended receiver's DSN is written into the destination address registers (DESTDSN[3-0]) by the host microcontroller. All modules within range hear the transmission, but only the module with the DSN that matches the destination address outputs the data on its UART. All others ignore the transmission. This mode does not support broadcast messages. Figure 1 shows some examples of this addressing mode.

HumPRO™ Series Transceiver DSN Addressing Mode Examples

Sender			Receiver	
Addressing Mode	MYDSN	DESTDSN	MyDSN	Response
0x04 (DSN)	0x00001000	0xFFFFFFFF	0x00002000	Not processed – discarded.
			0x00003000	
0x14 (DSN + ACK)	0x00001000	0xFFFFFFFF	0x00002000	Not processed – discarded.
			0x00003000	
0x14 (DSN + ACK)	0x00001000	0x00003000	0x00002000	Not processed – discarded.
			0x00003000	Data output. RF ACK sent to 0x00001000
0x04 (DSN)	0x00001000	0x00002000	0x00002000	Data output. No RF ACK sent.
			0x00003000	Not processed – discarded.

Figure 1: HumPRO™ Series Transceiver DSN Addressing Mode Examples

DSN Addressing mode only supports point-to-point transmissions. Since all of the modules have a unique device serial number, this mode ensures that there will not be crossover between adjacent systems.

User Addressing Mode

User Addressing Mode allows the creation of broadcast groups in addition to point-to-point communication. It uses the customer ID bytes (CUSTID[1-0]) and two of the user destination bytes (UDESTID[1-0]) as a destination address. The customer ID bytes are programmed at the factory and cannot be changed. These are determined by the factory for specific customers to prevent their systems from operating with any other systems. Standard modules have a default Customer ID value of 0x7FFF. Contact Linx for more details.

The module's local address is contained in two of the user source ID registers (USRCID[1-0]). In this mode, USRCID [1-0] contain the module's address and USRCID [3-2] must be 0 in the receiver.

Each module has a user ID mask (UMASK[1-0]) that splits the 16 address bits into up to three groups to provide a network address and address fields for sub-networks, supporting both individual addressing and broadcast addressing within the network.

The groups are designated with contiguous bits within the user mask. Group 1 is designated by zeroes in the high order bits. The following series of one bits specify Group 2, followed by a series of zero bits for Group 3. The result of additional groups is undefined.

In User Addressing mode, UMASK[3-2] should both be set to 0x00. Figure 2 shows an example for UMASK[1-0].

HumPRO™ Series Transceiver User Mask Example

UMASK1								UMASK0							
Group 1					Group 2					Group 3					
0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0

Figure 2: HumPRO™ Series Transceiver User Mask Example

The groups can have any number of bits in each up to a total of 16. It is also possible to only have 1 group of all 16 bits or a combination for two groups.

This mask is compared to the destination address in the received packet. All of the destination bits designated by Group 1 in the mask must match the module's source address exactly.

The bits designated by Groups 2 and 3 must either match exactly or be all ones in the received destination address.

If acknowledgements are enabled, the received destination address must match the module's local source address in order for the acknowledgement to be sent. The mask is not used for this determination.

Figure 3 shows an example of User Addressing Mode.

HumPRO™ Series Transceiver User Addressing Mode Example																	
	Group 1					Group 2					Group 3						HEX
UMASK	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	07C0
Module's USRCID	0	0	0	1	0	0	1	0	0	0	1	1	0	1	0	0	1234
Received UDESTID	0	0	0	1	0	0	1	0	0	0	1	1	0	1	0	0	1234

Figure 3: HumPRO™ Series Transceiver User Addressing Mode Example

In this example, the received destination address matches the module's local source address, so the received data is output on the UART and, if requested, an RF acknowledgement is sent to the transmitting module. Figure 4 gives more examples of how the mask is used.

In this method, Group 1 essentially becomes a network ID and Groups 2 and 3 can be used as subnets. This addressing system enables the module to be used in many different network configurations. Point-to-point, star, tree and mesh networks are all possible with the module serving as the MAC/PHY layer and an external microcontroller handling address tables and routing.

HumPRO™ Series Transceiver User Addressing Mode Examples

Example 1

	Group 1					Group 2					Group 3						HEX
UMASK	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	07C0
Module's USRCID	0	0	0	1	0	0	1	0	0	0	1	1	0	1	0	0	1234
Received UDESTID	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	FFFF

This is a broadcast message from legacy 250 Series modules and HumPRO™ modules with compatible operation enabled. None of the groups match so no data is output on the UART and no ACK is sent.

Example 2

UMASK	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	07C0
Module's USRCID	0	0	0	1	0	0	1	0	0	0	1	1	0	1	0	0	1234
Received UDESTID	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	17FF

Group 1 matches and Groups 2 and 3 are all ones. This is a network broadcast message. The received data is output on the UART and no ACK is transmitted.

Example 3

UMASK	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	07C0
Module's USRCID	0	0	0	1	0	0	1	0	0	0	1	1	0	1	0	0	1234
Received UDESTID	0	0	0	1	0	0	1	0	0	0	1	1	1	1	1	1	123F

G1 and G2 match and G3 is all ones. This is a G3 subnet broadcast. The received data is output on the UART and no ACK is transmitted.

Example 4

UMASK	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	07C0
Module's USRCID	0	0	0	1	0	0	1	0	0	0	1	1	0	1	0	0	1234
Received UDESTID	0	0	0	1	0	1	1	1	1	1	1	1	0	1	0	0	17F4

G1 and G3 match, G2 is all ones. This is a G2 subnet broadcast. The received data is output on the UART and no ACK is transmitted.

Example 5

UMASK	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	07C0
Module's USRCID	0	0	0	1	0	0	1	0	0	0	1	1	0	1	0	0	1234
Received UDESTID	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1000

G1 matches, G2 and G3 do not match and are not all ones. No data is output on the UART and no ACK is sent.

Example 6

UMASK	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	07C0
Module's USRCID	0	0	0	1	0	0	1	0	0	0	1	1	0	1	0	0	1234
Received UDESTID	0	0	0	1	0	0	1	0	0	0	1	0	1	1	0	0	122C

G1 and G2 match, G3 does not match and is not all ones. No data is output on the UART and no ACK is sent.

Figure 4: HumPRO™ Series Transceiver User Addressing Mode Examples

Extended User Addressing Mode

Extended User Addressing Mode is identical to User Addressing Mode except that it uses all 32 bits in the user source ID registers (USRCID[3-0]), the user destination registers (UDESTID[3-0]) and the User ID mask (UMASK[3-0]). The customer ID bytes (CUSTID[1-0]) are also used.

This simply gives the ability for larger networks and more uniqueness by using larger address sizes. All of the examples in the previous section still apply.

Network Masking Selection

The HumPRO™ Series transceiver can be configured to disable some of the address mask selection so that messages with different addresses are output. This can be advantageous for devices that need to monitor traffic in multiple networks.

Setting the COMPAT register to 0x03 enables the reception of User Address and Extended User Address Messages sent with the COMPAT register setting of 0x02 or 0x03.

The message is accepted if the message destination address is an exact match of USRCID or if the group 1 bits from the message destination address match the group 1 bits from the USRCID. This allows the receiver to receive all messages transmitted with a common network address. Acknowledgements are sent if the message requests them and destination address is an exact match of USRCID.

A UMASK value of 0xFFFFFFFF has no group 1 bits and causes all User Address and Extended User Address messages to be accepted. The external microcontroller needs to parse the data and determine what actions to take, so there is much more code required when using this mode.

If encryption is enabled, the key in the receiver must match the key in the transmitter or the packet is discarded.

Compatibility Operation

The HumPRO™ has a compatibility operation that allows it to communicate with older 250 Series modules. The following sections describe this operation for each of the addressing modes.

DSN Addressing Mode in Compatibility Operation

Compatibility operation (COMPAT register = 0x00) adds a broadcast message to the normal operation. A broadcast message is created when the destination address is 0xFFFFFFFF. In this case, all modules within range output the data. Figure 5 shows examples in this mode.

HumPRO™ Series Transceiver DSN Addressing Mode in Compatibility Operation Examples

Sender			Receiver	
Addressing Mode	MYDSN	DESTDSN	MyDSN	Response
0x04 (DSN)	0x00001000	0xFFFFFFFF	0x00002000	Data output by both modules. No RF ACK sent by either module.
			0x00003000	
0x14 (DSN + ACK)	0x00001000	0xFFFFFFFF	0x00002000	Data output by both modules. No ACK sent by either module. This configuration causes transmission problems.
			0x00003000	
0x14 (DSN + ACK)	0x00001000	0x00003000	0x00002000	Not processed – discarded.
			0x00003000	Data output. RF ACK sent to 0x00001000
0x04 (DSN)	0x00001000	0x00002000	0x00002000	Data output. No RF ACK sent.
			0x00003000	Not processed – discarded.

Figure 5: HumPRO™ Series Transceiver DSN Addressing Mode in Compatibility Operation Examples

This feature adds a simple way to broadcast to all modules in a simple network at once. However, there is no way to distinguish among networks. All modules in rage using the same addressing mode and hopping pattern receive the broadcast message and output the data regardless of whether or not they are in the same system or network.

This can be mitigated by including network-specific information in the data payload. This allows the host microcontroller to perform additional checks on the received data to limit crossover from adjacent systems.

Initiating a broadcast message with acknowledgements enabled can cause transmission issues. The receivers do not send an acknowledgement when a broadcast message comes in. This prevents collisions as all receivers in the network try to acknowledge at once. However, the transmitter is expecting an acknowledgement and repeats the data transmission until it reaches the retry limit. At this point it throws an EX_NOACK exception error, reducing throughput with no benefit.

User Addressing Mode in Compatibility Operation

Compatibility operation (COMPAT register = 0x00) also uses the customer ID bytes (CUSTID[1-0]), the user source ID registers (USRCID[1-0]), and the user destination registers (UDESTID[1-0]) for addressing just as in the normal operation. However, the User ID mask (UMASK[1-0]) is used differently.

The receiving module calculates the logical AND of

1. the received destination address with the mask
2. the local user source address with the mask

If these results are equal, then the payload is output on the UART. The transmitted customer ID bytes must match the local value.

Additionally, if the result of the user ID Mask AND the received user destination address equals the user ID mask, then the payload data is output on the UART. This acts as a broadcast message to the network.

Symbolically, these conditions are

if ((M & D) == (M & A)) accept message
if ((M & D) == M) accept message

where M = UMASK, D = message destination, A = USRCID.

In general, acknowledgement is not recommended when sending messages to more than one unit. If enabled, only the receiver with an exact address match sends an ACK. Other receiving units may miss packets that were acknowledged by the responding receiver.

As an example, if the mask is 0xFFF0 and the destination address transmitted by the sender is 1234, then all modules with a source ID of 123x respond. This gives a subnet of 16 modules (where x = 0 to F) and acts as a broadcast message to the sub-net. Acknowledgements should be disabled. Figure 6 shows this example.

HumPRO™ Series Transceiver User Addressing Mode in Compatibility Operation Example

UMASK	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	FFF0
Module's USRCID	0	0	0	1	0	0	1	0	0	0	1	1	0	1	0	1	1235
Received UDESTID	0	0	0	1	0	0	1	0	0	0	1	1	0	1	0	0	1234
UMASK AND USRCID	0	0	0	1	0	0	1	0	0	0	1	1	0	0	0	0	1230
UMASK AND UDESTID	0	0	0	1	0	0	1	0	0	0	1	1	0	0	0	0	1230

The results of the AND operations are equal, so the data is output on the UART. Since this acts as a broadcast message to the subnetwork, acknowledgements should be disabled.

Figure 6: HumPRO™ Series Transceiver User Addressing Mode in Compatibility Operation Example

Figure 7 and Figure 8 show additional examples of this operation. Values in these figures are shown in hexadecimal format.

HumPRO™ Series Transceiver User Addressing Mode in Compatibility Operation Example 1					
Sender			Receiver		
Addressing Mode	USRCID	UDESTID	USRCID	UMASK	Response
06 (User)	1000	FFFF	2000	FFFF	Data output by both modules. No RF ACK sent by either module.
			3000	FFFF	
16 (User + ACK)	1000	FFFF	2000	FFFF	Data output by both modules. No ACK sent by either module. This configuration causes transmission problems.
			3000	FFFF	
16 (User + ACK)	1000	3000	2000	E000	Data output. No RF ACK sent.
			3000	E000	Data output. RF ACK sent to 0x1000
06 (User)	1000	3000	2000	F000	Not processed – discarded.
			3000	F000	Data output. No RF ACK sent.

Figure 7: HumPRO™ Series Transceiver User Addressing Mode in Compatibility Operation Example 1

HumPRO™ Series Transceiver User Addressing Mode in Compatibility Operation Example 2					
Received UDESTID	Module's USRCID	Module's UMASK	UMASK AND UDESTID	UMASK AND USRCID	Action
3000	2000	E000	2000	2000	The results are equal, so the payload is output on the UART.
	3000			2000	The results are equal, so the payload is output on the UART. The destination ID and the source ID match, so an ACK is transmitted if enabled.
	4000			4000	The results do not match, so the packet is discarded.
3000	2000	F000	3000	2000	The results do not match, so the packet is discarded.
	3000			3000	The results are equal, so the payload is output on the UART. The destination ID and the source ID match, so an ACK is transmitted if enabled.
	4000			4000	The results do not match, so the packet is discarded.
E000	2000	E000	E000	2000	The destination ID matches the user ID mask, so the data is output on the UART.
	3000			2000	
	4000			4000	

Figure 8: HumPRO™ Series Transceiver User Addressing Mode in Compatibility Operation Example 2

Extended User Addressing Mode in Compatibility Operation

Compatibility operation (COMPAT register = 0x00) in Extended User Addressing mode works the same way as User mode but uses all of the address bytes.

Communicating Between Modules with Different Configurations

The addressing mode should be set the same on both modules. There are only two times when a module in normal operation can communicate with a module in compatible operation:

1. When DSN addressing is used and the address matches exactly

2. A module in normal operation transmits in DSN mode and a module in compatible operation receives with mask of all ones.

Network Types

The addressing methods offered by the HumPRO™ allow for a variety of network topologies to be created. The modules themselves do not implement anything more than a point-to-point link. An external microcontroller is required to implement the higher level layers of a network stack, including routing and address tables.

Since the routing and address tables are not stored inside the modules, their internal memory does not limit the number of possible nodes in the network. The external microcontroller can be sized for processing power and memory appropriate for the application.

Point-To-Point Network

The simplest network is the point-to-point network. This has two modules (or nodes) that only talk to each other.

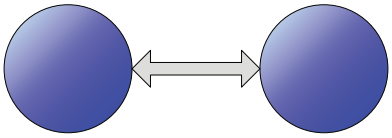

Figure 9: Point-to-Point Network

DSN Addressing Mode is the best for this. The DESTDSN[3-0] registers are programmed with the other module's DSN address and they only communicate with each other. User and Extended User addressing modes also support this network type, but requires more setup and requires the end user or manufacturer to maintain the addresses.

Star Network

A step up from point-to-point is a star network.

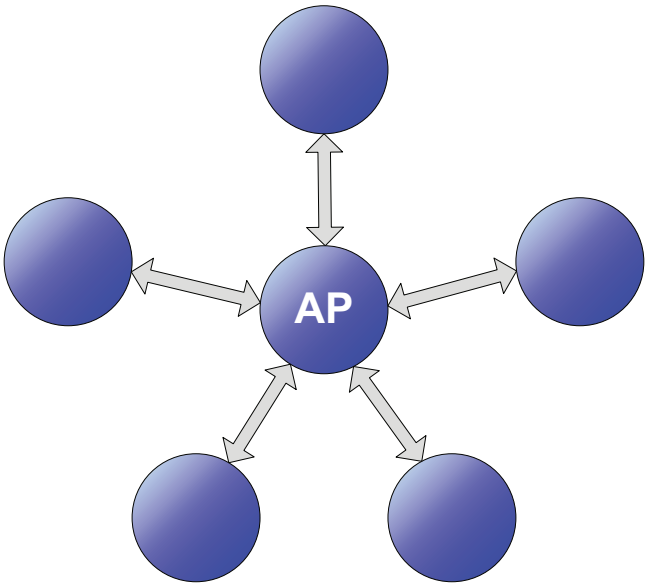

Figure 10: Star Network

In a star topology, each node has a point-to-point connection to a central node,

called the Access Point (AP) in this document. All of the traffic that transverses the network passes through the AP. The AP is generally in a gateway or bridge so that it can pass the data out of the network. This could be a USB link to a PC or some other link to a cloud server.

DSN Addressing Mode can be used to establish a star network. An external microcontroller in the AP maintains a table of the addresses of all of the modules in the network. It writes the DSN address of the module it needs to communicate with to the DESTDSN registers of the module in the AP and initiates a transmission. Each node has the address of only the AP in its DESTDSN registers. This is fairly simple to set up, but there is not a way to broadcast to all of the nodes at the same time.

User and Extended User Addressing Modes can be used in much the same way except that the UMASK provides a way of having a broadcast to the entire network. Further, it provides a way of setting a network ID so that adjacent networks do not inadvertently communicate with each other.

By setting the UMASK so that group 1 is the network ID and group 2 is the remaining bits the module can be made to output all data transmitted in the network. An external microcontroller can then write that data back into the module to retransmit it, creating a range extender. This allows the network to cover a larger physical area since the range extender can now communicate with nodes that are out of range of the AP. This kind of network is called an extended star network.

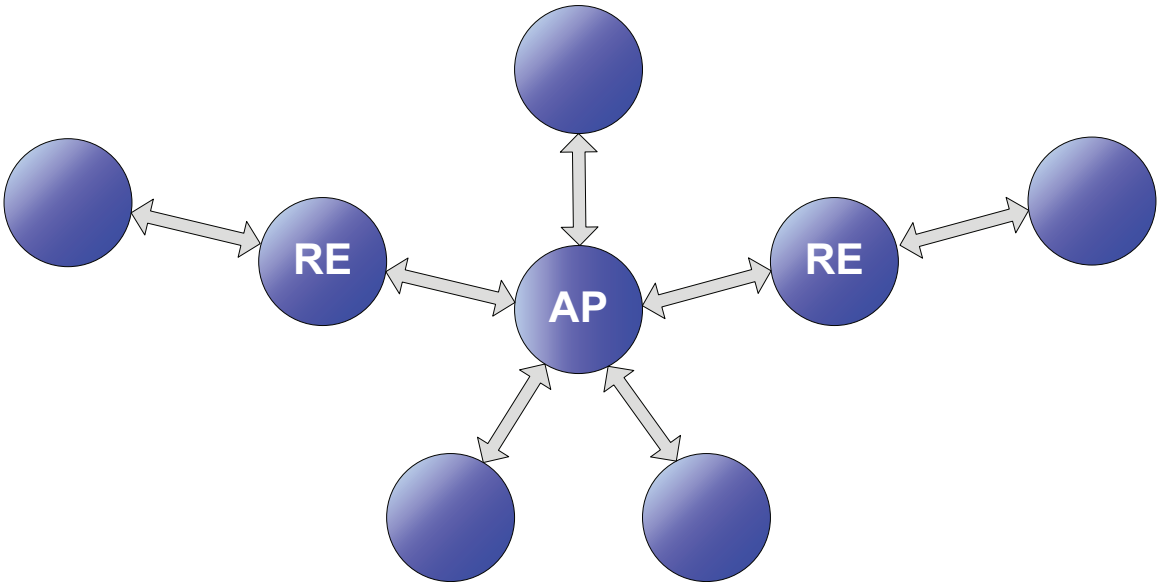

Figure 11: Extended Star Network

Tree Network

The next level of complexity is called a tree network. This adds another layer of routing and timing to the network, but allows for more overall nodes over a wider physical area.

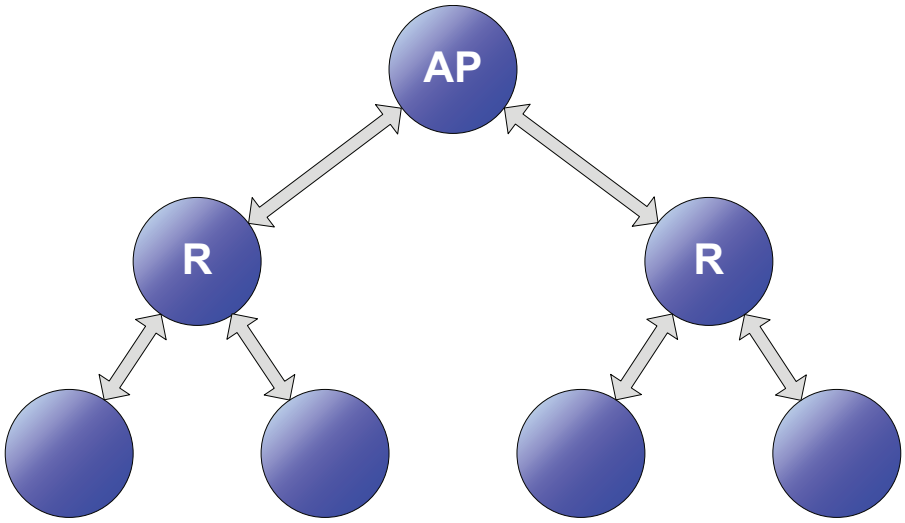

Figure 12: Tree Network

Mesh Network

The most complicated network is a full mesh network. In a mesh network each node can talk to all other nodes within its range. One node is typically an Access Point or Correlator and provides a gateway for data to get out of the network. It also controls the timing and other parameters of the link

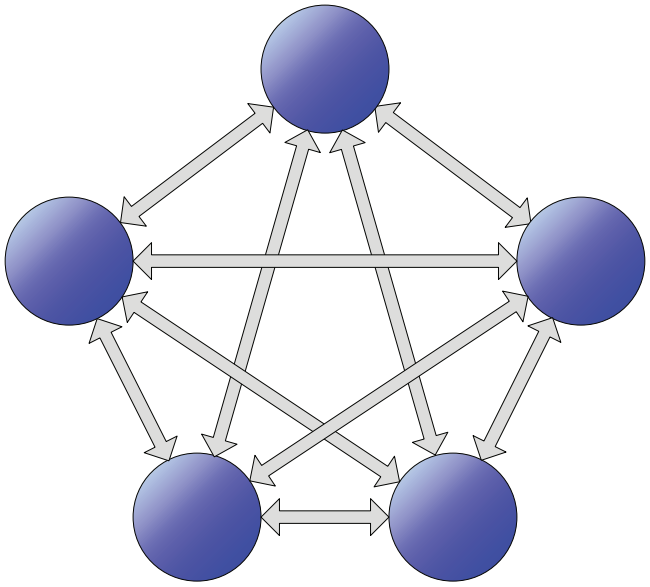

Figure 13: Mesh Network

The main advantage of a mesh network is redundancy since data can take multiple paths through the network. This makes the network very robust since the failure of any node does not take down the entire network. A mesh network can also cover a large physical area with low-power nodes. A node could potentially be miles away from the AP and use many short-range hops to get its data through.

User and Extended User Addressing Modes are the best for this. An external

micro in each node maintains a list of nodes that are within its range. The micro writes the address of the node that it needs to communicate with to the module and initiates a transmission.

Each network has advantages and disadvantages for specific applications. Star network are easy to set up, but have a single point of failure that can take down the entire network. Mesh networks are robust and reliable, but require much more logic and software to manage the routing, timing and other parameters.

The size, cost, power consumption and addressing modes offered by the HumPRO™ Series module make it suitable in small, low-cost, battery-powered nodes in networks of just about any configuration and size. Its robust protocol and operation provide a solid foundation for any system.

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