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Dube' et al.

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(54) **MODBUS PLUS ETHERNET BRIDGE**

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(58) **Field of Search** 370/401-405

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,971,000	A	7/1976	Cromwell
4,319,338	A	3/1982	Grudowski et al.
4,688,167	A	8/1987	Agarwal
4,845,644	A	7/1989	Anthias et al.
4,858,152	A	8/1989	Estes
4,897,777	A	1/1990	Janke et al.
4,912,623	A	3/1990	Rantala et al.
4,937,777	A	6/1990	Flood et al.
4,949,274	A	8/1990	Hollander et al.
4,953,074	A	8/1990	Kametani et al.
4,992,926	A	2/1991	Janke et al.

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

DE	296 00 609	U1	3/1997
DE	441 0 171	C1	4/1997
DE	196 15 093	A1	10/1997
EP	0 542 657	A1	5/1993
EP	0 814 393	A1	12/1997
WO	WO 97/18636		5/1997
WO	WO 98/53581		11/1998

OTHER PUBLICATIONS

Groupe Schneider, Modicon Modibus Plus Network BM85 Bridge Multiplexer User's Guide, Aug. 1995.*
When Technology Standards Become Counterproductive, Kenneth C. Crater, President, Control Technology Corporation, Hopkinton, MA dated Jul. 9, 1999, pp. 1-5.
A White Paper State Language for Machine Control, Kenneth C. Crater, President, Control Technology Corporation, Hopkinton, MA dated Jul. 9, 1999, pp. 1-11.
New PC-based Process Control & Data Acquisition Software Integrates Remote Internet Capabilities with Fast Pentium Support, Fred A. Putnam, LabTech President, pp. 1-3. Aug. 1996 Control Magazine—In The News—Electric Utility Industry Embarks on Automation Overhaul, pp. 1-10. Jul. 1997 Control Magazine—Magazine Software Review—NT Package Give Plant Access Through the Web, pp. 1-3.
Oct. 1996 Control Magazine—Software Review—Article Archives, pp. 1-2.

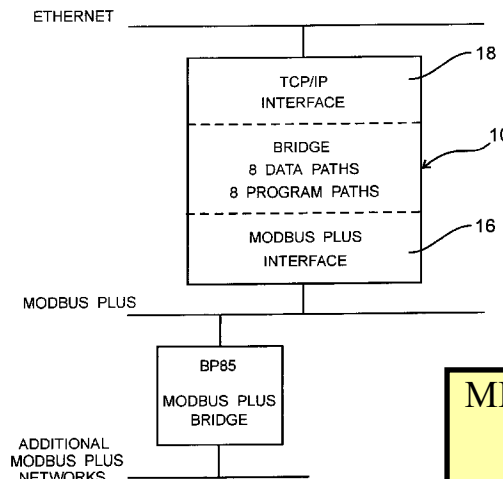
(List continued on next page.)

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(57) **ABSTRACT**

A bridge is disclosed for providing a connection between a MODBUS Plus network and an Ethernet network. The bridge includes a MODBUS circuit board, an Ethernet circuit board, and a CPU. The MODBUS circuit board is operably coupled to the local area network for receiving a message from an originating node having a five-byte routing path field. The CPU is operably connected to the circuit board for extracting a table location in response to a third byte within the routing path field. The Ethernet circuit board is operably connected to the CPU and the Ethernet network for forwarding the message to an IP destination in response to the table location.

26 Claims, 12 Drawing Sheets



MICROSOFT - EXHIBIT 1030
MICROSOFT CORP. v.
UNILOC 2017 LLC
IPR2019-01026

U.S. PATENT DOCUMENTS

5,012,402 A 4/1991 Akiyama
 5,023,770 A 6/1991 Siverling
 5,047,959 A 9/1991 Phillips et al.
 5,072,356 A 12/1991 Watt et al.
 5,072,412 A 12/1991 Henderson, Jr. et al.
 5,109,487 A 4/1992 Ohgomori et al.
 5,122,948 A 6/1992 Zapolin
 5,131,092 A 7/1992 Sackmann et al.
 5,134,574 A 7/1992 Beaverstock et al.
 5,151,896 A 9/1992 Bowman et al.
 5,151,978 A 9/1992 Bronikowski
 5,157,595 A 10/1992 Lovrenich
 5,159,673 A 10/1992 Sackmann et al.
 5,161,211 A 11/1992 Taguchi et al.
 5,165,030 A 11/1992 Barker
 5,179,700 A 1/1993 Aihara et al.
 5,225,974 A 7/1993 Mathews et al.
 5,245,704 A 9/1993 Weber et al.
 5,251,302 A 10/1993 Weigl et al.
 5,283,861 A 2/1994 Dangler et al.
 5,297,257 A 3/1994 Struger et al.
 5,307,463 A 4/1994 Hyatt et al.
 5,321,829 A 6/1994 Zifferer
 5,349,675 A 9/1994 Fitzgerald et al.
 5,398,336 A 3/1995 Tantry et al.
 5,406,473 A 4/1995 Yoshikura et al.
 5,420,977 A 5/1995 Sztipanovits et al.
 5,440,699 A 8/1995 Farrand et al.
 5,446,868 A 8/1995 Gardea et al.
 5,528,503 A 6/1996 Moore et al.
 5,598,536 A 1/1997 Slaughter, III et al.
 5,613,115 A 3/1997 Gihi et al.
 5,623,652 A 4/1997 Vora et al.
 5,625,781 A 4/1997 Cline et al.
 5,699,350 A 12/1997 Kraslavsky
 5,734,831 A 3/1998 Sanders
 5,805,442 A 9/1998 Crater et al.
 5,805,816 A * 9/1998 Picazo et al. 395/200.53
 5,862,391 A 1/1999 Salas et al.
 5,950,006 A 9/1999 Crater et al.
 5,975,737 A 11/1999 Crater et al.
 5,982,362 A 11/1999 Crater et al.
 5,997,167 A 12/1999 Crater et al.

OTHER PUBLICATIONS

ICS Instrumentation & Control Systems—Windows NT for real-time control: Which way to go?—ICS Magazine, pp. 1–8.

I&CS Jul. 1999—Special Report Software—Software: Open source OSs, objects, Web-based communications challenge status quo, (Wayne Labs, Senior Technical Editor), pp. 24–49.

Landis & Staefa MS 2000, pp. 1–2.

Landis & Staefa Standards and Open Protocols Integration System Architecture, p. 1.

Annabooks Bookstore, Programming and Interfacing the 8051, by Sencer Yeralan and Asutosh Ahluwalia, pp. 1–2.

SoftPLC Corporation—Java Support in SoftPLC Corp. Products, pp. 1–5.

Mach J. Company, MachJ, an embeddable, clean room Java Virtual Machine, p. 1.

SoftPLC Corporation—The History of Programmable Controllers, Looking Back From the Year 2000 A.D. (Or, How Computers Replaced Proprietary PLC'S), pp. 1–7.

SoftPLC Corporation—TOPDOC: Advanced PLC program development & documentation software, pp. 1–12.

Control Engineering Online Magazine Articles (Jul. 1998)—No, that's not a PC, it's a PLC, pp. 1–2.

Rockwell International Corporation, Allen-Bradley Introduces PLC-5/80E Controller for Ethernet Communication Networks.

Rockwell Automation—Search Results, pp. 1–2.

Rockwell International Corporation, Vision & Direction, The Direction of Automation Systems, pp. 1–4.

Rockwell International Corporation, Vision & Direction, The Role of Open Systems, pp. 1–4.

Rockwell International Corporation—Vision & Direction—The Direction of Automation Systems—Emergence of Application-Specific Control Solutions, pp. 1–2.

Rockwell International Corporation—Vision & Direction—The Direction of Automation Systems—The New Factory Worker, pp. 1–2.

Rockwell International Corporation, Vision & Direction, Control System Deliverables —The Next Step, pp. 1–2.

Rockwell International Corporation, Vision & Direction, Conclusion & Acknowledgments, pp. 1–2.

Rockwell International Corporation—Choices—Perspectives on the Future of Automation Control, p. 1.

Rockwell International Corporation—Allen-Bradley—Networks—Ethernet for Industrial Control—An Ethernet White Paper—Apr. 21, 1998, pp. 1–13.

Rockwell International Corporation—Automation Systems Control—General13 World-Class Automation Systems from Allen-Bradley, Last Updated: May 7, 1998, pp. 1–12.

PC Quest, Dec. '97—Point, click, Control—C—Programmable controllers take the pain out of embedded control, pp. 1–2.

berthel—automation with imagination—PCI 100—Programmable logic controller for SIMATIC/IBM IPC, pp. 1–3.

YAHOO! Personalized Search Results for programmable logic controller internet access, pp. 1–3.

SIEMENS—SIMATIC report 1/97—New in the SIMATIC Library, pp. 1–2.

Control Magazine Aug. 1998—Field Test—Dynamic Software Makes Control Integration Easier, pp. 1–2.

Design and Reuse Web Site—EDTN Network—Analyze IP Database Content—Analyze Reuse Blocks per taxonomy tree, pp. 1–10.

Engineering Information, Inc.—Ei CPX Web [1990–94].

“Internet Protocol, Darpa Internet Program, Protocol Specification—RFC:791,” Defense Advanced Research Projects Agency, Sep. 1981.

“Transmission Control Protocol, Darpa Internet Program, Protocol Specification—RFC:793,” Defense Advanced Research Projects Agency, Sep. 1981.

“Open MODBUS/TCP Specification,” A. Swales, Sep. 3, 1997.

“[comp.unix.programmer] Unix-Socket-FAQ For Network Programming,” Vic Metcalfe, Andrew Gierth and other contributors, Jan. 22, 1998.

“TCP/IP Illustrated, vol. 2, The Implementation,” Gary R. Wright, W. Richard Stevens, 1997.

“Winsock 2 Information,” Bob Quinn, 1995–1998 (last updated Dec. 5, 1998).

Website Information of PROFIBUS: Technical Overview.

Website Information of ODVA—The Open DeviceNet's Vendor Association.

Website of PROFIBUS International—Welcome Page.

“Ethernet Base Gateway Product,” AEG-Modicon, published 1991.

- “Modicon Modbus Plus Network BM85 Bridge Multiplexer User’s Guide,” Groupe Schneider, Aug. 1995.
- “Modicon Modbus Plus Network Planning and Installation Guide,” AEG Schneider Automation, Apr. 1996.
- “Open Modbus/TCP Specification,” A. Swales, Sep. 3, 1997.
- “MEB Installation and Programming Manual,” Niobara Research and Development Corporation, Sep. 24, 1997.
- “MEB-TCP Installation and Programming Manual,” Niobara Research and Development Corporation, Oct. 1, 1997.
- Abstract of “Implementing distributed controls for FMC’s using Internet utilities,” S. S. Jagdale and N. Merchant; Computers of Industrial Engineering, vol. 31 No. 1–2, p. 87–90; Oct., 1996 (UK).
- Abstract of “Process Control takes to the Net,” Greg Paula, Mechanical Engineering vol. 118 No. 12 Dec. 1996, p. 55.
- Abstract of “Remote interrogation and control of sensors via the internet,” Peter L. Fuh and Euan F. Mowat; Sensors, vol. 12 No. 12, 6 pp; Dec. 1995.
- Abstract of “Progress control takes to the Net,” G. Paula; Mechanical Engineering, vol. 118, No. 12, p. 55, Dec., 1996.
- Abstract of “Implementation of CAN/CAN bridges in distributed environments and performance analysis of bridged CAN systems using SAE benchmark,” H. Ekiz, A. Kutlu and E. T. Powner; Conference Paper, IEEE Southeastern ’97, Engineering the new energy, IEEE, p. 185–7, 1996.
- Abstract of “Managing interdisciplinary project teams through the Web,” R. E. Goodman and P. Chinowsky; Conference Paper, WebbNet 96—World Conference of the Web Society, pp. 180–185, 1996.
- Abstract of “Learning environment for a process automation system using computer networks,” J. Lindfors, L. Yliniemi and K. Leivska; Conference Paper, Step τ —Genes, Nets and Symbols, pp. 137–143, 1996 (Finland).
- Abstract of “Distributed agent systems for intelligent manufacturing,” D. H. Norrie and B. R. Gaines; Canadian Artificial Intelligence, No. 40, p. 31–3, Autumn 1996 (Canada).
- Abstract of Proceedings of AutoFact 1995 Conference, “Today’s Automated, Integrated Factory,” Soc. Manuf., Eng., Dearborn, MI; 1995.
- Abstract of “The ECOSSE Control HyperCourse,” C. M. Merrick and J. W. Ponton; Computers & Chemical Engineering, vol. 20, Part B, p. S 1353–8, 1996 (UK).
- Abstract of “Chemical—better batch controls,” T. Crowl; Control & Instrumentation, vol. 28, No. 5, p. 53–4, May 1996 (UK).
- Abstract of “Industrial software does 32-bit Windows, prepares for the net,” W. Labs; I 8CS, vol. 69, No. 3, p. 23–6, 31–4, Mar. 1996, USA.
- Abstract of “A case study of international remote machining,” G. C. I. Lin and Kao Yung-Chou; Conference Paper, Proc. SPIE—Int. Soc. Opt. Eng., vol. 2620, p 553–60, 1995.
- Abstract of “Standardization of long-distance protocols,” R. Dinges; Journal Paper, Generation Changes in Network Conductor Systems, ITG—Fachberichte, vol. 134, p. 97–113, 1995 (West Germany).
- Abstract of “Proceedings of AutoFact Conference,” Soc. Manuf. Eng., , 684 pp., Dearborn, MI; 1993.
- Abstract of “Control system design V. Communications orchestrate process control,” F. Glow; In Tech, vol. 36, No. 9, p. 68–74, Sep. 1989.
- Abstract of “Functions and characteristics of local networks adapted to industrial applications,” J. Morlais; Electronique Industrielle, No. 97, p. 56–63, Nov. 15, 1985; France.
- Abstract of “Intelligent supervisory control of submerged-arc furnaces,” Markus A. Reuter, Carla Pretorius, Chloe West, Peter Dixon and Morne Oosthuizen, JOM vol. 48, No. 12, Dec. 1996, p. 49–51.
- Abstract of “Simulation on the integration of process control systems of rolling mill plants through standard networks,” Choo Young Yeol, Hwang Hwa Won and Kim Cheeha, Proceedings of the Industrial Computing, Conference, Instrument Society of America, Research Triangle Park, NC, USA, P 1–14; vol. 6, No. 1, 1996.
- Abstract of “Environment waste control digest,” Clayton H. Billings; Public Works vol. 127 No. 7, 6 pp, Jun., 1996.
- Abstract of “Experiments in tele-handling and tele-machining at the macro and micro scales, using the internet for operational environment transmission,” Mamoru Mitsuishi, Toshio Hori, Tomaharu Hikita, Masao Teratani, Takuro Watanabe, Hirofumi Nakanishi and Bruce Kramer; IEEE International Conference on Intelligent Robots and Systems vol. 2, 1995.
- Abstract of “A phototyping and reverse engineering system for mechanical parts—on-demand on the national network,” Fred Hansen, Elias Pavlakos, Eric Hoffman, Takeo Kanade, Raj Reddy, Paul Wright; Journal of Manufacturing Systems, vol. 12 No. 4, p. 269–281; 1993.
- Abstract of “Mathematical model and optimization of furfural treating process,” Tao Peng, Jinshou Yu and Huihe Shao; Huadong Huagong Xueyuan Xuebao/Journal of East China Institute of Chemical Technology vol. 17 No. 1, p. 99–104; Feb. 1991.
- Abstract of User’s Aspect of Telecommunication and Information Processing in Plant Factory; Hashimoto Yasushi (1); Journal of the Institute of Electronics, Information and Communication Engineers, vol. 78, No. 5, p. 475–81, Fig. 3, Ref. 7, 1995. (Japan).
- Abstract of “High-efficient application technology of DCS from the viewpoint of users,” Oka Norihito (1); Narita Tsutomu (1); (1) Yamatake-Honeywell Co., Ltd.; Otomeson, vol. 40, No. 2, p. 24–28, Fig. 5, Part 2, 1995. (Japan).
- Abstract of Users’ experience with software tools for process integration. General results; Stougie, L.; Roeterink, H.J.H.; Van Wijk, A.; Stikkelman, R.M.; Nov. 1996.
- Abstract of “Integrated design and process technology. vol. 1;” Cooke, D.; Kraemer, B.J.; Sheu, P.C.Y.; Tsai, J.P.; Mittermeir, R.; Society for Design and Process Science, p. 51–57; 1996. (USA).
- Abstract of “Integrated design and process technology. vol. 2;” Tanik, M.M.; Bastani, F.B.; Gibson, D.; Fielding, P.J.; Society for Design and Process Science, p. 423–430, 1996. (USA).
- Abstract of “Integrated design and process technology. vol. 2” Tanik, M.M.; Bastani, F.B.; Gibson, D.; Fielding, P.J.; Society for Design and Process Science, p. 306–312, 1996.
- Abstract of “Need low-cost networking consider DeviceNet,” W. H. Moss; InTech vol. 43:11; p. 30–31, Nov. 1996.
- “Plastic Car Bodies Pass the Crash Test,” mechanical engineering; vol. 118, No. 12; Dec. 1996.
- “Remote Interrogation and Control of Sensors via the Internet,” Sensors and Systems; Peter L. Fuhr and Euan F. Mowat; University of Vermont; pp. 25–30; Dec., 1999.

* cited by examiner

PATH TYPE	OPENED IN NODE	OPENED FOR MODBUS COMMAND
DATA MASTER (DM)	ORIGINATOR	DATA ACCESS
DATA SLAVE (DS)	DESTINATION	DATA ACCESS
PROGRAM MASTER (PM)	ORIGINATOR	PROGRAMMING
PROGRAM SLAVE (PS)	DESTINATION	PROGRAMMING

Figure 1

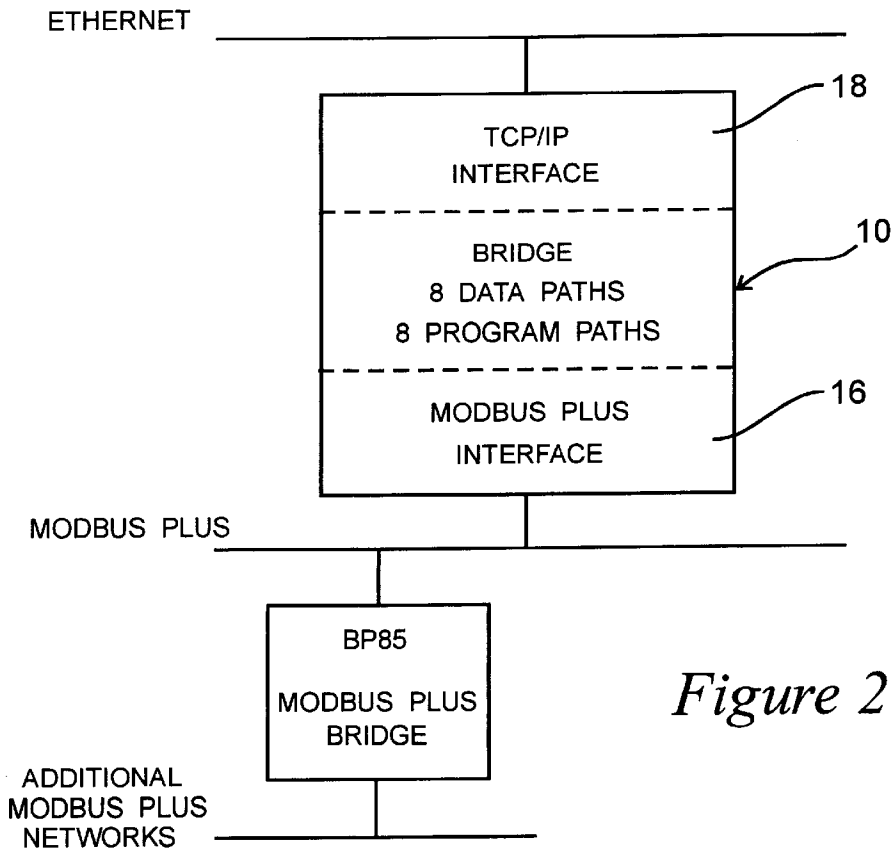


Figure 2

EXCEPTION CODE (HEXADECIMAL)	MEANING
01	ILLEGAL FUNCTION
02	ILLEGAL DATA ADDRESS
03	ILLEGAL DATA VALUE
04	UNEXPECTED FAILURE DURING COMMAND EXECUTION
05	ACK - - REQUESTED OPERATION IS IN PROGRESS
06	BUSY - - NOT READY TO PERFORM REQUESTED OPERATION
07	NAK - - REQUESTED OPERATION REJECTED
08	COULD NOT OPEN MODBUS PLUS PATH
09	ERROR DURING MODBUS PLUS SEND
0A	ERROR DURING MODBUS PLUS REPLY

Figure 3

FUNTION CODE (DECIMAL)	COMMAND NAME
1	READ DISCRETE OUTPUT STATUS (0xxxx)
2	READ DISCRETE INPUT STATUS (1xxxx)
3	READ OUTPUT REGISTER (4xxxx)
4	READ INPUT REGISTER (3xxxx)
5	FORCE SINGLE COIL (0xxxx)
6	PRESET SINGLE REGISTER (4xxxx)
7	READ EXCEPTION STATUS
8 SUBFUNCTION 21	GET/CLEAR NETWORK STATISTICS
15	FORCE MULTIPLE COILS (0xxxx)
16	PRESET MULTIPLE REGISTERS (4xxxx)
17	REPORT SLAVE ID

Figure 4

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