

PACKET DATA PROTOCOL FOR
WIRELESS COMMUNICATION

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BACKGROUND

The present invention relates generally to methods and systems for wireless communications and, more particularly, to protocols used in wireless communications to send and receive packet data.

Packet switched communication networks evolved from the need to
10 conserve data communication resources. Since data is sent in discrete packets, rather than as a continuous transmission, gaps in communication on one connection can be efficiently utilized by providing packets from other connections to fill those gaps. Since there is no direct connection between terminals in a packet switching environment, the link is called a virtual
15 connection. Rather than being readily identified by its association with a direct, physical channel, a connection on a packet switched network using a virtual channel is instead determined by a plurality of identifiers. These identifiers, and other information needed to provide smoothly flowing communications in packet switched networks, are provided by protocols which define the rules of
20 communicating on a packet switched network. These rules are also needed so that system programmers and developers have a common baseline from which to design compatible systems.

There are many different protocols for communicating over networks in general. Some protocols, such as the AT protocol commonly used in computer
25 modems, were initially designed for wire-bound networks and later expanded for use in wireless networks. Wire-bound networks, however, are relatively high speed systems as compared with wireless networks since it takes much longer to propagate a packet in a wireless environment. Thus, wire-bound protocols are not designed to effectively handle the idiosyncracies of wireless systems, e.g.,
30 propagation delays, transmission disturbances, etc.

Other protocols are provided in communication network adaptor cards which allow computers to communicate over, for example, wide area or local area networks. Examples of this type of protocol include Ethernet, TCP/IP, NetWare, etc. Much like the AT protocol, however, these protocols were
5 designed with high speeds, e.g., 10 Mbits/s, in mind.

Asynchronous transfer mode (ATM) is a more recent development in the communication protocol arena which can be used to transfer data with different requirements on a broadband ISDN network. Like the other protocols, however, ATM is defined only for high speed connections.

10 A network known as the Mobitex network has its own protocol, the Mobitex Asynchronous Communication (MASC), which is defined for a serial interface between a computer and a modem. This protocol, however, is complex and difficult to use. Moreover, MASC was developed a number of years ago without considering the possibility of wireless communication and has several
15 limitations in this regard. For example, an eight bit data byte is coded as two data bytes according to MASC so that each byte can be sent as seven data bits with one bit parity.

Over the years, MASC has evolved and new commands have been added. Unfortunately, these additions to MASC have not always been consistent and,
20 thus, there is no one algorithm or set of commands which is generic. Instead, each command is unique which creates many problems for those using the Mobitex system. Delimiters exemplify the inconsistencies of the MASC protocol. MASC uses both "," and "/" symbols as delimiters. Even the usage is inconsistent, as MASC sometimes uses delimiters even when the parameters
25 being communicated have fixed lengths.

SUMMARY

These and other drawbacks and deficiencies of conventional communication protocols are overcome according to the present invention which
30 provides a novel protocol that can be, for example, integrated into existing

systems. Protocols according to the present invention are specifically designed to accommodate, among other concerns, the unique characteristics of wireless communication. These protocols are independent of any particular medium and can be used with interfaces such as PCMCIA, serial or IR.

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BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing, and other, objects, features and advantages of the present invention will be more readily understood upon reading the following detailed description in conjunction with the drawings in which:

10 Figure 1 illustrates a conventional M-frame connection protocol according to the MASC between a host and a radio modem;

 Figure 2 illustrates a conventional FO-frame protocol according to the MASC between a host and a radio modem;

15 Figure 3 illustrates a connection protocol sequence between a host and a radio modem according to an exemplary embodiment of the present invention;

 Figure 4 illustrates a control protocol sequence between a host and a radio modem according to an exemplary embodiment of the present invention;

20 Figure 5 illustrates a protocol for data units transmitted between a host and a radio modem according to an exemplary embodiment of the present invention;

 Figure 6 illustrates a status protocol according to exemplary embodiments of the present invention; and

 Figure 7 illustrates an error protocol according to exemplary embodiments of the present invention.

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DETAILED DESCRIPTION

30 In order to fully appreciate protocols, systems using such protocols and methods of communicating according to the present invention, a brief description of exemplary protocols according to the conventional MASC system will first be provided.

The INIT frame is used to set communication parameters for the MASC protocol between the PC host and the radio modem. An exemplary structure of the frame INIT according to the MASC protocol is as follows.

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^	0	length	B	SP	len	,	int	:	check	CR
1	0	3	1	1	3	1	1-4	1	2	1

- 10 The text field is divided into five distinct sections. The B field is simply the letter B in hexadecimal notation, i.e., 42. This is followed by a space character, hexadecimal 20. Next, the LEN field is a three-digit ASCII coded hexadecimal number which sets the maximum length of an information frame. This field is typically set to a maximum possible frame size, e.g., hexadecimal 47E. The
- 15 fourth field is a comma sign which separates the LEN field from the INT field. The INT field specifies the shortest time between two subsequent frames. This value can, for example, be given in 10 ms increments with a default value of 0.

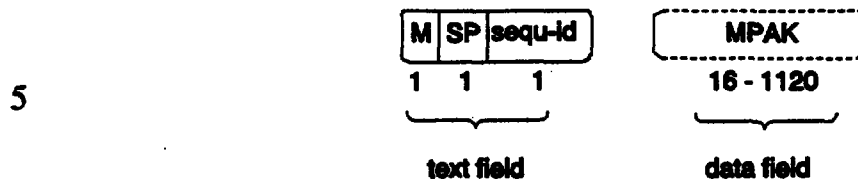
The default communication parameters are used until an INIT frame has been received. An INIT frame should be the first frame sent after start-up and,

20 after an INIT frame is received, the protocol should notify the application that connection with the radio modem has been established and that a start sequence can follow.

For sending and receiving data via the radio modem according to the MASC system, the M-frame protocol is used. A radio modem that receives an

25 M-frame from the PC sends a data packet (MPAK) via the radio path to the network. If the M-frame contains a sequence number, then an indicator is sent to the PC along with the sequence number. Data packets received via the radio path are sent over the MASC interface to the PC using the M-frame protocol. These data packets which come from the PC are required to have valid

information in the header, e.g., sender, traffic state, class, packet type, size, etc., and accurate length. The structure of the M-frame is as shown below.



An exemplary sequence of transmissions between the host and the radio modem for the M-frame protocol is illustrated in Figure 1. Therein, the host 10 transmits an MPAK, denoted 'M', to modem 14. After sending the MPAK on to the network, the modem 14 returns an F H signal to the host 10.

In addition to data transmission and reception commands, the MASC protocols also provide for various control commands including the following:

- | | | | |
|----|------|----|---|
| 15 | ACK | -- | acknowledgement of inaccurately received information frame. |
| | NACK | -- | negative acknowledgement, an inaccurately received information frame. |
| | RACK | -- | request for retransmission of the previous ACK. |
| | SENS | -- | link layer control. |
| 20 | SACK | -- | SENS acknowledgement. |

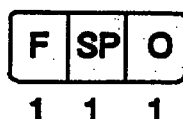
The structure of these control commands is illustrated below.



To turn off the radio modem, the FO-frame is used. When received, the radio modem starts to clear the buffers of stored data packets and tries to send the Q data packets to the network. The radio modem then sends an inactive packet to the network and confirms that the buffer is empty by sending an FO-

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frame back to the PC. The structure of the text field in the FO-frame is as follows.



An exemplary order of signal transmissions is shown in Figure 2 for the MASC FO-frame protocol.

Having described a conventional protocol for communicating in packet switched networks, protocols according to the present invention will now be described. The basic protocol data units (PDUs) and their parameters are:

Host to Radio modem

Function

- | | | |
|-----|---------|--|
| (1) | Open | Establish a connection to the radio modem. |
| (2) | Data | Sends a data packet. |
| (3) | Control | Control commands to the radio modem. |
| (4) | Close | Disconnect from the radio modem. |

Radio modem to Host

Function

- | | | |
|-----|----------------|---|
| (1) | Opened | The radio modem confirms the connection. |
| (2) | DataReport | Report of the request to send data. |
| (3) | Control Report | Report of the request to perform a control command. |
| (4) | Closed | The radio modem confirms the disconnection. |
| (5) | Status | Status information from the radio modem. |
| (6) | Error | The radio modem has received an erroneous command. |

The structure of the above-described PDUs generally looks like:

Function Code	Subfunction Code	Function dependent part
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- 5 Function Codes group the various messages into different categories, while the Subfunction Codes provide more specific information about each Function Code. For example, the Function Code for "status" merely indicates that a status change has occurred, while the appended Subfunction Code provides information indicating what type of status change occurred, e.g., loss of contact with the
- 10 network. The PDU structure for Report PDUs, i.e., DataReport and ControlReport, looks like:

Function Code	Subfunction Code	Status	Function dependent part
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The function code and subfunction code shown can be related for a request and a report. Thus, the function code and the subfunction code used for the PDU Data can also be used in the PDU DataReport and the same is true for PDU Control and PDU ControlReport.

- 20 In the report PDUs, a status field is added. The status field has some common status codes that are defined for all report PDUs. They are:

Ok	Requested function completed with no errors
Fail	Fail to do requested function
25 Aborted	Requested function aborted
Busy	Requested function already active

- 30 The different report PDUs also have type specific status codes. For example, the DataReport PDU can have a type-specific status codes entitled "Illegal

Addressee." These status codes, of course, are exemplary in nature and may be network dependent.

The above-defined PDUs are now described as they can be used in exemplary systems and methods according to the present invention. Figure 3 illustrates in block fashion the PDUs used for establishing and ending a connection between host unit 10 and radio modem 14.

To establish a connection, the host 10 sends a PDU Open 12 to the radio modem 14. The radio modem 14 replies with PDU Opened 16, including radio modem parameters such as, for example, a subscriber number. By this exchange of PDU's, the connection is established and the radio modem 14 activates the radio function.

When the connection is to be terminated, the host 10 initiates a disconnection with the PDU Close 18. The radio modem 14 answers with PDU Closed 20 to confirm the disconnection. The radio modem 14 then deactivates the radio function.

The host 10 can also control the radio modem 14. For example, the host can block operation of the transmitter. The host uses the PDU Control 22 for that purpose as shown in Figure 4. The radio modem 14 indicates the result with PDU ControlReport 24.

In Figure 5, the host 10 sends data with the PDU Data 32. The radio modem 14 answers with PDU DataReport 34 to indicate if the request was successful or not. Incoming data from the radio modem 14 comes in the PDU Data 36. No reply is returned from the host 10 for incoming data.

In Figure 6, the radio modem 14 indicates status changes with the PDU Status 40. Exemplary status changes include loss of network contact or establishment or network contact. If the host 10 sends an unknown or illegal PDU 50, the radio modem 14 replies with the PDU Error 52 as seen in Figure 7.

By using protocols according to the present invention, many advantages over conventional systems are realized, particularly in wireless environments. As compared, for example, with the conventional MASC system, protocols

according to the present invention have minimal protocol overhead which is correspondingly more important in environments (e.g., wireless) where data throughput is relatively low. Moreover, having been designed as a whole, rather than piecemeal, the PDP protocol provides an approach that is consistent, as well
5 as easy to implement and extend.

The above-described exemplary embodiments are intended to be illustrative in all respects, rather than restrictive, of the present invention. Thus the present invention is capable of many variations in detailed implementation that can be derived from the description contained herein by a person skilled in
10 the art. All such variations and modifications are considered to be within the scope and spirit of the present invention as defined by the following claims.

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**CLAIMS:**

1. A method for communicating over a network between a host and a remote unit comprising the steps of:

5 transmitting one of a first group of network protocol data units for communicating in a host-to-remote unit direction, said first group including an open protocol data unit, a data protocol data unit, a control protocol data unit and a close protocol data unit; and

10 providing a second group of network protocol data units for communicating in a remote unit-to-host direction, said second group including an opened protocol data unit, a data report protocol data unit, a control report protocol data unit, a status protocol data unit, and a closed protocol data unit corresponding to the network protocol data units in said first group, respectively; and

15 transmitting a corresponding one of said network protocol data units in said second group to said host in response to said one of said first group of network protocol data units received by said remote unit.

20 2. The method of claim 1 wherein at least one of said protocol data units includes a function code field, a subfunction code field, and a function dependent part.

3. The method of claim 2, wherein said data report protocol unit and said control report protocol unit also include a status field.

25 4. The method of claim 2 further comprising the steps of:
transmitting as said one of said protocol data units from said first group a data protocol data unit; and
transmitting as said one of said protocol data units from said second group a data report protocol data unit having a function code field and a



subfunction code field with values that are the same as those found in the corresponding fields of said data protocol data unit.

- 5 5. A method for communicating in a network between a host and a remote unite, said remote unit for transmitting data over an air interface comprising the steps of:

 sending an open protocol data unit from said host to said remote unit to establish a connection therebetween;

- issuing an opened protocol unit responsive to the open protocol data unit to the host from the remote unit confirming a connection therebetween;

- 10 sending a data protocol data unit from the host to the remote unit; transmitting data contained in said data protocol data unit from said remote unit over said air interface:

- issuing a data report protocol data unit to the host from the remote unit reporting an outcome of the request to send data;

- 15 transmitting a closed protocol data unit from the host unit to the remote unit; and

- returning a closed protocol data unit to the host unit from the remote unit indicating that the remote unit has disconnected the link.

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6. The method of claim 5 further comprising the steps of:

 sending a control protocol data unit to the remote unit from the host; and

- returning a control report protocol data unit to the host from the remote unit which reports an outcome of the request to perform a control command associated with the control protocol data unit.

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7. The method of claim 6 further comprising the step of providing, as said control report protocol data unit, a function code field, a subfunction code field, a status field, and a function dependent part field, wherein said status field

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includes information which indicates said outcome of the request to perform the control command.

8. The method of claim 5 further comprising the step of issuing a
5 status protocol data unit to the host from the remote unit which reports status information relating to the remote unit.

9. The method of claim 5 further comprising the step of:
generating an error protocol data unit which indicates that the
10 remote unit has received an erroneous command from the host.