speed connection and act as a proxy for users on slower links. In so doing it conserves the user's bandwidth and situates slower hosts at the edge of the network. Via a Reflector, a network of users can use Gnutella with far less aggregate bandwidth than would otherwise be required. Most Reflectors are run on behalf of a particular user population and not publicly advertised, although a handful of public-access ones are available at any given time.

November and December saw the introduction of two significant new Gnutella applications. First, Lime Wire LLC introduced LimeWire, then Free Peers, Inc. released BearShare. Both programs apply connection-preferencing rules that decide whether a given connection will be maintained. One common example: connections to unresponsive hosts are dropped. The consistent repeated application of this simple rule to a series of connections will tend to drive slower hosts to have fewer connections and sit at the edge of the network, a bit like a poor conversationalist might find himself marginalized at a party.

Coincident with these developments and the uptake in adoption of these applications, Clip2 has seen a steady increase in the number of responsive hosts active at any given time on the network, rising from a typical figure of 500 in October to more than 1500 in early January 2001. The quantity of search results has increased as well. According to Clip2 estimates, the number of Gnutella users per day has risen from 10,000 to 30,000 in November to between 20,000 and 50,000 in January.

Download Failure

Download failure looms as one of the most serious problems according to many. Although attractive search results may come back, they are useless if the associated files cannot be downloaded. Quantitative study of the problem is complicated since users have preferences in the files they download and upload. Since all files are not equal, there is much room for inaccuracy in the results of any test that assumes otherwise. Nonetheless, there is a preponderance of perception that downloads fail too often, particularly relative to other peer-to-peer file-sharing systems.

Spurred by an August 2000 paper by Eytan Adar and Bernardo Huberman of Xerox PARC, there is belief that "freeloading" - users downloading much more than they upload - is a major source of the download failure problem, although the critical ratio of supply and demand is anyone's guess. The response to commentator Clay Shirky's counterpoint that "bandwidth over time is infinite" is that the server bandwidth available to users who want to download a file right now is too finite.

Developers are taking two major actions:

1. removing as much friction as possible from the upload process, such as defaulting a user's upload directory to be his download directory; and
2. blocking uploads to users who are not themselves uploading.

Web sites such as Gnute and Gnutella.it allow users to search and download from the Gnutella network without providing a direct means of contributing files back into the network. Seizing on this asymmetry, recent versions of LimeWire and BearShare have taken the offensive of denying download requests from Web site users. Instead of the file, the user finds a suggestion to download LimeWire or BearShare. The next step in this evolution may be to prioritize download requests even among users of these applications based on how much they have uploaded or made available for upload. The situation begins to resemble the model of Mojo Nation, in which downloading has a cost that is payable by providing resources back into the community. An alternative approach that might potentially be effective would be to not advertise a file -- not respond to a query for it -- so long as there is no bandwidth available to serve the file.

"Busy signals" are not the only possible cause for download failure. Hosts may be unreachable due to firewalls or intervening network address translation devices, applications may be buggy or incompatible, hosts may go offline or change their content between the point of advertising a file and the point of receiving a download request, and so on. A mechanism that enabled hosts to verify each other's ability to upload any file would address some of these issues.

What Next?

"What next?" is a fitting conclusion, for it is a problem that looms over Gnutella's future. Non-compliant implementations, connectivity, a lack of search results, download failure - these are all nuts-and-bolts problems with Gnutella. Sorting them out is necessary for Gnutella to meet commonly held basic expectations of it as a usable, public, decentralized file-sharing system. What happens when these core issues are sufficiently resolved?

The answer is that users spur developers to push on to new features. But which features? The trouble of "What's next?" is the contentious issue of agreeing on what problems need to be solved. Some aspire to see Gnutella be more scalable or more secure. Some want the system to be more anonymous, some want it to be less. Some hope it becomes a more generalized distributed search medium and grow beyond its file-sharing origins. Some imagine other applications riding upon it, even commerce. It seems there is no end to the expectations.

Unfortunately, Gnutella has a history of aborted, failed or poorly supported attempts to unite developers; the analogy of herding cats has rarely been so apt. One of the most notable efforts -- Gnutella Next Generation -- never significantly advanced beyond the proposal stage. Media reports have confused a spin-off effort known as gPulp as a Gnutella organization, but as the principal behind it has recently stated, "We are not a working group on Gnutella."

As of this writing, then, there is no clear leader in terms of a working group or other form of organization. There is, however, one arbiter of innovations: the market. Gnutella developers who have experimented with "improvements" that run counter to, outsid, or in between the lines of the de facto protocol have been kept in check by the fact that their applications must be able to communicate with those produced by other developers.

When the developer of an application known as Gnotella wanted to place more information in search-response messages than existing protocol specifications called for, he made sure he did it in a way that could still be passed on by the original Gnutella application, which was dominant in terms of user base at the time. Some other applications regarded Gnotella's search responses as noncompliant and dropped or otherwise "mishandled" the messages. The ability of Gnotella users to respond to queries was impaired, but the degree of impairment depended on the popularity of applications that regarded Gnotella as noncompliant. This story is being repeated with BearShare, which has recently released a version that also places extra information in search responses.

Will this market-driven pattern continue, so that Gnutella evolves in a competitive, Darwinian, decentralized and bottom-up manner? Or will it "grow up" and follow the trajectory of many other protocols, evolving through top-down committee processes? Only time will tell.

Kelly Truelove is the founder and CEO of Clip2, where he has led the company's efforts on P2P systems, distributed search, and Gnutella. He is a speaker at the upcoming Peer to Peer and Web Services Conference.

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Return to the P2P DevCenter.

By Patricia A. Murphy,
Manager Emerging Technology and Standards,
Rockwell Automation Control Systems.

The Next Generation Networking Paradigm: Producer/Consumer Model

As today's source/destination-based networks cannot offer the required functionality or accommodate increased traffic, system capabilities and productivity improvements are restricted. Consequently, a new network model - one that provides more functionality, makes more efficient use of bandwidth, and increases information flow, all while reducing traffic on the wire - is needed.
In a discussion of what is needed in the new network model regarding diagnostics, explicit and I/O messaging and throughput, the producer/consumer network model is revealed as the only model available today that can meet the control environment's demanding requirements and allow for future migration. The paper concludes with a discussion of the benefits of the producer/consumer network model, including Multicast and two one-way I/O trigger mechanisms: change-of-state and cyclic I/O production.

INTRODUCTION

If there's one thing we've all learned over the past decade, it's that users are demanding more from their control systems, and consequently, from the networks that tie the system together. Users want better diagnostics available over the network, less downtime, and reduced installation and maintenance costs. At the same time, they are demanding improved throughput.

With increased functionality comes more traffic and data on the wire. Today's networks, which are source/destination based, cannot offer the required functionality and accommodate increased traffic, thus restricting system capabilities and productivity improvements.

Increased demands on networks have forced the evolution of a new network model - one that provides more functionality, makes more efficient use of bandwidth, and increases information flow, all while reducing traffic on the wire.

Unfortunately, much of the discussion to date about networks has focused on baud rates, protocol efficiency, and physical characteristics (i.e. type of wire used). In reality, it's more complex than that. Available diagnostics, messaging types and throughput must all be considered when evaluating a network.

The most important factor affecting these capabilities in the control environment is the network model.

The source/destination model used for the past two decades can no longer meet today's network needs. The only model available today that can meet these demanding requirements and allows for future migration is the producer/consumer network model. Here's why:

DIAGNOSTICS

Networks provide a convenient way to retrieve diagnostics from devices. Device-specific information, such as detection of a photoelectric sensor's low margin due to a dirty lens can be communicated over the network to the control system during run time. The network delivers the diagnostic to the system operator interface, alerting plant personnel to the problem. The lens can be cleaned at a convenient time before there is a glitch in the process. Trouble-shooting a device, reading its fault codes, updating data logs -- all while not impacting the remote I/O control data exchange among other nodes -- is a must.

EXPLICIT AND I/O MESSAGING

Explicit messages, used for device configuration and diagnostics, are extremely flexible, with the data field carrying protocol information and instructions for service performance. For example, a message would be able to write new presets to five timers in a controller, or to execute a self-test. Explicit messages are used for uploading and downing programs, modifying device configurations, and data logging, trending and diagnostic functions. Nodes must interpret each message, perform the requested task, and generate responses. These types of messages are highly variable in both size and frequency.

I/O messages on the other hand are implicit in nature. The data field contains no protocol information, only real-time I/O control data. The meaning of the data has been predefined and processing time in the node is minimized. An example of an I/O message is a controller sending output data to an I/O block, and the I/O block responding with its input data. Such messages are low overhead, short, vary frequently and require high performance.

In the past, manufacturers have had separate networks to deal with the very different requirements of these two messaging types. A network used for I/O control cannot tolerate the variability introduced by explicit messaging. Allen-Bradley's blue-hose duo, DH+/RIO and Siemens' Profibus FMS/ Profibus DP are examples of this situation.

Today's users are demanding both functions on the same wire. And today's smarter devices need the functionality provided by both messaging types. Yesterday's source/destination networks cannot deal with these modern demands.

THROUGHPUT

Ultimately it's the throughput required by the application that determines what type of network model is required. Throughput is the rate at which input data from devices can be delivered to all nodes that need it and the resulting output data (decisions) can be delivered to all the devices that need it. Nodes include sensors, operator interfaces, controllers, data loggers, alarm monitors, actuators, etc. It is determined by baud rate, protocol efficiency, and most important of all, the network model, or delivery method. Let's briefly discuss each.

Baud rate is raw speed. It's unfortunate that this is often the most used measure of performance because it's the most misleading. Not only that, but with today's new networks, it's the least important of the three throughput factors.

Protocol efficiency - data bytes (the payload) versus the total bytes in the packet - typically expressed as a percent, is a measure of the network protocol overhead. While important, it is not nearly as significant as the data delivery and exchange method (network model) used. If a particular information exchange takes two or more packets on the wire as compared to one, the fact the one protocol has 25 percent greater efficiency becomes meaningless.

Network model. Every control vendor has its own favorite networks, whether it be Data Highway Plus, Remote I/O, Profibus FMS, Profibus DP, Interbus-S, ASI, Modbus Plus, GeniusLan, or Lonworks. All these networking options have the same thing in common. They follow the legacy source/destination network model. A typical packet is shown below.

src	dst	data	crc

Figure 1.

In master/slave implementations of this model, the source field is usually not present, as the master is the only source and all responses from slaves are for the master. This master/slave polling is inherently a one-to-one data exchange. It is typically used for the exchange of real time control data (I/O messaging). When used for I/O exchange, such networks are typically limited to that function alone to obtain the necessary repeatability and throughput for control.

Peer-to-peer networking goes beyond master/slave, providing considerably more flexibility. But as a result most networks that support peer-to-peer use explicit messaging.

PC-based programming and configuration of controllers uses explicit peer-to-peer messaging. PC-based MMI also use explicit peer-to-peer messaging. As additional MMI units are added, the network load increases dramatically as each unit typically will read all the same variables out of each controller as does the prior units so an operator can get the same alarms, trends, and graphics from multiple locations.

To keep nodes from dominating the wire, most peer-to-peer networks use some sort of token rotation algorithm. While these algorithms have been enhanced over the years to be more "fair, the basic flexibility that makes it attractive makes its use for peer-to-peer interlocking between controllers very problematic. Response times vary considerably for any given message, depending on load and on how "far away" one is from the token holder when there is a need to speak.

Frequently low-end electronic operator interface (EOI) units will be found on I/O networks, basically replacing simple push button, pilot light and meters. But as each EOI device is added, an additional load of typically the same data new node with a different destination address is added to the network. While variability isn't a factor because of the fixed nature of such loads, the increase in data load slows response time for all nodes, including the real I/O. It's not just EOI that's causing excess network loading. As I/O devices get smarter, the extra diagnostic and configuration data can absorb considerable bandwidth.

identifier	data	crc

Figure 2.

Whether master/slave or peer-to-peer, destination-oriented networks waste considerable bandwidth sending the same data set to multiple nodes. Trying to do coordinated control like sending a new setpoint to different drives in a synchronized manner is very difficult, as data arrives at each drive at a different time.

The new network paradigm: The producer/consumer network model

To manage the growing need for data, smarter devices and better control, new networks that simply increase the baud rate or number of nodes only postpones the inevitable. What is needed is a whole new network model that is designed to manage today's control issues.

That new model is producer/consumer. With producer/consumer networks, messages are identified by content. If a node needs data, it will "accept" that identifier and consume it.

Multicast. Because data is identified by its content; if a node needs that data, multiple nodes can consume the same data at the same time from a single producer. Nodes may be synchronized more precisely while achieving more efficient bandwidth usage. The source of data has to produce the information only once. Additional EOI and MMI can be added without increasing network traffic, since they can consume these same messages. And nodes can produce more than one data set, each using a unique identifier.

Multicast is inherently impossible with source/destination networks, although attempts have been made. Some have added a third field for a group destination and then reserved node numbers for group destination. Others allow a node to carry more than one node number. But these are all band-aid approaches, desperately trying to extend the exhausted legacy source/destination model.

Producer/consumer also allows for two new powerful I/O triggers, in addition to traditional polling. Polling is born out of the source/destination model, and is inherently a two message bi-directional transaction (originator sends output data, and receiving node responds with input data). This transaction is repeated as rapidly as possible to minimize latency from when an input occurs and is delivered to the controller. Most polling cycles are filled with the same outputs and inputs, wasting bandwidth.

With the producer/consumer model, two more efficient and effective one-way I/O trigger mechanisms are available: change-of-state and cyclic I/O production.

Change-of-state (event-based) data production. Nodes produce data only when that data changes. There is no "network polling cycle delay," and, as a result, the data is delivered to all consumers when it changes. A background heartbeat is produced cyclically so that consumers can tell if a device hasn't changed from one that is no longer online. Change-of-state can dramatically reduce network traffic and the load-on typically needed to repeatedly receive, process and generate the same data.

Cyclic (time-based) data production. Cyclic data production involves nodes producing data at a user-configured rate. Data is updated at a rate appropriate to the node and the application. Data can be sampled and produced by sensors at precise intervals for better PID control. Controllers can collect a stock of data for operator interfaces and produce it a couple times a second, plenty fast for human consumption; thereby preserving bandwidth for nodes with rapidly changing I/O.

Both peer-to-peer and controller-to-device exchanges can be handled more efficiently with cyclic and change-of-state data production of producer/consumer networks. Operator interface needs can be layered on top of I/O traffic with minimal increases to network load.

At the same time, producer/consumer networks can accommodate the flexible explicit messaging, point-to-point needs for device configuration and programming. Certain identifiers are typically specified for such traffic and nodes know they contain destination and other protocol information. These identifiers, coupled with the network access method, combine to insure that explicit messages, with their assorted larger overhead are much lower priority on the network than the I/O messages. Large uploads and downloads adjustments to configurations parameters, and diagnostic activities by users with their S/W tools are relegated to background traffic, fitted between the higher priority I/O messages.

No need for users to run both an I/O network and explicit message network through the plant. And no need for vendors to put an I/O port and an explicit message network port on devices. Is it any wonder that the newest open control networks -- DeviceNet, ControlNet, and FOUNDATION Fieldbus -- are all based on the producer/consumer model?

Will the source/destination model disappear?

Source/destination is a "hand me down" from the computer and data processing industry. While limited, source/destination systems are still well-suited for a variety of applications which do not require complex coordination and sharing of data. The flexibility and efficiency of the producer/consumer network model will allow for the expanded functionality demanded by today's applications and is well suited for tomorrow's smarter devices. In this day in age where users are demanding more (functionality, diagnostics) with less (one wire, not two), both users and vendors need a control networking strategy that works smarter -- and, consequently, a network model that works smarter and accomodates the future

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Patricia A. Murphy is manager for Emerging Technology and Standards at Rockwell Automation Control Systems.

Murphy's responsibilities include:

- *Integrating advanced technology into Rockwell Automation Control System's Communications Business.*
- *Coordinating advanced technology projects.*
- *Participating in industry consortia such as Fieldbus Foundation, ODVA and ControlNet International.*
- *Leading business standards activity and participating in international standards committees as appropriate.*

Murphy has many years of marketing and product management experience in technology driven industries including automation, with Rockwell Automation Control Systems, and telecommunications, with Ericsson and GE.

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Jeanne Connelly

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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

IN RE APPLICATION OF:
FRED B. HOLT AND VIRGIL E. BOURASSA
APPLICATION NO.: 09/629,570
FILED: JULY 31, 2000
FOR: JOINING A BROADCAST CHANNEL

ART UNIT NO. 2744

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Technology Center 2600

Supplemental Information Disclosure Statement Within Three Months of Application Filing or Before First Action – 37 CFR 1.97(b)

Commissioner for Patents
Washington, D.C. 20231

Sir:

1. Timing of Submission

This information disclosure is being filed within three months of the filing date of this application or date of entry into the national stage of an international application or before the mailing date of a first Office action on the merits, whichever occurs last [37 CFR 1.97(b)]. The references listed on the enclosed Form PTO/SB/08A (modified) may be material to the examination of this application; the Examiner is requested to make them of record in the application.

2. Cited Information

☒ Copies of the following references are enclosed:

- ☒ All cited references
- ☐ References marked by asterisks
- ☐ The following:

☐ Copies of the following references can be found in parent application Ser. No. :

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☐ The following references are not in English. For each such reference, the undersigned has enclosed (i) a translation of the reference; (ii) a copy of a communication from a foreign patent office or International Searching Authority citing the reference, (iii) a copy of a reference which appears to be an English-language counterpart, or (iv) an English-language abstract for the reference prepared by a third party. Applicant has not verified that the

[/Supplemental IDS-NO O-A - JAN2002.DOC] translation, English-language counterpart or third-party abstract is an accurate representation of the teachings of the non-English reference, though, and reserves the right to demonstrate otherwise.

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3. Effect of Information Disclosure Statement (37 CFR 1.97(h))

This Information Disclosure Statement is not to be construed as a representation that: (i) a search has been made; (ii) additional information material to the examination of this application does not exist; (iii) the information, protocols, results and the like reported by third parties are accurate or enabling; or (iv) the cited information is, or is considered to be, material to patentability. In addition, applicant does not admit that any enclosed item of information constitutes prior art to the subject invention and specifically reserves the right to demonstrate that any such reference is not prior art.

4. Fee Payment

No fees are believed due. However, should the Commissioner determine that fees are due in order for this Information Disclosure Statement to be considered, the Commissioner is hereby authorized to charge such fees to Deposit Account No. 50-0665.

5. Patent Term Adjustment (37 CFR 1.704(d))

☒ The undersigned states that each item of information submitted herewith was cited in a communication from a foreign patent office in a counterpart application and that this communication was not received by any individual designated in 37 C.F.R. § 1.56(c) more than thirty days prior to the filing of this statement. 37 C.F.R. § 1.704(d).

Respectfully submitted,
Perkins Coie LLP

Date: 6/13/02

Maurice J. Pirio
Registration No. 33,273

Correspondence Address:
Customer No. 25096
Perkins Coie LLP
P.O. Box 1247
Seattle, Washington 98111-1247
Phone: (206) 583-8888

RELIABLE BROADCAST IN MOBILE WIRELESS NETWORKS[1]

S. Alagar and S. Venkatesan
Department of Computer Science, University of Texas at Dallas
Richardson, TX 75083

J. R. Cleveland
C3 Systems Division, Electrospace Systems, Inc., A Chrysler Company
Richardson, TX 75081

ABSTRACT

This paper presents preliminary results of our research on wireless networking that supports reliable communications between nomadic hosts engaged in distributed computing and collaborative conferencing. Our network model consists of a set of low-power, radio frequency (RF) transceivers which move relative to each other across an irregular terrain subject to RF propagation impairments. The low transmitter power defines a radio coverage which limits the probability of intercept and the number of neighbors but optimizes frequency reuse. The combination of low power and propagation environment produces a network characterized by stochastic link failures. The rapidity of these failures and perturbations to the network topology defeats the use of routing policies based on maintaining routing tables or determining least cost paths. With these conditions as the background, our work addresses the need to provide reliable information exchange, mitigate bottlenecks, avoid excessive traffic, and offer scalable services without the benefit of static base station or fixed backbone support. Meeting such challenges demands a robust, flexible information transport system that delivers all required information for diverse operational scenarios. The approach emphasizes the importance of achieving guaranteed delivery across a network of limited size operating in a hostile environment rather than obtaining a high throughput per unit area, typical of commercial enterprises.

The basic premise of the protocol is that host mobility and terrain prevents *a priori* knowledge of any host location and optimum path. Message broadcasting, or flood routing, provides the means for reliable delivery of information in the presence of uncertain connectivity and node locations. Knowledge of the network results, instead, from a measure of transmitted and received message traffic. Central to the protocol is the provision for each mobile host to retain a *HISTORY* of messages broadcast to and received from its neighbor(s). A host which receives a message broadcasts an acknowledgment to the sender, updates its local *HISTORY*, and then retransmits the message if it is not a duplicate message. Duplicated messages are discarded. If a sending host does not receive an acknowledgment from a neighbor within a certain time, it timeouts and resends the message. If a host does not receive an acknowledgment after several retries, it assumes that the link disconnection is not transient and stops sending the message. When a host detects a new neighbor, a handshake procedure results in the exchange of active messages not common to the respective *HISTORY* of each host. Once the handshake procedure terminates, the contents of the *HISTORY* for each host are identical. Thus, using handshake procedures, mobile hosts receive messages that they did not receive previously due to link disconnections. Idle hosts will periodically broadcast a sounding message to maintain their network presence.

1. INTRODUCTION.

Winning the information war with complete and up-to-date intelligence is vital to the entire spectrum of possible operational requirements, whether engaged in war or corporate strategic planning. Military commanders engaged in rapid force projection, as well as public safety officers, medical staff, and corporate managers, demand accurate information regardless of location or situation. Each requires a clear and accurate picture of a changing situation to reach well-informed decisions and successful conclusion. Information must flow throughout the network toward the users at each level of the management hierarchy whether at the sustaining base or at the forward most part of the mission. Participating staff must have the capability to acquire or send accurate information that defines their space and situation. The information transport network must extend reliable voice, data, video, and imagery transmissions to nomadic users at any location. The availability of assured communications directly relates to mission success through computing, conferencing, and synchronized tasking while fixed or on-the-move. Invariably, this critical information is required when communications services normally provided by a reliable,

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fixed infrastructure are unavailable or severely degraded.

The wireless networking of mobile (i.e., nomadic) subscribers is an emerging paradigm in the field of distributed command, control, and computing, with the potential to improve command and control responsiveness. In our context, the phrase "mobile wireless network" means that the network does not contain any static support stations. This network model supports the needs of subscribers to mobile command posts and mobile satellite ground entry points. In this role, the network must provide reliable information transfer, mitigate bottlenecks, avoid excessive traffic, offer scalable services, and, above all, adapt to dynamic topologies. The RF coverage area should conform as closely as possible to the area over which subscribers move, thereby offering a low probability of detection and improving frequency re-use. Low-cost implementation and operation are critical.

Nomadic wireless networks currently are characterized by limited bandwidth and frequent changes in link connectivity. The challenge is to allow updates from multiple users simultaneously, but only for those users that require the service. The major requirements include the capability to: minimize updates, provide fault-tolerant service, provide service scalability, and minimize communication and computation overhead. Many of the algorithms that assume static hosts or well-defined point-to-point links cannot be directly used for mobile systems due to the changes in physical connectivity and limited bandwidth of the wireless links. This has spawned considerable research in mobile computing: designing communication protocols [1, 2, 3, 4], file system operations [5, 6], managing data efficiently [7, 8], and providing fault tolerance [9]. Most research on these topics is based on a model in which the mobile hosts are supported by static base stations such as cellular telephony or personal communications systems (PCS). A typical PCS topology takes the form of a single-hop network in which each host is within radio range of the base station or all other hosts. In this paper, we consider the problem of providing reliable broadcast in mobile wireless networks where single-hop and known topologies may not exist. Applications include disaster relief operations, highly mobile military or law enforcement operations, and rapid response contingency operations where it is not economical to place support stations.

2. WIRELESS NETWORK MODEL. The model of the mobile wireless network consists of several mobile hosts distributed over an irregular terrain (Figure 1). The mobile hosts use low-power transmitters and novel, efficient receivers [10] to communicate. Emerging technologies and products for PCS applications that operate in the ISM bands with a transmitter power of 1W [11] provide the basis for practical implementation. In this network concept, the *cell* of a mobile host is the geographical area within which the mobile hosts can directly communicate with other mobile hosts. Note that the cell of a host does not remain fixed, but moves with each attached host. The nominal cell size (R) is determined by a path loss model that denotes the *local average* received signal power relative to the transmit power. A general path loss (PL) model that has been demonstrated through measurement uses a parameter $2 \le \mu \le 5$ [12] to denote the power law relati nship between distance and received power. Based on both analysis and measured results, $\mu \approx 4$ for the microcell propagation environment beyond a characteristic distance R_o. The power law model takes the form [13]:

$$PL(R) = PL(R_o) + 10\mu \log(R/R_o) + X_\sigma \qquad (1)$$

where $PL(R_o)$ gives the power loss at the characteristic distance R_o and X_σ denotes a zero mean Gaussian random variable that reflects the fluctuations in average received power. Nelson and Kleinrock [14] show that for a slotted ALOHA network protocol, the optimum throughput occurs with a cell size defined by a range that includes an average of six nearest neighbors. Their results are reproduced in Figure 2. These results assume a random distribution of nodes across the terrain and a perfect capture condition. Perfect capture occurs when a node will always receive and detect the strongest of several simultaneous transmissions within its hearing range. The weaker signals appear as noise to the detection process. A non-caputre condition occurs if simultaneous transmissions always result in collisions. The reduced power supports frequency reuse, as well as low probability of detection. Their analysis also shows that mobile hosts with sufficient

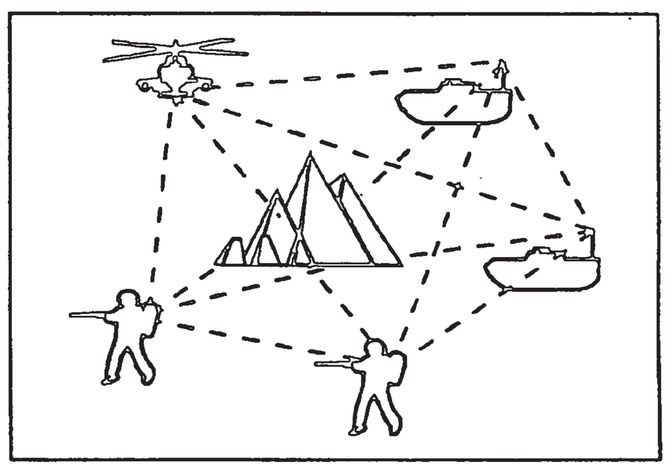

Figure 1. Model of a wireless computer network that experiences link failures due to range limitations and terrain impairments.

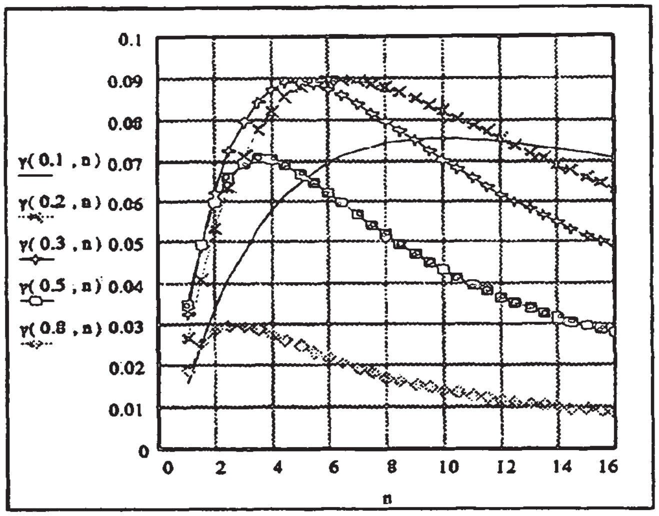

Figure 2. Normalized throughput for perfect capture with the slotted ALOHA protocol versus the average number of nearest neighbors for different probabilities that a node is busy.

transmitter power to reach all other hosts (i.e., a single-hop network) support a significantly lower throughput.

Detecting Neighbors. Neighbors are detected by a strategy common to a general class of survivable and adaptive network protocols that use sounding procedures [15, 16]. Two mobile hosts are *neighbors* if they can "hear" each other. Each host detects its neighbors by periodically broadcasting a probe message. A host that hears a probe message sends an acknowledgment to the probing host. Every host maintains a list of neighbors and periodically updates the list based on acknowledgments received. When two hosts become neighbors, a wireless link is established between them, and they execute a *handshake* procedure. As part of the handshake procedure, they each update their list of neighbors.

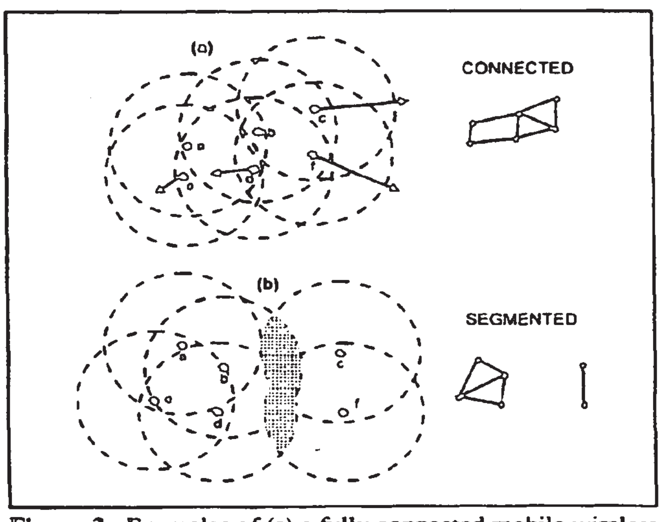

Figure 3. Examples of (a) a fully connected mobile wireless network and (b) a decomposed network due to mobility of hosts *c* and *f*. The shaded region indicates the common area within the range of hosts *c* and *f* and the rest of th network.

Link Disconnections. The wireless link between two neighbors is unreliable due to RF propagation effects such as loss of line-of-sight (LOS), moving out of range, multipath fading, or inclement weather. There are two types of link disconnections: (1) transient and (2) permanent. In the transient case, a host is unable to communicate briefly with a neighbor due to: (a) the neighbor moving out of sight; (b) multipath fading; or (c) inclement weather. Multipath fading has a time dependence that varies from microseconds to seconds, depending on the terrain and the host velocity [17]. Fade depths range up to 20 dB. The stochastic behavior of such transient link disconnections is very similar to that encountered for high frequency radio networks [18]. In the permanent case, a host is unable to communicate with a neighbor because their separation exceeds the range described by the cell geometry. We assume that each mobile host can communicate with an arbitrary mobile host in its cell without any interference (from other mobile hosts in the same cell) using techniques such as TDMA or code division multiple access (CDMA) spread spectrum signaling. One such technique is presented in [16].

3. BROADCAST CONSIDERATIONS. Terrestrial networks provide the means to manage RF spectrum utilizati n to minimize the inherent latency for transmission, the probability of detection, and the cost of utilization not afforded by satellite services. Reliable broadcast in a mobile wireless network is not easy due to the following reasons: (1) It may be difficult to maintain a convenient structure (spanning tree, virtual ring) for broadcasting because of the mobility of hosts and the absence of an established backbone network. While an adaptive algorithm can be used to maintain the structure, the small cell size leads to cases where two neighbors may frequently move out of each others' range leading to the invocation of the adaptive algorithm frequently. (2) The wireless network itself may not be connected always (see Figure 3). They may be decomposed into several connected components for a while and merge after some time (we assume "quite often"). We also assume that permanent disconnections do not occur. In the next section we present a preliminary solution for reliable broadcast in mobile wireless network. Our solution is based on simple (restricted) flooding and handshaking.

Flooding ultimately involves transmitting the message to every node in the network, which is a disadvantage, particularly for large networks. The main advantage of flooding is that there is little explicit overhead and network management. As a consequence, no provisions are made to store or maintain routing or management data. Instead, hosts keep track of individual messages received and determine whether or not to retransmit the message. It is well suited to network requirements for highly mobile user groups on the digitized battlefield or in disaster relief operations where there is a need for reliable delivery in the presence of uncertain connectivity and rapid topology changes [19].

4. BROADCAST PROTOCOL. To broadcast a message, a mobile host transmits the message to all of its neighbors. On receiving a broadcast message, an intermediate mobile host retransmits the message to all of its neighbors. The technique would suffice if the network remained connected forever. Additional steps are necessary to cope with network link disconnections.

For example, mobile host h_i maintains a sequence counter, CNT_i. At any instant, the value of CNT_i denotes the number of messages broadcast by host h_i. CNT_i is incremented when h_i is about to broadcast a new message. In addition, host h_i maintains a history of messages ($HISTORY_i$) it has broadcast as well as received from other hosts. The j^{th} component of $HISTORY_i$ contains information about messages broadcast from h_i and received from h_j. A rebroadcast count and a time stamp provide the means to limit the propagation of the message in a large network.

A sample pictorial representation of $HISTORY_i$ is shown in Figure 4. Host h_j has received messages 1 and 4, but not

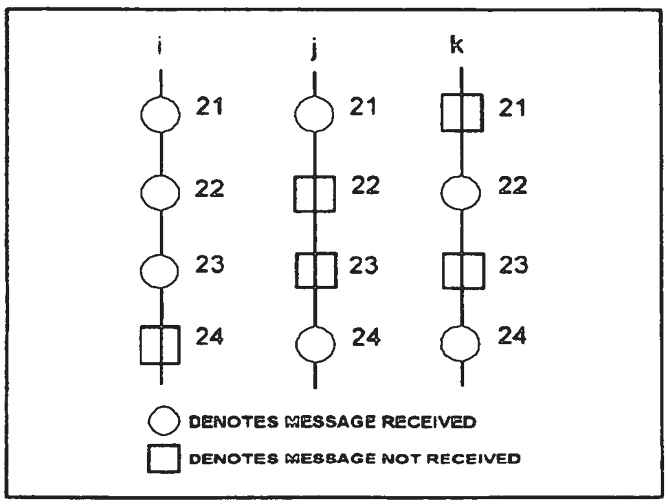

Figure 4. A snapshot of the status of the $HISTORY_i$ showing messages stored in h_i, h_j and h_k.

messages 2 and 3. Similarly, h_k has received messages 2 and 4 from h_k, but not messages 1 and 3. It is easy to maintain $HISTORY$, for each h, as an array of lists. We now describe our solution for reliable broadcast.

Normal Operation. Let us assume that host h_i wants to broadcast message m. The following occurs:

- Host h_i first increments CNT_i and then transmits message (m , h_i, CNT_i) to all neighbors. It also stores (m , h_i , CNT_i) in a buffer locally.
- When host h_j receives message (m , h_i , CNT_i), it sends an acknowledgment to the sender, updates the i^{th} component of $HISTORY_j$ and buffers the message locally. Host h_j then retransmits the message (m , h_i , CNT_i) to its neighbors.
- If h_j receives another copy of (m , h_i , CNT_i), it discards the message, but sends an acknowledgment to the sender.
- A mobile host h, after sending a message (m , h_i , CNT_i) to its neighbors, waits for acknowledgments from all of its neighbors. If h does not receive acknowledgment from a neighbor within a certain time, h timeouts and resends the message (with a hope that link disconnection is transient). If h does not receive acknowledgment after several retries, h assumes that the link disconnection is not transient and stops sending the message.

During periods of heavy message exchange activity, this strategy substitutes for the polling or sounding procedure described in Section 2.

Handshake Procedure. When host h_j detects a new neighbor, h_k, a handshake procedure is executed by hosts h_j and h_k:

- h_j sends $HISTORY_j$ to h_k and receives $HISTORY_k$ from h_k.
- h_j compares $HISTORY_k$ with $HISTORY_j$ to identify messages available in $HISTORY_j$ but not in $HISTORY_k$, and broadcasts those messages. Host h_k does likewise.
- h_k then receives the "new" messages send by h_j and updates $HISTORY_k$. h_j does the same for messages received from h_k. also sends these "new" messages to other neighbors.

At the conclusion of the handshake procedure, the contents of $HISTORY_j$ and $HISTORY_k$ are equal. Thus, using handshake procedure, mobile hosts receive messages that they did not receive due to link disconnections. The size of $HISTORY$ stored at each h can be reduced as follows. If the first message received by h_j from h_k is CNT_k=t then it is sufficient for the k^{th} component of $HISTORY_i$ to start from t. Storage for entry of messages 1 to t - 1 need not be provided. Further optimization can be done by storing either the $HISTORY$ of messag s received or the $HISTORY$ messages not received depending on which list is smaller.

5. CONCLUSIONS AND FUTURE WORK. We have presented a protocol model designed to achieve assured delivery of information in a multi-hop nomadic wireless network. To mitigate a handicap of flood routing, the protocol includes a mechanism to restrict the retransmission of messages. The protocol accounts for the temporary separation of a node, or node segments, from other network members. Our continued research is devoted to methods which improve the protocol efficiency given the limitation of flood routing. In order to reduce the size of the buffer at each mobile host, a buffered message can be deleted after it is received by all the hosts. For each message a host receives, the host sends an acknowledgment to the sender of the message. Once acknowledgments from all hosts have reached the originator, the originator can direct the hosts to delete the message from the buffer [2]. To this end, we may have to broadcast and buffer acknowledgments also, which will increase the overhead. One of our objectives is to design an efficient acknowledgment policy that does not adversely increase the congestion and storage required at each host. Another option in deleting the buffered messages is to use timeouts, but this may not be suitable in critical applications where messages cannot be lost. Also the timeout period has to be chosen carefully (incorporating the mobility and link disconnections) so that the probability of message loss is very low. Some related research issues are: (1) deriving the necessary conditions, with respect to the host mobility pattern for our protocol to work; (2) identifying structures that are easy to maintain and are suitable for broadcasting; and (3) designing efficient routing schemes for unicasting messages.

We are investigating the efficiency and performance characteristics of survivable and adaptive network protocols with computer simulation techniques. Preliminary results will be reported on the evaluation of the algorithm in terms of message delay and acknowledgment overhead for different network sizes and routing restrictions. Our preliminary results indicate the viability of the message management protocol for collaborative computing in a dynamic computer network topology when the reliability of information is paramount.

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PATENT COOPERATION TREATY

DOCKETED

JUN 11 2002

From the INTERNATIONAL SEARCHING AUTHORITY

PCT

To:
PERKINS COIE LLP
Attn. Pirio, Maurice J.
P.O. Box 1247
Seattle, WA 98111-1247
UNITED STATES OF AMERICA

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

(PCT Rule 44.1)

	Date of mailing *(day/month/year)* 05/06/2002
Applicant's or agent's file reference 030048001WO	**FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. PCT/US 01/ 24240	International filing date *(day/month/year)* 31/07/2001
Applicant THE BOEING COMPANY	

1. [X] The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:
The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Fascimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. [ ] The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. [ ] **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

[ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

[ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90*bis*.1 and 90*bis*.3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the International Searching Authority	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Claude Berthon

Form PCT/ISA/220 (July 1998)

NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the PCT Applicant's Guide, a publication of WIPO.

In these Notes, "Article", "Rule", and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions respectively.

INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international pbulication. Furthermore, it should be emphasized that provisional protection is available in some States only.

What parts of the international application may be amended?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

When? Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

Where not to file the amendments?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

How? Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Administrative Instructions, Section 205(b)).

The amendments must be made in the language in which the international application is to be published.

What documents must/may accompany the amendments?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the language of the international application is English, the letter must be in English; if the language of the international application is French, the letter mu t be in French.

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped),whether

(i) the claim is unchanged;

(ii) the claim is cancelled;

(iii) the claim is new;

(iv) the claim replaces one or more claims as filed;

(v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]: "Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers; claims 30, 33 and 36 unchanged; new claims 49 to 51 added."
2. [Where originally there were 15 claims and after amendment of all claims there are 11]: "Claims 1 to 15 replaced by amended claims 1 to 11."
3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]: "Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or "Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."
4. [Where various kinds of amendments are made]: "Claims 1-10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

"Statement under article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

It must be in the language in which the international appplication is to be published.

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)."

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the same time of filing the amendments with the International Bureau, also file a copy of such amendments with the International Preliminary Examining Authority (see Rule 62.2(a), first sentence).

Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, where upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see Volume II of the PCT Applicant's Guide.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 030048001WO	**FOR FURTHER ACTION** see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/US 01/ 24240	International filing date *(day/month/year)* 31/07/2001	(Earliest) Priority Date *(day/month/year)* 31/07/2000
Applicant THE BOEING COMPANY		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 1

   [ ] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [X] because this figure better characterizes the invention.

   [ ] None of the figures.

Form PCT/ISA/210 (first sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 01/24240

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L12/18 H04L12/56

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, IBM-TDB, INSPEC, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4 912 656 A (CAIN JOSEPH B ET AL) 27 March 1990 (1990-03-27) column 5, line 60 -column 7, line 20	1-3, 7-10,12, 19,20, 22,24-27
A		13-18, 21,28-33
Y	US 5 056 085 A (VU THU V) 8 October 1991 (1991-10-08) column 2, line 49 -column 3, line 12	1-3, 7-10,12, 19,20, 22,24-27

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 May 2002	05/06/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Ströbeck, A.

1

International Application No
PCT/US 01/24240

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	ALAGAR S ET AL: "Reliable broadcast in mobile wireless networks" MILITARY COMMUNICATIONS CONFERENCE, 1995. MILCOM '95, CONFERENCE RECORD, IEEE SAN DIEGO, CA, USA 5-8 NOV. 1995, NEW YORK, NY, USA,IEEE, US, 5 November 1995 (1995-11-05), pages 236-240, XP010153965 ISBN: 0-7803-2489-7 page 237, left-hand column, line 43 -page 239, right-hand column, last line	1-33

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 01/24240

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4912656 A	27-03-1990	NONE	
US 5056085 A	08-10-1991	NONE	

Form PCT/ISA/210 (patent family annex) (July 1992)

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/629,570	07/31/2000	Fred B. Holt	030048002US	5411

25096 7590 10/17/2003

PERKINS COIE LLP
PATENT-SEA
P.O. BOX 1247
SEATTLE, WA 98111-1247

EXAMINER	
WINTERS, MAREISHA N	
ART UNIT	**PAPER NUMBER**
2153	7

DATE MAILED: 10/17/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

PTO-90C (Rev. 10/03)

PRG

Office Action Summary	Application No.	Applicant(s)
	09/629,570	HOLT ET AL.
	Examiner	**Art Unit**
	Mareisha N. Winters	2153

-- The MAILING DATE of this communication appears on the cover sheet with the correspond nce address --

Peri d for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 1 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on 31 July 2000 .

2a)☐ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 1-49 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☐ Claim(s) _____ is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☒ Claim(s) 1-49 are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

1. Claims 1-49 are pending in the application.

Election/Restrictions

2. Restriction to one of the following inventions is required under 35 U.S.C. 121:

I. Claims 1-17 and 32-40, drawn to a method for adding a participant to a network, the method comprising identifying a pair, disconnecting the pair and reconnecting the pair, classified in class 709, subclasses 204, 205.

II. Claims 18-31, drawn to a method for sending a connection edge search message for adding a participant to a network, classified in class 709, subclass 225.

III. Claims 41-49, drawn to a method for detecting neighbors with empty ports in a network, classified in class 709, subclass 229.

3. The inventions are distinct from each other for the following reasons:

Inventions I, II and III are unrelated. Inventions are unrelated if it can be shown that they are not disclosed as capable of use together and they have different modes of operation, different functions, or different effects (MPEP § 806.04, MPEP § 808.01). In the instant case the different inventions are unrelated because:

- Invention I defines the function of adding a participant to a network by identifying a pair, disconnecting the pair and reconnecting the pair with the added participant that is not disclosed in Inventions II and III;
- Invention II defines the function of sending a connection edge search message for adding a participant to a network that is not disclosed in Inventions I and III; and

- Invention III defines the function of detecting neighbors with empty ports in a network that is not disclosed in Inventions I and II.

4. Because these inventions are distinct for the reasons given above and have acquired a separate status in the art as shown by their different classification, restriction for examination purposes as indicated is proper.

5. These inventions are distinct for the reason given above and the search required for each group is different and not co-extensive for examination purpose. For example, the searches for the two inventions would not be co-extensive because these groups would require different searches on PTO's classification class and subclass as following:

a. Group I search (claims 1-175 and 32-40) would require use of search class 709, subclasses 204 and 205 (not required for Groups II and III).

b. Group II search (claims 18-31) would require the search of class 709, subclass 225 (not required for Groups I and III).

c. Group III search (41-49) would require the search of class 709, subclass 229 (not required for Groups I and II).

6. Because these inventions are distinct for the reasons given above and they require different searches, restriction for examination purposes as indicated is proper.

7. Applicants are advised that the response to this requirement to be complete must include an election of the invention to be examined even though the requirement be traversed.

Conclusion

8. A shortened statutory period for response to this action is set to **expire 1 (one) month and 0 (zero)** days from the mail date of this letter. Fail to respond within the period for response

will result in **ABANDONMENT** of the application (see 35 U.S.C. 133, M.P.E.P 710.02, 710.02(b)).

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Mareisha N. Winters whose telephone number is (703) 305-7838. The examiner can normally be reached on Monday-Friday, 8:00am-5:00pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Glenton B. Burgess can be reached on (703) 305-4792. The official fax phone number for the organization where this application or proceeding is assigned is (703) 872-9306.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703) 305-3900.

Mareisha N. Winters MNW
Patent Examiner
Art Unit 2153
October 15, 2003

ZARNI MAUNG
PRIMARY EXAMINER

10-30-03

2153

Attorney Docket No. 030048002US #8/6

PATENT

Express Mail No. EV335523788US

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

IN RE APPLICATION OF:	FRED B. HOLT *ET AL.*	EXAMINER: MAREISHA N. WINTERS
APPLICATION NO.:	09/629,570	ART UNIT: 2153
FILED:	JULY 31, 2000	CONF. NO: 5411
FOR:	**JOINING A BROADCAST CHANNEL**	

Amendment in Response to Restriction Requirement

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In response to the Office Action dated October 17, 2003, please amend the application as reflected in the following listing of claims.

Amendment to the Claims

1. (Original) A computer-based method for adding a participant to a network of participants, each participant being connected to three or more other participants, the method comprising:

identifying pair of participants of the network that are connected;

disconnecting the participants of the identified pair from each other; and

connecting each participant of the identified pair of participants to the added participant.

A1

2. (Original) The method of claim 1 wherein each participant is connected to 4 participants.

3. (Original) The method of claim 1 wherein the identifying of a pair includes randomly selecting a pair of participants that are connected.

4. (Original) The method of claim 3 wherein the randomly selecting of a pair includes sending a message through the network on a randomly selected path.

5. (Original) The method of claim 4 wherein when a participant receives the message, the participant sends the message to a randomly selected participant to which it is connected.

6. (Original) The method of claim 4 wherein the randomly selected path is approximately proportional to the diameter of the network.

7. (Original) The method of claim 1 wherein the participant to be added requests a portal computer to initiate the identifying of the pair of participants.

8. (Original) The method of claim 7 wherein the initiating of the identifying of the pair of participants includes the portal computer sending a message to a connected participant requesting an edge connection.

9. (Original) The method of claim 8 wherein the portal computer indicates that the message is to travel a certain distance and wherein the participant that receives the message after the message has traveled that certain distance is one of the participants of the identified pair of participants.

10. (Original) The method of claim 9 wherein the certain distance is approximately twice the diameter of the network.

A1 cont

11. (Original) The method of claim 1 wherein the participants are connected via the Internet.

12. (Original) The method of claim 1 wherein the participants are connected via TCP/IP connections.

13. (Original) The method of claim 1 wherein the participants are computer processes.

14. (Original) A computer-based method for adding nodes to a graph that is m-regular and m-connected to maintain the graph as m-regular, where m is four or greater, the method comprising:

identifying p pairs of nodes of the graph that are connected, where p is one half of m;

disconnecting the nodes of each identified pair from each other; and

connecting each node of the identified pairs of nodes to the added node.

15. (Original) The method of claim 14 wherein identifying of the p pairs of nodes includes randomly selecting a pair of connected nodes.

16. (Original) The method of claim 14 wherein the nodes are computers and the connections are point-to-point communications connections.

a1 cont

17. (Original) The method of claim 14 wherein m is even.

18–31. (Cancelled)

32. (Original) A computer-readable medium containing instructions for controlling a computer system to connect a participant to a network of participants, each participant being connected to three or more other participants, the network representing a broadcast channel wherein each participant forwards broadcast messages that it receives to its neighbor participants, by a method comprising:

a2

identifying a pair of participants of the network that are connected;

disconnecting the participants of the identified pair from each other; and

connecting each participant of the identified pair of participants to the added participant.

33. (Original) The computer-readable medium of claim 32 wherein each participant is connected to 4 participants.

34. (Original) The computer-readable medium of claim 32 wherein the identifying of a pair includes randomly selecting a pair of participants that are connected.

35. (Original) The computer-readable medium of claim 34 wherein the randomly selecting of a pair includes sending a message through the network on a randomly selected path.

36. (Original) The computer-readable medium of claim 35 wherein when a participant receives the message, the participant sends the message to a randomly selected participant to which it is connected.

37. (Original) The computer-readable medium of claim 35 wherein the randomly selected path is approximately twice a diameter of the network.

38. (Original) The computer-readable medium of claim 32 wherein the participant to be added requests a portal computer to initiate the identifying of the pair of participants.

9? cont

39. (Original) The computer-readable medium of claim 38 wherein the initiating of the identifying of the pair of participants includes the portal computer sending a message to a connected participant requesting an edge connection.

40. (Original) The computer-readable medium of claim 38 wherein the portal computer indicates that the message is to travel a certain distance and wherein the participant that receives the message after the message has traveled that certain distance is one of the identified pair of participants.

41–49. (Cancelled)

REMARKS

In the above referenced Office Action, the Examiner divided the claims into the following groups:

I. Claims 1-17 and 32-40, drawn to a method for adding a participant to a network, the method comprising identifying a pair, disconnecting the pair and reconnecting the pair;

II. Claims 18-31, drawn to a method for sending a connection edge search message for adding a participant to a network; and

III. Claims 41-49 drawn to a method for detecting neighbors with empty ports in a network.

In response, the applicants elect Group I without traverse. Non-elected claims 18-31 and 41-49 have been canceled.

No fees are believed due with this communication. However, the Commissioner is hereby authorized and requested to charge any deficiency in fees herein to Deposit Account No. 50-0665.

Respectfully submitted,
Perkins Coie LLP

Date: 10/28/03

Chun M. Ng
Registration No. 36,878

Correspondence Address:
Customer No. 25096
Perkins Coie LLP
P.O. Box 1247
Seattle, Washington 98111-1247
(206) 359-8000

IEEE Search:

"flood routing"

new <near/3> node <near/5> (add or added or adding or join or joining or joins or connect or connected or connecting) <near/5> network

configur* <near/3> connection <near/5> network <near/5> (node or computer)

configur* <near/5> connection <near/5> network

(disconnect* or add* or connect* or join*) <near/4> (node) <near/4> network

(disconnect* or add* or connect* or join*) <near/4> (node) <near/4> network and (configur* or topology)

(configur* or reconfigur*) <near/3> (node or network) and graph

(configur* or reconfigur*) <near/3> (node or network) and graph and (add* or join*)

(configur* or reconfigur*) <near/5> (network) and (add* or join* or connect*) <near/5> node and graph

m-connected or k-connected or n-connected or m-regular or k-regular or n-regular

Google Terms used

graph topology network node connected
join add addition
internet regular disconnect configure incomplete
hypercube

L Numb r	Hits	S arch T xt	DB	Tim stamp
1	20	"5471623"	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 16:18
2	2	"6553020"	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 16:19
3	409	new near3 node near5 (add or added or adding or join or joining or joins or connect or connected or connecting) near5 network	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 16:27
4	380	new near3 node near3 (add or added or adding or join or joining or joins or connect or connected or connecting) near5 network	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 16:28
5	98	(new near3 node near3 (add or added or adding or join or joining or joins or connect or connected or connecting) near5 network).ti,ab,clm.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 16:33
6	56	((new near3 node near3 (add or added or adding or join or joining or joins or connect or connected or connecting) near5 network).ti,ab,clm.) and (@ad<20000731 or @prad<20000731)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 16:33
7	105	(new near3 node near3 (add or added or adding or join or joining or joins or connect or connected or connecting or enter or entering or entered) near5 network).ti,ab,clm.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 17:27
8	61	((new near3 node near3 (add or added or adding or join or joining or joins or connect or connected or connecting or enter or entering or entered) near5 network).ti,ab,clm.) and (@ad<20000731 or @prad<20000731)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 17:25
9	2310	configur$6 near5 connection near5 network	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 17:25
10	501	configur$6 near5 connection near5 network with (n de r c mputer)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 17:25

11	213	configur$6 n ar3 c nn cti n n ar5 n twork n ar5 (node r comput r)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 17:28
12	121	(configur$6 near3 c nn cti n n ar5 n tw rk near5 (node or computer)) and (@ad<20000731 or @prad<20000731)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 17:28
13	121	((configur$6 near3 connection near5 network near5 (node or computer)) and (@ad<20000731 or @prad<20000731)) not "5471623" not (((new near3 node near3 (add or added or adding or join or joining or joins or connect or connected or connecting or enter or entering or entered) near5 network).ti,ab,clm.) and (@ad<20000731 or @prad<20000731))	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 17:26
14	39	(((configur$6 near3 connection near5 network near5 (node or computer)) and (@ad<20000731 or @prad<20000731)) not "5471623" not (((new near3 node near3 (add or added or adding or join or joining or joins or connect or connected or connecting or enter or entering or entered) near5 network).ti,ab,clm.) and (@ad<20000731 or @prad<20000731))) and topology	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 17:26
15	12	(((configur$6 near3 connection near5 network near5 (node or computer)) and (@ad<20000731 or @prad<20000731)) not "5471623" not (((new near3 node near3 (add or added or adding or join or joining or joins or connect or connected or connecting or enter or entering or entered) near5 network).ti,ab,clm.) and (@ad<20000731 or @prad<20000731))) and (new near4 (node or computer or device) near (add or added or adding or join or joining or joins or connect or connected or connecting or enter or entering or entered))	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 17:28
16	404	configur$6 near3 connection near5 network near5 (node or computer or device)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 17:28
17	31	(configur$6 near3 connection near5 network near5 (node or computer or device)) and (new n ar4 (n de r computer or d vice) n ar (add r added r adding or join or joining r joins r connect or c nnect d or conn cting r nt r r ent ring r ent r d))	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 17:28

18	22	((configur$6 n ar3 c nn ction n ar5 n tw rk n ar5 (node or comput r r d vic)) and (n w n ar4 (node or comput r r d vic) n ar (add or added r adding or j in or j ining or j ins r conn ct or conn ct d r c nn cting or ent r or entering or nt red))) and (@ad<20000731 or @prad<20000731)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 17:34
19	2	"6490247"	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 17:34
20	32	m-connected or k-connected or n-connected or m-regular or k-regular or n-regular	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 18:24
21	263810	"32" and network	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 18:24
22	12	(m-connected or k-connected or n-connected or m-regular or k-regular or n-regular) and network	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 18:26
23	1377	(configur$6 or reconfigur$6) near3 (node or network) and graph and (add$3 or join$3) near4 (node or network)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 18:27
24	15	(configur$6 or reconfigur$6) near3 (node or network) same graph same (add$3 or join$3) near4 (node or network)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 18:27
-	36	"4912656"	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 12:31
-	0	m-regular	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 12:32
-	3	m-connected	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 12:48
-	12	5101480.URPN.	USPAT	2004/01/02 12:33

-	11	5099235.URPN.	USPAT	2004/01/02 12:45
-	6075	((disconn ct$4 or add$3 r c nn ct$3 r j in$3) n ar4 (node) n ar4 n twork).ti,ab,clm.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 12:48
-	232	(((disconnect$4 or add$3 or connect$3 or join$3) near4 (node) near4 network).ti,ab,clm.) and satellite	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 18:23
-	155	((((disconnect$4 or add$3 or connect$3 or join$3) near4 (node) near4 network).ti,ab,clm.) and satellite) and (@ad<20000731 or @prad<20000731)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 16:28
-	152	(((((disconnect$4 or add$3 or connect$3 or join$3) near4 (node) near4 network).ti,ab,clm.) and satellite) and (@ad<20000731 or @prad<20000731)) not "4912656" not m-connected not 5101480.URPN. not 5099235.URPN.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 13:20
-	4	k-regular or n-regular	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/01/02 16:16

PRG

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/629,570	07/31/2000	Fred B. Holt	030048002US	5411

25096 7590 01/12/2004

PERKINS COIE LLP
PATENT-SEA
P.O. BOX 1247
SEATTLE, WA 98111-1247

EXAMINER	
EDELMAN, BRADLEY E	
ART UNIT	**PAPER NUMBER**
2153	9

DATE MAILED: 01/12/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

PTO-90C (Rev. 10/03)

Office Action Summary	Application No.	Applicant(s)
	09/629,570	HOLT ET AL.
	Examiner	Art Unit
	Bradley Edelman	2153

-- The MAILING DATE of this communication appears on the cover sheet with the c rrespondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on _28 October 2003_.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) _1-17 and 32-40_ is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) _1-17 and 32-40_ is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☒ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. §§ 119 and 120

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

13)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application) since a specific reference was included in the first sentence of the specification or in an Application Data Sheet. 37 CFR 1.78.

a) ☐ The translation of the foreign language provisional application has been received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121 since a specific reference was included in the first sentence of the specification or in an Application Data Sheet. 37 CFR 1.78.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _5,6_ .

4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .

5) ☐ Notice of Informal Patent Application (PTO-152)

6) ☐ Other: .

DETAILED ACTION

This Office action is in response to Applicant's response to the restriction requirement and amendment filed on October 28, 2003. Claims 1-17 and 32-40 are presented for further examination.

Specification

1. This application does not contain an abstract of the disclosure as required by 37 CFR 1.72(b). An abstract on a separate sheet is required.

The disclosure is objected to because of the following informalities:

The status of the related cases listed on page 1 of the specification must be updated.

Appropriate correction is required.

Claim Rejections - 35 USC § 112

The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

2. Claims 1-40 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

In considering claims 1, 14, and 32, these claims all contain the phrase "the added participant" or "the added node" in the last line of the claim. These phrases lack sufficient antecedent basis, as none of these claims mention a step of actually adding a node or participant to the network.

Claims 2-13, 15-31, and 33-40 depend from these claims, and are thus rejected as well.

In addition, claim 6 uses the term “approximately proportional,” while claims 10 and 37 use the term “approximately twice the diameter.” The term "approximately" is a relative term that renders the claim indefinite. The term is not defined by the claim, the specification does not provide a standard for ascertaining the requisite degree, and one of ordinary skill in the art would not be reasonably apprised of the scope of the invention.

Appropriate correction is required.

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

3. Claims 1, 2 and 13 are rejected under 35 U.S.C. 102(e) as being anticipated by Steele, Jr., et al. (U.S. Patent No. 6,603,742, hereinafter “Steele”).

In considering claim 1, Steele discloses a computer-based method for adding a participant ("node") to a network of participants, each participant connected to three or more participants (see Fig. 6), the method comprising:

Identifying a pair of participants of the network that are connected, disconnecting the participants of the identified pair from each other, and connecting each participant of the identified pair of participants to the added participant (col. 12, lines 45-51; Figs. 5 and 6, wherein nodes 3 and 1 disconnect from each other, and each of them connects to the added node 7 – note that Fig. 6 of Steele appears incorrect and that the connection between nodes 5 and 2 in Fig. 6 should have been removed).

In considering claim 2, Steele further discloses that each participant is connected to 4 participants (See Figs. 5-6, wherein each participant is connected to at least 4 participants).

In considering claim 13, Steele further discloses that the participants are computer processes ("nodes").

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. Claims 32-33 are rejected under 35 U.S.C. 103(a) as being unpatentable over Steele, in view of Cho et al. ("A Flood Routing Method for Data Networks," ICICS '97, hereinafter "Cho").

In considering claim 32, the claim contains a computer readable medium for performing the same steps as claim 1, and additionally requires that each network participant forwards broadcast messages that it receives to its neighbor participants. See the discussion of claim 1 for the description of those steps. Note, however, that Steele does not disclose that each network participant forwards broadcast messages that it receives to its neighbor participants. This is because Steele is only concerned with how nodes are added and/or subtracted to the network and how that affects network configuration. The system taught by Steele remains silent regarding the actual passing of data between nodes. Nonetheless, flood routing (i.e. broadcasting messages from each node to each neighboring node in a network) is well known, as evidenced by Cho. In a similar art, Cho discloses that flood routing is well known (p. 1418, Introduction, ¶ 1) and further describes a network system with multiple interconnected nodes (see Figs. 1, 3) that uses flood routing to pass information between nodes (p. 1418-1419, § 2, "Flood Routing Mechanism"). Given the teaching of Cho, a person having ordinary skill in the art would have readily recognized the desirability and advantages of using flood routing to send information between nodes in the system taught by Steele, because flood routing is a very reliable and robust method of data transmission (see Cho, p. 1418, Introduction, ¶ 1). Therefore, it would have been obvious to use flood routing to pass information in the network taught by Steele.

In considering claim 33, Steele further discloses that each participant is connected to 4 participants (See Figs. 5-6, wherein each participant is connected to at least 4 participants).

5. Claims 1-5, 7, 8, and 11-17 are rejected under 35 U.S.C. 103(a) as being unpatentable over Gilbert et al. (U.S. Patent No. 6,490,247, hereinafter "Gilbert") in view of Hughes et al. (U.S. Patent No. 6553,020, hereinafter "Hughes").

In considering claim 1, Gilbert discloses a computer-based method for adding a participant ("node") to a network of participants, the method comprising:

Identifying a pair of participants of the network that are connected (col. 6, lines 26-49, wherein the additional node contacts the two participants), disconnecting the participants of the identified pair from each other (col. 7, lines 7-8, "the two adjacent nodes drop connection to one another"), and connecting each participant of the identified pair of participants to the added participant (col. 7, lines 13-19, "the additional node connects with each of the adjacent nodes").

However, Gilbert does not disclose that each participant is connected to three or more other participants. Gilbert discloses instead, a ring-type network, wherein each node is connected to two other nodes (see col. 3, lines 25-36). Nonetheless, the use of other types of networks to connect participants, wherein each participant is connected to three or more participants, and wherein participants can be added to the network, is well known, as evidenced by Hughes. In a similar art, Hughes discloses a network for interconnecting nodes for communication across the network, wherein the nodes can be connected in a hypercube-type topology, or in some other type of topology such that each node is connected to 4 other nodes, wherein nodes can be added to the network (col. 14, lines 25-30, 67; col. 15, lines 1-5, 45-52; col. 4, lines 6-9, "additional users can be added later as demand grows"). Given the teaching of Hughes, a person having ordinary skill in the art would have readily recognized the desirability and advantages of using a similar technique as taught by Gilbert (i.e. disconnecting certain node connections and connecting the newly disconnected links to the added node) to connect additional participants in the system taught by Hughes, in order to maintain the network topology for added nodes, thereby maintaining the interconnectivity and reliability associated with hypercube and 4-connected networks. Therefore, it would have been obvious to use the technique disclosed by Gilbert for connecting new participants in a system such as the one taught by Hughes.

In considering claim 2, Hughes further discloses that each participant is connected to 4 participants (col. 14, lines 25-30, "hypercube"; col. 15, lines 45-52, "nodes 2 are connected in an arbitrary manner to up to a fixed number n of nearest nodes... where n=4..."; Fig. 9).

In considering claim 3, Gilbert further discloses that the pair of nodes selected for disconnection is selected arbitrarily (col. 6, lines 37-40, "the actual node that is contacted by the additional node does not matter," and can simply be "the first node on the list"). Although Gilbert does not explicitly state that selection is done randomly, the node is effectively being selected randomly, since any node can be first on the list. The same result would be achieved by selecting a node randomly from somewhere else on the list. Thus, the limitation of selecting the node randomly does not render the claimed invention patentably distinct over the method taught by Gilbert.

In considering claim 4, Gilbert further discloses that arbitrarily selecting the pair includes sending a message through the network on an arbitrarily selected path (col. 6, lines 30-31, 37-40, "an additional node contacts two adjacent nodes in the network," wherein "the actual node that is contacted by the additional node does not matter," such that the path selected will be the path to whichever node is arbitrarily and thus randomly selected).

In considering claim 5, Gilbert further discloses that when a participant ("primary node") receives the message, it sends the message to a selected participant to which it is connected ("adjacent node," col. 6, lines 50-59). However, Gilbert does not disclose that the message is sent to a randomly selected participant. Nonetheless, Gilbert discloses that the actual initial nodes contacted do not matter (see col. 6, lines 37-40). It follows then that the selection of the adjacent node also doesn't matter, so long as it is adjacent (note that Gilbert does not specify which adjacent node is selected). Selecting an adjacent node randomly, rather than, say, selecting one particular adjacent node over the other, is thus a matter of preference, and does not render the claimed invention patentably distinct over the method taught by Gilbert.

In considering claim 7, Gilbert further discloses that the participant to be added requests a portal computer to initiate the identifying of the pair of participants (col. 6, lines 45-47, "additional node 100 would contact node 10, and node 10 would provide additional node 100 information regarding node 16").

In considering claim 8, Gilbert further discloses that the initiating of the identifying of the pair of participants includes the portal computer sending a message to a connected participant requesting an edge connection (col. 6, lines 53-57, "primary node... receives all incoming calls from other nodes wishing to enter the network. The point of entry in the network for these other nodes is then between the primary node and an adjacent node to the primary node").

In considering claim 11, Hughes further discloses that the participants are connected via the Internet (col. 1, line 14, "Internet"; col. 14, lines 55-59, "Internet web-browsing"). It would have been obvious for the network in the participant adding system taught by Gilbert and Hughes to be the Internet, so that the participants could communicate with other users anywhere in the world. Therefore, it would have been obvious to use the participant adding system taught by Gilbert and Hughes on the Internet network.

In considering claim 12, although Hughes does not explicitly teach TCP/IP, Examiner takes official notice that TCP/IP is a standard well known protocol used for Internet communications. Therefore, it would have been obvious to connect the participants via TCP/IP for the same reasons as connecting participants via the Internet – i.e. to allow global communications on the existing Internet network.

In considering claim 13, Gilbert further discloses that the participants are computer processes ("nodes").

In considering claim 14, Gilbert discloses a computer-based method for adding nodes ("nodes") to a graph that is m-regular and m-connected (see Fig. 1, which is 2-regular and 2-connected) to maintain the graph as m-regular, the method comprising:

Identifying p pairs of nodes of the graph that are connected where p is half of m (p. is 1, see col. 6, lines 30-42, wherein a pair of adjacent nodes is identified);

Disconnecting the nodes of each identified pair from each other (col. 7, lines 7-8); and

Connecting each node of the identified pair of nodes to the added node (col. 7, lines 13-19).

However, Gilbert does not disclose that m is four or greater, and thus that the graph is at least 4-connected and 4-regular. Nonetheless, the use of 4-connected and 4-regular networks wherein nodes can be added to the network is well known, as evidenced by Hughes. In a similar art, Hughes discloses a network for interconnecting nodes for communication across the network, wherein the nodes can be connected in a hypercube-type topology, or in some other type of topology such that each node is connected to 4 other nodes, wherein nodes can be added to the network (col. 14, lines 25-30, 67; col. 15, lines 1-5, 45-52; col. 4, lines 6-9, "additional users can be added later as demand grows"). Given the teaching of Hughes, a person having ordinary skill in the art would have readily recognized the desirability and advantages of extending the node addition method taught by Gilbert (i.e. disconnecting p pairs of nodes node connections and connecting the newly disconnected links to the added node) to more highly connected (i.e. 4-connected) networks, in order to maintain the network topology for added nodes, thereby maintaining the interconnectivity and reliability associated with hypercube and 4-connected networks. Therefore, it would have been obvious to use the technique disclosed by Gilbert for connecting new participants to the 4-connected system taught by Hughes.

In considering claim 15, Gilbert further discloses that the pair of nodes selected for disconnection is selected arbitrarily (col. 6, lines 37-40, "the actual node that is contacted by the additional node does not matter," and can simply be "the first node on the list"). Although Gilbert does not explicitly state that selection is done randomly, the node effectively is being selected randomly, since any node can be first on the list. The same result would be achieved by selecting a node randomly from somewhere else on the list. Thus, the limitation of selecting the node randomly does not render the claimed invention patentably distinct over the method taught by Gilbert.

In considering claim 16, Hughes further discloses that the nodes are computers and the connections are point-to-point connections (abstract).

In considering claim 17, both Gilbert and Hughes further disclose that m is even (i.e. 2 or 4).

6. Claims 32-36, 38, and 39 are rejected under 35 U.S.C. 103(a) as being unpatentable over Gilbert in view of Hughes, and further in view of Cho et al. ("A Flood Routing Method for Data Networks," ICICS '97, hereinafter "Cho").

In considering claim 32, the claim contains a computer readable medium for performing the same steps as claim 1, and additionally requires that each network participant forwards broadcast messages that it receives to its neighbor participants. See the discussion of claim 1 for the description of those steps. Note, however, that neither Gilbert nor Hughes disclose that each network participant forwards broadcast messages that it receives to its neighbor participants. Nonetheless, flood routing (i.e. broadcasting messages from each node to each neighboring node in a network) is well known, as evidenced by Cho. In a similar art, Cho discloses that flood routing is well known (p. 1418, Introduction, ¶ 1) and further describes a network system with multiple interconnected nodes (see Figs. 1, 3) that uses flood routing to pass information between nodes (p. 1418-1419, § 2, "Flood Routing Mechanism"). Given the teaching of Cho, a person having ordinary skill in the art would have readily recognized the desirability and advantages of using flood routing to send information between nodes in the system taught by Gilbert and Hughes, because flood routing is a very reliable and robust method of data transmission (see Cho, p. 1418, Introduction, ¶ 1). Therefore, it would have been obvious to use flood routing to pass information in the network taught by Gilbert and Hughes.

In considering claim 33, Hughes further discloses that each participant is connected to 4 participants (col. 14, lines 25-30, "hypercube"; col. 15, lines 45-52, "nodes 2 are connected in an arbitrary manner to up to a fixed number n of nearest nodes... where n=4..."; Fig. 9).

In considering claim 34, Gilbert further discloses that the pair of nodes selected for disconnection is selected arbitrarily (col. 6, lines 37-40, "the actual node that is contacted by the additional node does not matter," and can simply be "the first node on the list"). Although Gilbert does not explicitly state that selection is done randomly, the node effectively is being selected randomly, since any node can be first on the list. The same result would be achieved by selecting a node randomly from somewhere else on the list. Thus, the limitation of selecting the node randomly does not render the claimed invention patentably distinct over the method taught by Gilbert.

In considering claim 35, Gilbert further discloses that arbitrarily selecting the pair includes sending a message through the network on an arbitrarily selected path (col. 6, lines 30-31, 37-40, “an additional node contacts two adjacent nodes in the network,” wherein “the actual node that is contacted by the additional node does not matter,” such that the path selected will be the path to whichever node is arbitrarily and thus randomly selected).

In considering claim 36, Gilbert further discloses that when a participant (“primary node”) receives the message, it sends the message to a selected participant to which it is connected (“adjacent node,” col. 6, lines 50-59). However, Gilbert does not disclose that the message is sent to a randomly selected participant. Nonetheless, Gilbert discloses that the actual initial nodes contacted do not matter (see col. 6, lines 37-40). It follows then that the selection of the adjacent node also doesn’t matter, so long as it is adjacent (note that Gilbert does not specify which adjacent node is selected). Selecting an adjacent node randomly, rather than, say, selecting one particular adjacent node over the other, is thus a matter of preference, and does not render the claimed invention patentably distinct over the method taught by Gilbert.

In considering claim 38, Gilbert further discloses that the participant to be added requests a portal computer to initiate the identifying of the pair of participants (col. 6, lines 45-47, “additional node 100 would contact node 10, and node 10 would provide additional node 100 information regarding node 16”).

In considering claim 39, Gilbert further discloses that the initiating of the identifying of the pair of participants includes the portal computer sending a message to a connected participant requesting an edge connection (col. 6, lines 53-57, "primary node... receives all incoming calls from other nodes wishing to enter the network. The point of entry in the network for these other nodes is then between the primary node and an adjacent node to the primary node").

Allowable Subject Matter

7. As allowable subject matter has been indicated, applicant's reply must either comply with all formal requirements or specifically traverse each requirement not complied with. See 37 CFR 1.111(b) and MPEP § 707.07(a).

Claims 9 and 40 would be allowable if rewritten to include all of the limitations of the base claim and any intervening claims, and if the base claims were rewritten to overcome the rejection(s) under 35 U.S.C. 112, second paragraph, set forth in this Office action.

The following is a statement of reasons for the indication of allowable subject matter: the prior art of record fails to disclose or render obvious all of the limitations of the claims, including the claimed distance-related selection steps described in claims 9, and 40.

Conclusion

The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Bradley Edelman whose telephone number is (703) 306-3041. The examiner can normally be reached on Monday to Friday from 8:30 AM to 5:00 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Glen Burgess can be reached on (703) 305-4792. The fax phone numbers for the organization where this application or proceeding is assigned are as follows:

For all correspondences: (703) 872-9306.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703) 305-3900.

Bradley Edelman

BE
January 6, 2004

Notice of References Cited	Application/Control No. 09/629,570	Applicant(s)/Patent Under Reexamination HOLT ET AL.	
	Examiner Bradley Edelman	Art Unit 2153	Page 1 of 2

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	B	US-6,553,020 B1	04-2003	Hughes et al.	370/347
	C	US-6,603,742 B1	08-2003	Steele et al.	370/254
	D	US-5,471,623 A	11-1995	Napolitano, Jr., Leonard M.	709/243
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	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	Cho et al., "A Flood Routing Method for Data Networks," September 1997, Proceedings of 1997 International Conference on Information, Communications and Signal Processing, Vol. 3, pp. 1418-1422.
	V	Bandyopadhyay et al., "A Flexible Architecture for Multi-Hop Optical Networks," October 1998, 7th International Conference on Computer Communications and Networks, 1998, pp. 472-478.
	W	Hsu, "On Four-Connecting a Triconnected Graph," October 1992, Annual Symposium on Foundations of Computer Science, 1992, pp. 70-79.
	X	Shiokawa et al., "Performance Analysis of Network Connective Probability of Multihop Network under Correlated Breakage," June 1996, 1996 IEEE International Conference on Communications, Vol. 3, pp. 1581-1585.

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Notice of References Cited	Application/Control No. 09/629,570	Applicant(s)/Patent Under Reexamination HOLT ET AL.	
	Examiner Bradley Edelman	Art Unit 2153	Page 2 of 2

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
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	B	US-			
	C	US-			
	D	US-			
	E	US-			
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*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	Komine et al., "A Distributed Restoration Algorithm for Multiple-Link and Node Failures of Transport Networks," December 199 IEEE GLOBECOM '90, 'Communications: Connecting the Future,' Vol. 1, pp. 459-463.
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

International Conference on
Information, Communications and Signal Processing
ICICS '97
Singapore, 9-12 September 1997

3F1.4

A Flood Routing Method for Data Networks

Jaihyung Cho

Monash University
Clayton 3168, Victoria
Australia
jaihyung@dgs.monash.edu.au

James Breen

Monash University
Clayton 3168, Victoria
Australia
jwb@dgs.monash.edu.au

Abstract

In this paper, a new routing algorithm based on a flooding method is introduced. Flooding techniques have been used previously, e.g. for broadcasting the routing table in the ARPAnet [1] and other special purpose networks [3][4][5]. However, sending data using flooding can often saturate the network [2] and it is usually regarded as an inefficient broadcast mechanism. Our approach is to flood a very short packet to explore an optimal route without relying on a pre-established routing table, and an efficient flood control algorithm to reduce the signalling traffic overhead. This is an inherently robust mechanism in the face of a network configuration change, achieves automatic load sharing across alternative routes, and has potential to solve many contemporary routing problems. An earlier version of this mechanism was originally developed for virtual circuit establishment in the experimental Caroline ATM LAN [6][7] at Monash University.

1. Introduction

Flooding is a data broadcast technique which sends the duplicates of a packet to all neighboring nodes in a network. It is a very reliable method of data transmission because many copies of the original data are generated during the flooding phase, and the destination user can double check the correct reception of the original data. It is also a robust method because no matter how severely the network is damaged, flooding can guarantee at least one copy of the data will be transmitted to the destination, provided a path is available.

While the duplication of packets makes flooding a generally inappropriate method for data transmission, our approach is to take advantage of the simplicity and robustness of flooding for routing purposes. Very short packets are sent over all possible routes to search for the optimal route of the requested QoS and the data path is established via the selected route. Since the Flood Routing algorithm strictly controls the unnecessary packet duplication, the traffic overhead caused from the flooding traffic is minimal.

Use of flooding for routing purposes has been suggested before [3][4][5], and it has been noted that it can be guaranteed to form a shortest path route[10]. And an earlier protocol was proposed and implemented for the experimental local area ATM network (Caroline [6][7]). However the earlier protocol had problems with scaling timer values, and also required complex mechanism to solve potential race and deadlock problem. Our proposal greatly simplifies the previous mechanism and reduces the earlier problems.

Chapter 2 explains the procedure for route establishment and the simulation results are presented in chapter 3. The advantages of the Flood Routing are reviewed specifically in chapter 4. Chapter 5 concludes this paper with suggesting some possible application area and the future study issues.

2. Flood Routing Mechanism

Figure 1, 3, 4 show the stepwise procedure of the route establishment.

In the Figure 1, the host A is requesting a connection set up to the target host B. In the initial

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stage, a short connection request packet (CREQ) is delivered to the first hop router 1 and router 1 starts the flood of the CREQ packets.

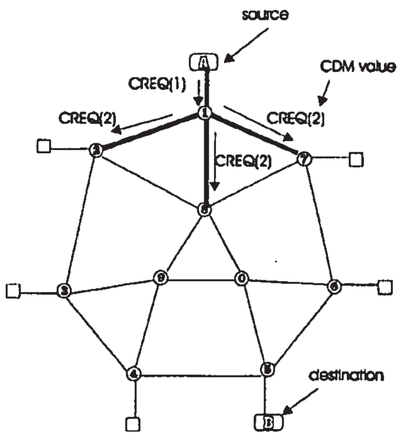

Figure 1

VC number (1byte=0)
Packet Type (1byte="CREQ")
CDM (1byte)
Source Address
Connection No (1byte)
Destination Address
QoS

Figure 2 CREQ Packet Format

Figure 2 shows the format of the CREQ packet. The CREQ packet contains a connection difficulty metric (CDM) field, QoS parameters and the source & destination addresses and connection number. The metric can be any accumulative measure representing the route difficulty, such as hop count, delay, buffer length, etc. The connection number is chosen by the source host to distinguish the different packet floods of the same source and destination.

When a router receives the CREQ packet, the router matches the packet information with the internal Flood Queue to see if the same packet has been received before. If the CREQ packet is new, it records the information in the Flood Queue, increases the CDM value, and forwards the packet to all output links with adequate capacity to meet the QoS except the received one. Thus the flood of CREQ packets propagate through the entire network.

The Flood Queue is a FIFO list which contains the information relating to the best CREQ packet the router has received for each recent flood. As the flood packet of a new connection arrives and the information is pushed into the Flood Queue, the old information gradually moves to the rear and eventually is removed. The queueing delay from the insertion to the deletion depends on the queue size and the call frequency, and provided this delay is enough to cover the time for network wide flood propagation and reply, there is no need for a timer to wait to the completion of the flood.

Since the CDM value is increased as the CREQ packet passes the routers, the metric value represents the route difficulty that the CREQ packet has experienced. Because of the repeated duplication of the packet, a router may receive another copy of the CREQ packet. In this case, the router compares the metric values of the two packets and if the most recently arrived packet has the better metric value, it updates the information in the Flood Queue and repeats the flood action. Otherwise the packet is discarded. As a consequence, all the routers keep the record of the best partial route and the output link to use for setting up the virtual circuit.

Figure 3 shows the intermediate routers 2, 7, 8 have chosen the links toward the router 1 as the best candidate link. If one of them is requested for the path to the source node A, the router will use this link for the virtual circuit set up.

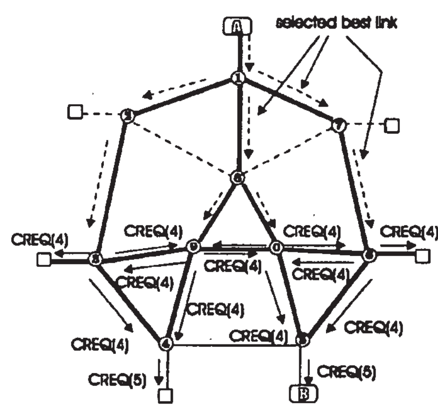

Figure 3

When the destination host receives a CREQ packet, it opens a short time-window to absorb possible further arriving CREQ packets. The expiration of the timer triggers the sending of the connection acceptance (CACC) packet along the best links indicated by the CREQ packet with the lowest CDM. The CACC packet is relayed back to the source host by the routers which at the same time install the virtual circuit via the optimal route. Finally, when the source host receives the CACC packet, the host may initiate data transmission.

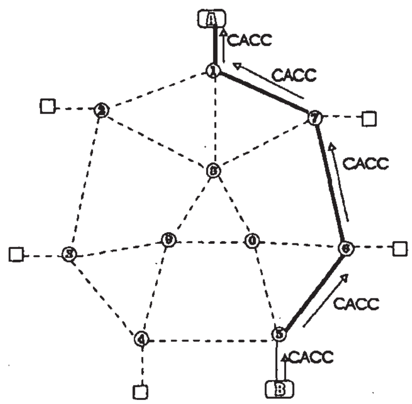

Figure 4

Note that bandwidth reservation occurs during the relay of the CACC packet. It is possible that the available QoS will have dropped below the requested level in one or more links. In this case, the source may either accept the lower QoS, or close the connection and try again.

More implementation details of the flooding protocol can be found in [9].

3. Simulation Result

One concern of Flood Routing is whether it will lead to congestion of the network by the signalling traffic. A simulation was carried out using various network conditions. Figure 5 shows the number of flooding packets produced in a connection trial in a normal traffic condition on a network consisting of 5 switching nodes, 9 hosts and 16 links. The simulation tested the event of 2000 seconds.

The graph shows that the total number of flooding packets per connection converges on the lower bound 18 with some exceptions. This is slightly higher than the number of the network links (16). This shows how the flood control mechanism is efficient in that the routers usually generate only one flooding packet per output link and this duplication process is rarely repeated again. As a result, the total number of flooding packets per connection is nearly same as the number of network links.

Considering the small size of the flooding packet, the bandwidth consumed by the signalling traffic is small. Suppose an ATM network using the Flood Routing generates 1000 calls per seconds, the bandwidth consumption by the signalling traffic will only be about 424 Kbps (= 1 K * 53 byte) per link and this does not include any additional route management traffic such as the routing table update.

From the simulation, it is observed that the average number and the maximum number of the flooding packets depends on the network topology and the traffic condition. If the network is simple topology such as a tree or a star shape, the average number of the flooding packets is nearly identical to the number of the network links. If the network is a complex topology such as a complete mesh topology, and there is a high traffic load, the routers tend to generate more packets because of the racing of the flooding packets.

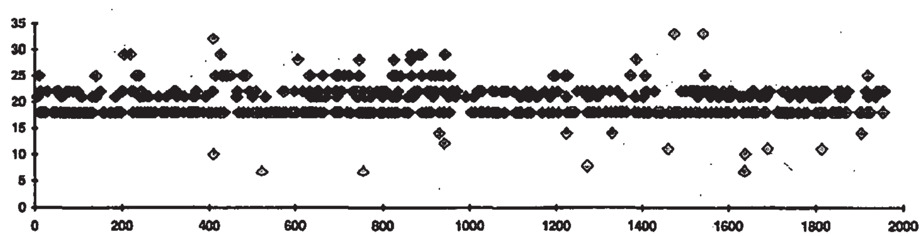

Figure 5

The connections established by Flood Routing successfully avoid busy links and disperse the communication paths to all possible routes. This reduced the chance of congestion and utilizes all network resources efficiently.

4. Advantages of the Flood Routing

The distinctive features of the Flood Routing method are :

(a) It facilitates the load sharing of available network resources. If many possible routes exist between two end points in a network, the Flood Routing can disperse different connections over different routes to share the network load. Figure 6 shows this example.

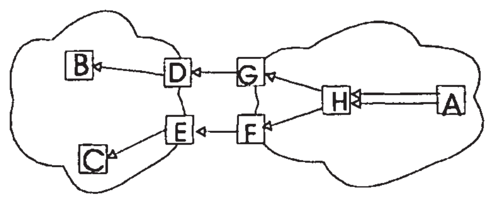

Figure 6 Example of Multipath Connection

In the sample network, there are more than two links exist between node A and H, and the node A used all links for different connections with balancing the load. More than two exterior routers are connecting the subnet 1 and the subnet 2, and the node H distributed the connections to all exterior routers. Therefore, all the network resources are utilized fully in Flood Routing network. This load sharing capability has been considered to be a difficult problem in table based routing algorithms.

(b) It automatically adapts to changes in the network configuration. For example, if the overall traffic between two end points has been increased, the network bandwidth can simply be expanded by adding more links between routers. The Flood Routing algorithm can recognize the additional links and use them for sharing the load in new connections.

(c) The method is robust. The Flood routing can achieve a successful connection even when the network is severely damaged, provided flooding packets can reach the destination. Once a flooding packet reaches the destination, the connection can be established via the un-damaged part of the network which was searched by the packet. This is very useful property in networks which are vulnerable but which require high reliability, such as military networks.

(d) The method is simple to manage, as it makes no use of routing tables. This table-less routing method does not have the problem like "Convergence time" of the Distance Vector routing [8].

(e) It is possible to find the optimal route of the requested bandwidth or the quality of service. While the packet flood is progressing, bandwidth requirement and QoS constraints specified in the flooding packets are examined by the routers and the links that does not meet the requirements are excluded from the routing decision. As a result, the route constructed with the qualified links can meet the bandwidth and the QoS requirements, usually in the first attempt.

(f) It is a loop-free routing algorithm. The only possible case that the route may consist a loop can be caused from the corrupted metric information. However this can be detected by a check sum.

(g) Since the flooding method is basically a broadcast mechanism, it can be used for locating resources in network. Many network applications are best served by a broadcast facility, such as distributed data bases, address resolution, or mobile communications. Implementing broadcast in point-to-point networks is not straight forward. The flooding technique provides a means to solve this problem. In particular, locating a mobile user by Flood Routing, and establishing a dynamic route is an interesting issue. Application to a movable network in which entire network units including both the mobile users as well as the switching nodes and the wireless links is another potential research area.

5. Future Study and Conclusion

In this paper, we introduced a revised Flood Routing technique. Flood Routing is a novel approach to network routing which has the potential to solve many of the routing problems in contemporary networks. The basic Flood Routing presented in this paper has been developed to be used in an ATM style network, however we believe a similar technique can also be applied to IP routing. Another promising area of application of this method would be military or mobile networks which require high mobility and reliability. Research to extend the point-to-point Flood Routing to optimal multi-point routing is now progressing. Further analysis of performance, and application to large scale networks are the future issues.

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A flood routing method for data networks

Jaihyung Cho Breen, J.
Monash Univ., Clayton, Vic., Australia ;

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Number of Pages: 3 vol. xxxiv+1819
Inspec Accession Number: 5978904

Abstract:
A new routing algorithm based on a flooding method is introduced. Flooding techniqu have been used previously, e.g. for broadcasting the routing table in the ARPAnet an other special purpose networks. However, sending data using flooding can often satu the network and it is usually regarded as an inefficient broadcast mechanism. Our approach is to flood a very short packet to explore an optimal route without relying c preestablished routing table, and an efficient flood control algorithm to reduce the signalling traffic overhead. This is an inherently robust mechanism in the face of a network configuration change, it achieves automatic load sharing across alternative routes, and has the potential to solve contemporary routing problems. An version of mechanism was originally developed for virtual circuit establishment in the experime Caroline ATM LAN at Monash University

Index Terms:
data communication packet switching telecommunication congestion control telecommunica network routing telecommunication signalling telecommunication traffic ARPAnet ATM network Caroline ATM LAN Monash University automatic load sharing data networks flo control algorithm **flood routing method** network configuration optimal route routing algori routing table broadcasting signalling traffic overhead reduction virtual circuit establishment

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Examiner Name	
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First Named Inventor	Fred B. Holt
Group Art Unit	2744
Examiner Name	
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A DISTRIBUTED RESTORATION ALGORITHM FOR MULTIPLE-LINK AND NODE FAILURES OF TRANSPORT NETWORKS

Hiroaki Komine, Takafumi Chujo, Takao Ogura, Keiji Miyazaki, and Tetsuo Soejima

Fujitsu Laboratories, Ltd.
1015 Kamikodanaka, Nakahara-ku, Kawasaki, 211, Japan

Abstract

Broadband optical fiber networks will require fast restoration from multiple-link and node failures as well as single-link failures. This paper describes a new distributed restoration algorithm based on message flooding. The algorithm is an extension of our previously proposed algorithm for single-link failure. It restores the network from multiple-link and node failures, using multi-destination flooding and path route monitoring. We evaluated the algorithm by computer simulation, and verified that it can find alternate paths within 0.5s whenever the message processing delay at a node is 5ms.

1. Introduction

There is an increasing dependency on today's communication networks to implement strategic corporate functions. User demands for high-speed and economical communications services lead to the rapid deployment of high-capacity optical fibers in the transport networks. At the same time, the demands for high-reliability services raise a network survivability problem. For example, if the network is disabled for one hour, up to $6,000,000 loss of revenue can occur in the trading and investment banking industries [1]. As the capacity of the transmission link grows, a link cut results in more loss of services. Therefore, rapid restoration from failures is becoming more critical for network operations and management.

There have been many algorithms developed to restore networks, including centralized control [1] and distributed algorithms [2-4]. In centralized control, the network is controlled and managed from a central office. In distributed control, the processing load is distributed among the nodes and restoration is thus faster. However, more computation capability and high speed control data channels are required. Recently it has been possible to provide high performance microprocessors for digital cross-connect system (DCS). High capacity optical fibers enable high speed data transmission for OAM through overhead bytes, which is under study by CCITT.

The distributed algorithms proposed so far [2-4] are based on simple flooding [5]. When a node detects failure, it broadcasts a restoration message to adjacent nodes to find an alternate route. In the algorithm [2], a restoration message requests a spare DS-3 or STS-1 path and is sent through the path overhead of each spare path. To avoid congestion of the messages in this algorithm, a message in both the algorithms [3,4] requests a bundle of spare paths and is sent through the section overhead of each link. Algorithm [3] finds the maximum capacity along an alternate route, and our algorithm [4] finds the shortest alternate route. As described in [4], our algorithm was faster. However these algorithms are designed to handle single-link failures, they cannot handle multiple-link or node failures.

In this paper, we first discuss the major issues that must be addressed in order to handle multiple-link and node failures in Section 2. Based on these consideration, we propose a new restoration algorithm using multi-destination flooding and path route monitoring. These are described in Section 3. For a node failure, the node which detected the failure sends a restoration message to the last N-consecutive nodes each logical path passed through. An alternate path is made between the message sender node and one of the multiple nodes specified in the message. Each node collects the identifier of these nodes, using a path route monitoring technique. The algorithm was evaluated by computer simulation for multiple-link failure as well as for node failure. The results will be described in Section 4.

2. Limitations of simple flooding

In this section, we review simple flooding and discuss its limitations to handle multiple-link and node failures. In principle, the distributed algorithms [2-4] based on simple flooding work as follows. When a link fails, the two nodes connected to the link detect the failure and try to restore the path. One node becomes the sender and the other becomes the chooser (Fig. 1). The sender broadcasts restoration messages to all links with spare capacity. Every node except the sender and the chooser respond by re-broadcasting the message. When the restoration message reaches the chooser, the chooser returns an acknowledgement to the sender. In this way, alternate paths are found. Message congestion caused by routing messages far away is avoided by limiting the number of hops.

These algorithms based on simple flooding [2-4] usually assume a single-link failure, but in reality, some links which go different nodes may be in the same conduit. Therefore, if the conduit is cut, many links fail at the same time [3]. This is the case of multiple-link failure. Fire or earthquakes can also damage a large number of nodes, so the restoration algorithm must be able to handle these situations.

Simple flooding can not handle multiple-link or node failures because of following problems.

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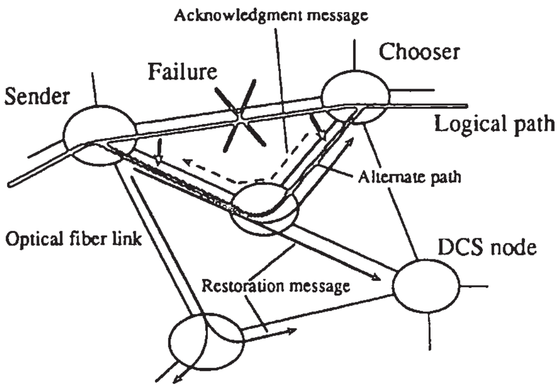

Fig. 1 Distributed restoration based on simple flooding

- *Contention of spare capacity*

In case of multiple-link failure, restoration messages coming from different nodes might contend for spare capacity on the same link. For example, if capacity is assigned to arriving messages in turn, the first message reserves the capacity. Whether or not the reserved capacity is later used for an alternate path, the reserved capacity is not released and therefore can not be assigned to another restoration message. Thus, the restoration ratio decreases.

- *Fault location*

Because the algorithms assume link failure, one of the two nodes connected to the failed link becomes the sender and the other becomes the chooser. However, for a node failure, there is a chooser and sender for each affected path. They are neighbors of the failed node and depend on the route of the paths. Each node detects failure by the loss of the signal on the link, and cannot distinguish between link or node failure.

The first problem could be alleviated by simple message cancelling. Spare capacity is assigned to restoration messages on a first-come, first-served basis. Assignment is cancelled when the message can not go forward due to hop limits or lack of capacity. During message flooding, cancel messages are sent to inform a node that a restoration message, which reserves spare capacity on a specific link, did not reach its destination and the served capacity of this link can be released for other restoration messages. Restoration messages are canceled immediately after reception if they are identical to messages already received, if the hop limit is reached, or if there is no more capacity at the node. In these cases, the unused capacity can be assigned to another restoration message.

Solving the second problem requires more sophisticated techniques and we propose a new distributed restoration algorithm in the following section.

3. Multi-destination flooding

To solve the fault location problem described above, we propose a new multi-destination flooding technique. We also propose path route monitoring which is essential to achieve multi-destination flooding.

3.1 Principle of multi-destination flooding

Simple flooding methods assume just one chooser. We extended this to allow multiple choosers as message destinations. When a node detects the loss of a signal from a link, the node can not tell whether the link or the node at the other end has failed. It sends a restoration message directed to the node which is the chooser in a link failure as well those that are choosers in a node failure. In Fig.2, for example, the link between nodes B and C fails, node B is the chooser for all affected paths, and nodes A and D are possible choosers for paths P1 and P2. If node B fails, nodes A and D become choosers for paths P1 and P2. The restoration message contains all choosers and the required capacity for each sender-chooser pair. The node which received the restoration message checks the destination field of the message, and if it is a chooser candidate, it returns an acknowledgment to the sender.

Thus, by extending simple flooding into multi-destination flooding, link or node failures do not have to be distinguished because there is always at least one chooser. Different messages are sent to the chooser candidates, but the same restoration message listing all candidates is sent towards all candidates. The number of restoration messages decreases and congestion is reduced.

Restoration processing consists of a broadcast phase, an acknowledgment phase, and a confirmation phase. To handle multiple failures, cancel processing is performed during the broadcast and acknowledgment phases.

The node states are sender, chooser, reserved tandem, and fixed tandem. The sender is the node which detected the failure. The chooser is the destination node of a restoration message. Chooser candidates set by the sender become choosers when they receive

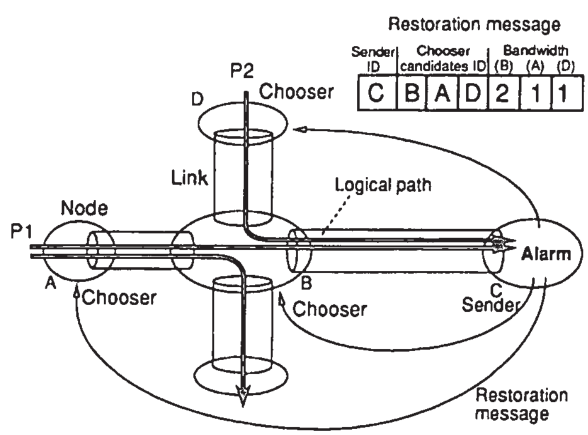

Fig. 2 Multi-destination flooding

a restoration message. The reserved tandem is a candidate node for alternate paths reserved by the restoration message. A received confirmation message of the sender turns a reserved tandem node into a fixed tandem node.

a) Broadcast phase

In the broadcast phase, the sender broadcasts restoration messages which reserve spare capacity in the network toward chooser candidates. A failure occurring on a link or node is detected by the next node on the path below the failure. This node becomes the sender. The sender looks up the chooser candidates and their capacities for the failed paths which were determined before by the path route monitoring described in the following section. The restoration message is then broadcast.

The restoration message contains the following information.

1) Message type : restoration, acknowledgment, confirmation, cancel
2) Message index
3) Sender ID
4) Chooser IDs (Multiple destination)
5) Required capacity of each sender-chooser pair
6) Reserved capacity
7) Hop count

The message index is set by the sender. It represents the number of flooding waves broadcast. The combination of the message index, the sender ID and chooser IDs is the Message ID. The required capacity is the capacity required between the sender and the various choosers. The reserved capacity is the capacity of the route taken by the restoration message.

The sender broadcasts the restoration message to all connected links except failed links and then waits for an acknowledgment from one of the choosers. Each node in the network except the sender and chooser receives a restoration message, and examines the hop count and the Message ID. If the hop count reaches the limit set by the sender, or a message with the same ID has arrived before, the node returns a cancel message to the link originating the restoration message. Otherwise, the state of the node is set to reserved tandem. If spare capacity is available, a restoration message is broadcast. If the spare capacity of a link is insufficient, the reserved capacity is set to the spare capacity of the link. A node that finds its own node ID among the chooser IDs in the restoration message becomes the chooser. Figure 3 shows the broadcast phase when a failure has occurred at node B.

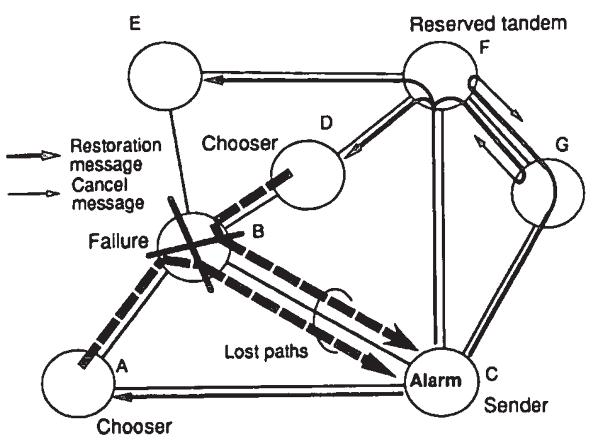

Fig. 3 Broadcast phase

b) Acknowledgment phase

In the acknowledgment phase, the chooser sends an acknowledgment message to the sender. By the entries in the acknowledgment message, the sender is informed which chooser the acknowledgement message is from. If another restoration message with the same message ID arrives at the chooser, it is canceled.

A reserved tandem node which receives an acknowledgment message passes it back to the source of the corresponding restoration message. All other reserved spare capacity of this restoration message is canceled. Message flow during an acknowledgment phase is shown in Fig. 4.

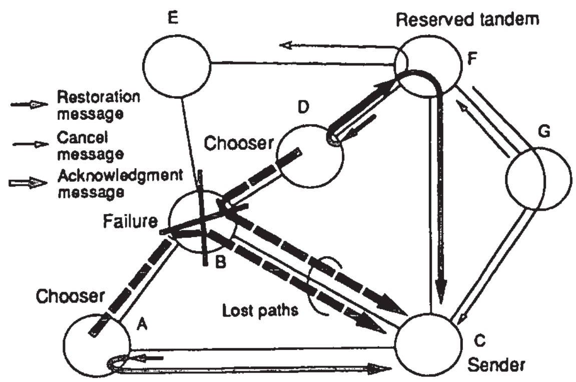

Fig. 4 Acknowledgment phase

c) Confirmation phase

When the acknowledgment message reaches the sender, a confirmation message is sent to the chooser. The reserved spares are switched over to alternate paths. If the sender received acknowledgment or canceled messages from all links it sent restoration messages to, and if the restoration of the failure is not completed, the sender increments the message index and attempts restoration from the broadcast phase again.

The reserved tandem node which received a confirmation message changes its status to fixed tandem and connects the reserved spares. In Fig. 5, node F has become fixed tandem, and the failed path between node D and node C is rerouted through the nodes D, F, and C. The other path which failed between node A and node C are also rerouted.

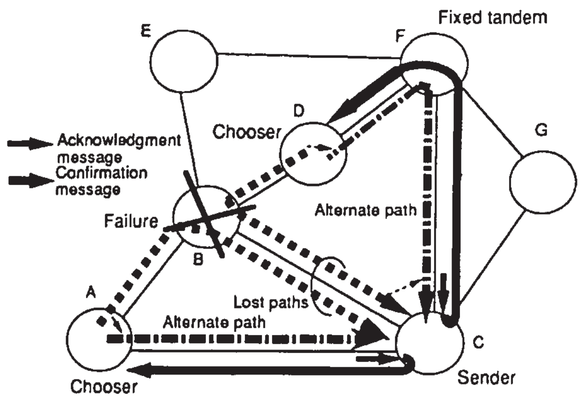

Fig. 5 Confirmation phase

3.2 Path route monitoring

For multi-destination flooding, each node must have route information on the paths passing through the node. One approach is to have the central office distribute such route information to all nodes. However, the routes are changing dynamically under customer control and nodes might receive inconsistent route information because updating route data takes time. We propose a path route monitoring method in which each node collects route information in real time.

The route information required at every node are the ID's of the last two consecutive nodes in every path before the node. This information is collected as follows. Node ID's are sent through assigned space in the path overhead. For every path going through a node, the data in the ID area is shifted and the ID of the node it is going through is written in. In this way, every node receives continuous and real-time route information.

4. Simulation

4.1 Simulation tool and conditions

We evaluated the ability of the algorithm to restore multiple-link and node failures using an event-driven network simulator [4,6] which works on the SUN3 workstation. We used the mesh network model shown in Fig. 6. This network consists of 25 nodes and 40 links. Each link length was generated at random, and the average link length is 184 km. Every link has 35 working paths.

We assumed a transmission speed of 64 kb/s. Messages were 16 bytes long, and the hop limit was 9. In a SONET frame structure, 64 kb/s for transmission speed means that one byte of overhead is used for message communications between nodes. The processing delay time from the arrival of a message to the end of the processing depends on the architecture of the DCS hardware. We assumed a 5 ms delay. This simulation does not include failure detection or crossconnection times.

4.2 Simulation results

Figure 7 shows a cumulative restoration ratio of node failure. The restoration ratio of the network is the ratio of restored to lost paths. For node failure, paths terminating at the failed node are not counted as lost paths because it is impossible to restore them.

We also simulated the algorithm for single-link failure. The result is shown in Fig. 7.

Figure 8 shows the cumulative restoration ratio in a multiple-link failure. There are many link combinations, but only one is shown. Failures between node N8 and N13, and one of the other links, occured simultaneously on two links. The results indicate

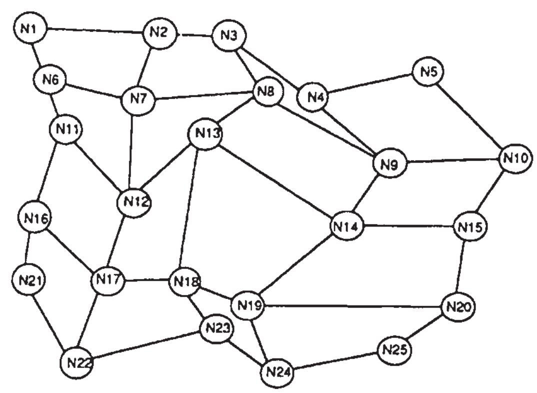

Fig. 6 Network model

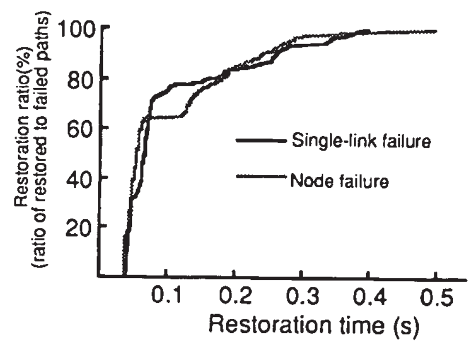

Fig. 7 Simulation results on single-link and node failure

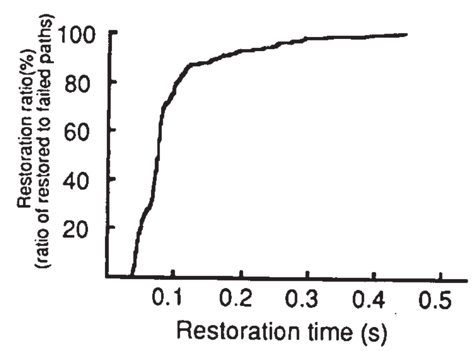

Fig. 8 Simulation result on multiple-link failure

that the proposed algorithm can handle multiple-link and node failure as well as single-link failure. All restorations are completed within 0.5s with message processing delay at the nodes being 5ms.

5. Conclusion

We pointed out problems associated with adapting a restoration algorithm based on flooding to recover from multiple-link and node failures. The main problem is to position the chooser nodes correctly. We proposed multi-destination flooding and path route monitoring. We simulated the algorithm with a mesh network and verified that the algorithm can handle multiple-link and node failures as well as single-link failures.

The message delay within a node depends on the architecture of the DCS and the processing load. The next step will be to analyze these delays and to include restoration time.

Acknowledgment

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