the threshold; a child is created under root node's 130th record. Now every packet coming from or going to the targeted machines not only causes an update in record 130 in the root node, but also in record 37 in the child node. As soon as the packet rate to subnet 130.37.0.0/16 exceeds the threshold, another child is created. Soon thereafter, that child creates yet another child. This last child keeps track of packet rates to and from single hosts. If the targeted machines cannot handle the traffic, the packet rate from those machines will be lower than the packet rate going to those machines. This observed asymmetry causes the router to drop all packets going to the three victims. The attack is stopped. This block is maintained as long as the attackers keep sending packets. Note that legitimate packets to those machines are also dropped.

3.8 Folding

The reverse of unfolding is folding. Folding a record means deleting the whole subtree under that record. We say that the record is **eligible** for folding if both packet rates to and from subnet S are less than Q. The primary motivation behind folding is to constrain memory use and to avoid (maliciously intended) memory exhaustion. Several issues around folding need to be addressed:

- How often should records in a MULTOPS be folded?

  Compacting can be made: (1) packet-triggered, (2) time-triggered, or (3) memory-triggered.

  Packet-triggered folding means folding the MULTOPS for every N packets that pass by. This means that the folding frequency increases when the traffic rate goes up. Since some computational effort is associated with folding, this is a bad idea because a router should have its resources free for routing, not for folding when packet rates go up.

  Time-triggered folding means folding the MULTOPS every N ms. Obviously, time-triggered folding does not have the problem that packet-triggered folding has. Choosing a correct value for N is tricky, though. Choosing N too low is bad because folding might not be necessary every N ms and as a result, routing slows down unnecessarily. Choosing N too high is dangerous because a router may run out of memory before N ms have passed.

  Memory-triggered folding means folding the MULTOPS when its memory use hits a certain threshold. A variation is to make the folding frequency increase as the MULTOPS memory use nears the threshold.

- Which records are folded and which are not?

  Obviously, folding eligible records before other records is best. Finding eligible records can be expensive, though. A depth-first search through the whole tree is unattractive when the tree has many nodes. Compacting should be quick because packets keep pouring in and may get dropped if folding takes too long.

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If no record in the tree is eligible but folding must be done to avoid memory exhaustion, then the following strategies can be followed: (1) fold records with symmetric rates before records with asymmetric rates, or (2) fold records with low rates before records with high rates.

Section 4.6 deals with these issues in the context of the MULTOPS implementation.

3.9 Memory exhaustion attacks

An attacker might try to launch a memory exhaustion attack on a MULTOPS-equipped router by causing the MULTOPS to branch profusely. The two opposing forces in such an attack are the attacker sending packets on one side, and the MULTOPS folding parts of the tree on the other side. The attacker causes nodes to be created, folding causes them to be destroyed. Since a node for subnet S is destroyed when the aggregate packet rates to and from S are both less than Q, the attacker will try to generate a bandwidth higher than Q for as many different subnets as possible. Section 4.7 deals with memory exhaustion attacks in a quantitative context.

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Chapter 4

Implementation of MULTOPS

4.1 Click

A MULTOPS is implemented as a Click [18] element. Click is a modular software router architecture developed at the MIT Laboratory for Computer Science. A Click router is an interconnected collection of modules called elements. Each element performs a simple, straightforward task such as communicating with devices, queueing packets, and implementing a dropping policy. A Click router is configured by feeding it a file written in a language designed to describe the interconnection between different elements. Click runs under Linux as a user program or as a kernel module.

Figure 4-1 shows a simple Click configuration with 5 elements. Each rectangle is an element; the arrows represent connections between elements. The arrows indicate the direction of the packet flow between elements. Elements can have 0 or more inputs and outputs. `FromDevice`, for example, has no inputs and 1 output; `Split` has 1 input and 2 outputs.

Incoming packets are grabbed from a network card (eth0) by `FromDevice`. `FromDevice` has one argument (`eth0`) that tells it what device to grab packets from. Depending on its specification, an element can have zero, one, or any number of arguments. Every packet flows through `Counter` which simply keeps track of the number of packets by increasing a counter by 1 for each packet that comes by. `Split` creates

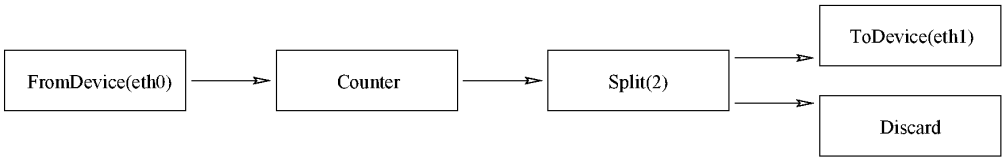


Figure 4-1: Simple Click configuration

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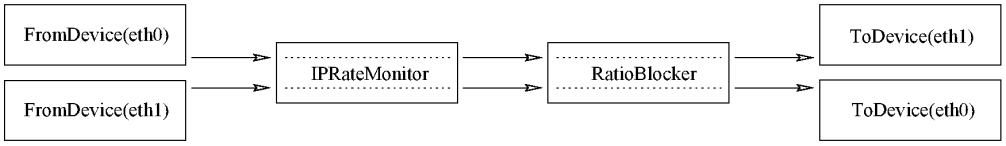


Figure 4-2: Click configuration with IPRateMonitor

a copy of each packet and pushes one copy on each of its outputs. Note that the number of copies `Split` makes (and the number of outputs it has) is determined by the argument passed to it. `Split` pushes one copy to `Discard` which simply drops each packet on the floor. The other copy goes to `ToDevice`, which hands the packet over to a network card (eth1) where it gets sent out.

When Click runs as a kernel module, it allows user-level programs to query some elements. Interaction between user-level programs and Click goes through the `/proc` file system. For example, the command `cat /proc/click/Counter/count` prints the number of packets `Counter` has seen so far. Certain elements allow their behavior to be influenced in real time by writing to a `/proc` file. For example, the count of `Counter` can be reset to zero by executing `echo 0 > /proc/click/Counter/reset`.

Click elements can write "annotations" on a packet. An annotation is a per-packet piece of information that exists as long as a packet resides in Click. Annotations enable elements to pass information to each other.

More information on Click is available at `http://pdos.lcs.mit.edu/click`.

4.2 IPRateMonitor

A MULTOPS is implemented as a Click element called `IPRateMonitor`. Figure 4-2 shows a simple Click configuration with an `IPRateMonitor`. This Click configuration sends all packets that come in on eth0 to eth1 and vice versa. Every packet is led through `IPRateMonitor` and `RatioBlocker`. Collaboration between `IPRateMonitor` and `RatioBlocker` is achieved through two annotations. Before `IPRateMonitor` pushes a packet p on one of its outputs, it annotates p with the packet rates that p itself is a part of.

The `RatioBlocker` element implements **bandwidth attack protection**. `RatioBlocker` calculates R from both annotations and drops the packet if R violates either R_{min} or R_{max}. Otherwise it pushes the packet on one of its outputs. Thus, `RatioBlocker` distinguishes between packets that are part of a symmetric flow and packets that are part of an asymmetric flow.

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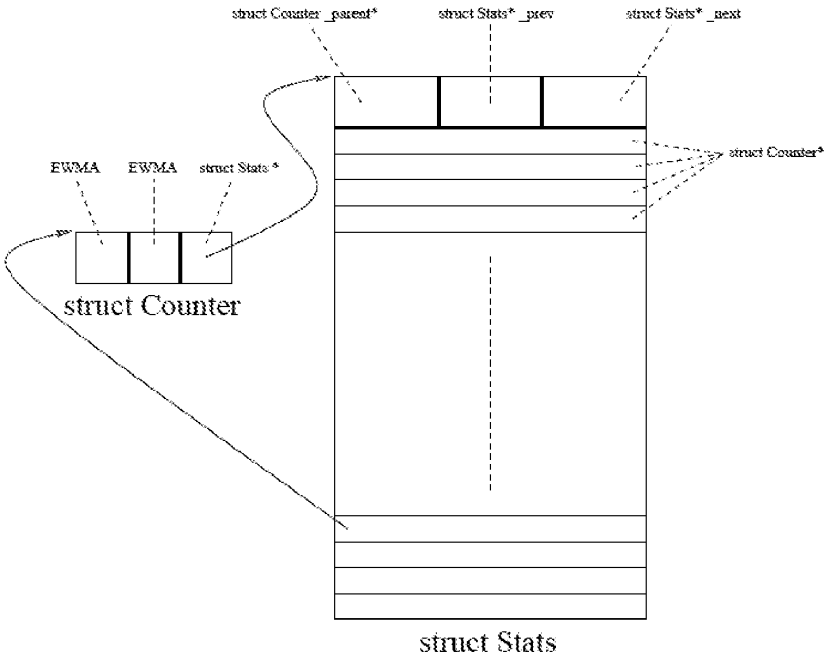


Figure 4-3: Counter and Stats

4.3 Data structure

`IPRateMonitor` is implemented using two `structs`: `Counter` and `Stats`.

```
struct Counter {
    EWMA rev_rate;
    EWMA fwd_rate;
    Stats *next_level;
};

struct Stats {
    Counter *_parent;
    Stats *_prev, *_next;
    Counter* counter[256];
};

Stats *_base;
```


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Class EWMA implements an exponentially weighted moving average. EWMAs are used to keep track of rates. Counter is the C++ equivalent of a MULTOPS record. In addition to 2 EWMAs, Counter contains a pointer to a child node (next_level) which is NULL if the record is not unfolded and has a non NULL value if the record is unfolded. In that case, next_level points to the child node. Stats is the C++ equivalent of a MULTOPS node. It contains 256 Counter * pointers and some additional pointers. _base is a pointer to the root node. Figure 4-3 shows a schematic representation of both data structures.

4.4 Algorithm

Figure 4-4 shows the simplified code that is executed for each packet in a router that is operating in inside protection mode. When a packet is ready, Click wakes up IPRateMonitor by calling handle_packet. handle_packet calls update with either p's source address or destination address, depending on the input that the packet arrived on. After update, it pushes the packet on the corresponding output.

update starts with a for-loop in which it uses i to extract a specific byte from address. This byte (x) is used to get s->counter[x] (i.e., the x-th record in node s). If s->counter[x] is NULL, a Counter is allocated and assigned to c. In any case, either c->fwd_rate or c->rev_rate is updated. Finally, it checks for a deeper Stats by looking at c->next_level. If non NULL (i.e., c is unfolded), another iteration is done for c = c->next_level. Otherwise the loop is broken.

After execution of the for-loop, c points to the deepest available (i.e., unfolded) Counter for this address. Packet p is annotated with c->fwd_rate and c->rev_rate. After that, c is unfolded if either c->fwd_rate or c->rev_rate is higher than _thresh. _thresh is the C++-equivalent of Q. As long as both rates stay below _thresh, the Counter remains folded. The i<3 part in the if-statement prevents the deepest level from being unfolded.

4.5 Unfolding

In an experiment, an early implementation of MULTOPS using memory-triggered folding was subjected to a bandwidth attack that involved IP source addresses from many different subnets. The MULTOPS had an imposed memory limit of M_{max}. Results show that the memory use of the MULTOPS fluctuates extremely within a small time scale. This behavior occurs regardless of the size of M_{max}, provided that the attack forces the MULTOPS to allocate more memory than M_{max}. The fluctuations are the result of the following sequence of events: if no records are eligible for folding, the process divides Q by 2 and tries again. After several iterations of not finding any records to delete, Q becomes so low that nearly every record in the tree suddenly becomes eligible for folding; the tree collapses. After that, the tree expands quickly due to incoming packets, violates the memory limit again, and the cycle starts anew. These extreme fluctuations occur for less aggressive methods of lowering Q, too.

The solution to this problem is to never unfold a record if that would violate the memory limit. This

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```
IPRateMonitor::handle_packet(int input_port, Packet *p)
{
    if(input_port == 0)
        update(p->src_address, p, true);
    else
        update(p->dst_address, p, false);
    output(input_port).push(p); /* push packet on output input_port. */
}

IPRateMonitor::update(char address[4], Packet *p, bool forward)
{
    struct Stats *s = _base;
    struct Counter *c;

    /* Descend into MULTOPS tree while updating rates. */
    for(int i=0; i<4; i++) {
        char x = address[i];
        if(!(c = s->counter[x]))
            c = make_counter(s->counter, x)

        if(forward)
            c->fwd_rate.update();
        else
            c->rev_rate.update();

        if(!c->next_level)
            break;
        s = c->next_level;
    }

    annotate_packet(p, c->fwd_rate, c->rev_rate);

    /* Unfold if necessary */
    if((c->fwd_rate >= _thresh || c->rev_rate >= _thresh) && (i < 3)) {
        c->next_level = new Stats();
        c->next_level->_parent = c;
    }
}
```

Figure 4-4: Code executed for each packet

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policy is a variation of memory-triggered folding and is called the "no-grow" policy. `IPRateMonitor` follows the no-grow policy. This introduces a problem, though: the tree can no longer unfold any record after it has reached its memory limit. This condition is called "no-grow lockup". The next section looks at possible solutions against no-grow lockup.

4.6 Folding

In `IPRateMonitor`, the no-grow policy is combined with time-triggered folding. Thus, no memory is allocated if that would violate the imposed memory limit and the MULTOPS is folded every N ms whatever its state is. If a no-grow lockup occurs, it lasts no longer than N ms. Furthermore, there is no risk of choosing N too large because memory will never run out. $N = 1000$ ms in `IPRateMonitor`.

The nodes in the tree are kept in a linked list, hence `_prev` and `_next` in each `struct Stats`. During folding, the process traverses this list of nodes in search of eligible records (i.e., records for which $T(S)$ and $F(S)$ are both lower than Q). In an initial implementation, the linked list was ordered such that the most recently updated nodes were in the front of the list and the longest untouched nodes were in the back of the list. This strategy is based on the assumption that the longest untouched nodes were most likely to contain records eligible for folding and could, therefore, be found in the back of the list. Keeping the list ordered in this fashion required an update in the linked list for each packet. The total overhead induced by keeping the list ordered was bigger than the time gained during folding. For that reason, the current implementation of `IPRateMonitor` simply appends new nodes at the end of the (unordered) list. Compacting traverses the linked list and inspects each node on records eligible for folding. If no records are eligible for folding, then Q is decreased by 5% and searching starts again.

To avoid heavy fluctuations in memory use (as described in section 4.5), folding stops when a certain fraction f of allocated memory has been freed. To avoid that nodes in front of the list are more likely to get folded than nodes at the back of the list, the process randomly traverses the list in forward or backward direction. When MULTOPS memory use is at its imposed maximum and suddenly no more packets arrive, its memory use will decrease by a fraction f every N ms. The graph in Figure 4-5 shows the drop in memory use after 1000 attackers from 100 subnets cease their bandwidth attack. The y-axis shows memory use in bytes and the x-axis shows time in seconds. At $t = 5$ the attack starts, at $t = 10$ the attack stops. $N = 1000$ and $f = 10$, i.e., every second 10% of memory used by `IPRateMonitor` is freed.

4.7 Memory exhaustion attacks

Section 3.9 sketches a scenario in which an attacker tries to run a MULTOPS-equipped router out of memory by forcing the MULTOPS to branch profusely. This section explains how `IPRateMonitor` deals with such attacks.

To keep memory consumption as low as possible, `IPRateMonitor` only allocates records (`Counter`

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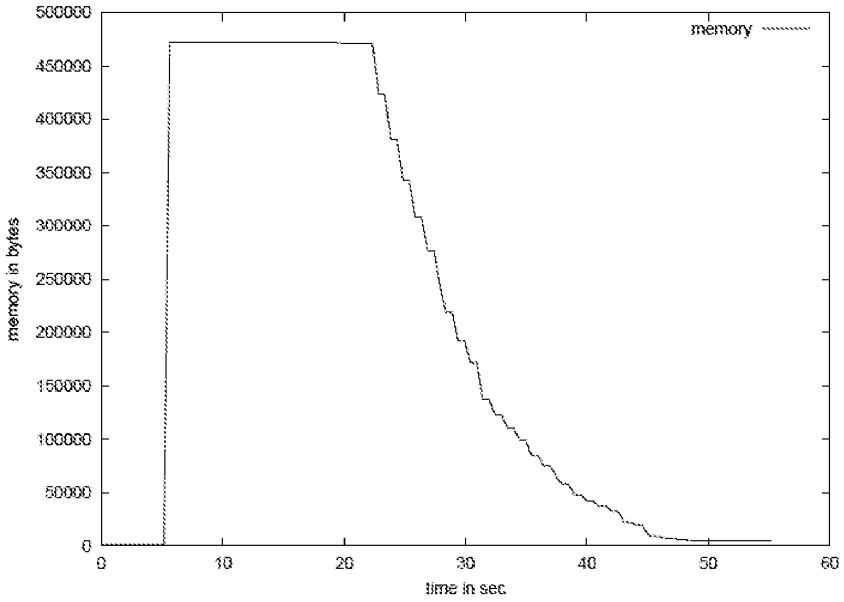


Figure 4-5: Memory use of IPRateMonitor as a result of folding

`structs`) and nodes (`Stats structs`) when necessary. Implementing a `Stats` as an array of `Counter *` pointers as opposed to an array of `Counter` reduces the size of `Stats` from 7180 bytes to 1040 bytes. Although keeping the data structure small is desirable for many different reasons, it only stretches the time before a router runs out of memory. It does not prevent memory exhaustion.

Since nodes require more memory than records, the most effective way to run `IPRateMonitor` out of memory is by forcing it to allocate many nodes. Assume that the attacker has infinite resources and is not constrained by any ingress/egress filtering. The attacker runs the following program:

```
for(l=0; l<=255; l++)
  for(k=0; k<=255; k++)
    for(j=0; j<=255; j++)
      for(i=0; i<=255; i++) {
        fork(program sending packets with source address i.j.k.l at rate Q+1);
        if(--max_addresses == 0)
          exit(0);
      }
```

Each iteration of the innermost loop starts a program that keeps sending IP packets with IP source address *i.j.k.l* at rate of $Q+1$ packets per second through the attacked router. After forking off `max_addresses` programs, the loop stops. This algorithm most effectively maximizes the number of nodes in the MULTOPS.

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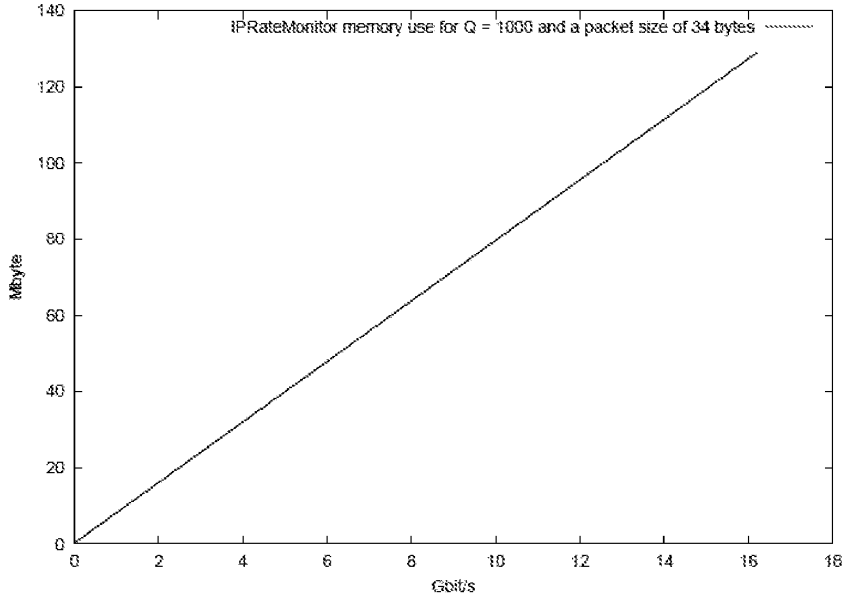


Figure 4-6: Relation between bandwidth and memory use

The amount of memory (M) the MULTOPS allocates in the attacked router, as function of i, j, k, and l, is:

$$M = n + \begin{cases} l = k = j = 0 & : \quad c_0(i) = (4r + 3n)(i + 1) \\ l = k = 0 & : \quad c_1(j) = c_0(256) + (3r + 2n)(256(j - 1) + (i + 1)) \\ l = 1 & : \quad c_2(k) = c_1(256) + (2r + n)(256^2(k - 1) + 256j + (i + 1)) \\ & : \quad c_3(l) = c_2(256) + r(256^3(l - 1) + 256^2k + 256j + (i + 1)) \end{cases}$$

where n is the size of a `Stats` (1040 bytes) and r is the size of a `Counter` (28 bytes).

The graph in Figure 4-6 shows that an attacker, running the above algorithm, needs to generate spoofed packets at a bandwidth of roughly 16 Gbit/s to make `IPRateMonitor` allocate 128MB of memory, provided that the network has the physical capability to carry this traffic to the target router. The graph is plotted for a packet size of 34 bytes and for $Q = 1000$. Given a maximum available bandwidth and a memory limit in a router, Q can be set to a value that ensures memory never to run out. It is safe to conclude that it is impossible to run `IPRateMonitor` out of memory.

4.8 Measurements

To measure performance of `IPRateMonitor`, a simple Click configuration was run in a Linux kernel 2.2.16 on an off-the-shelf PC (Pentium III, 700Mhz, 256 KB cache, 256 MB memory) that sends packets

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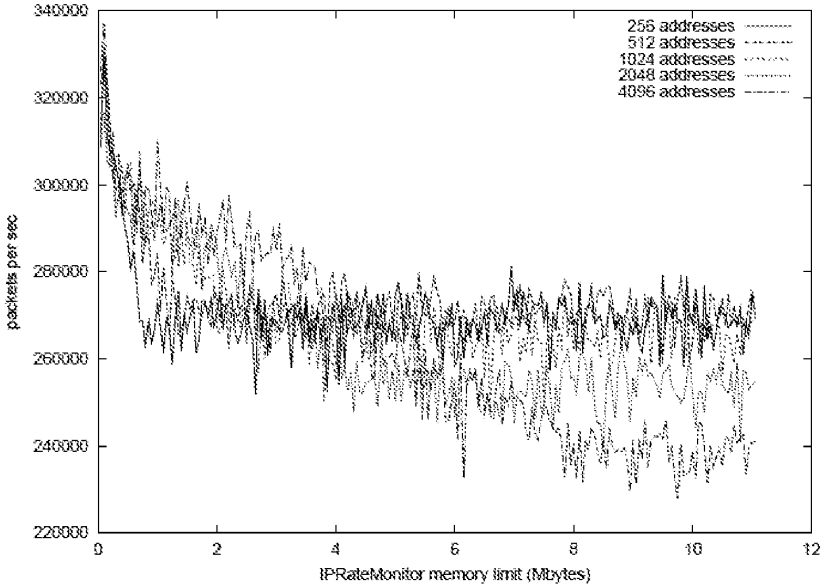


Figure 4-7: Packet rate as a function of memory limit

through an `IPRateMonitor` element that uses the packets' IP source address to index in the MULTOPS. Bogus UDP/IP packets were generated by Click itself to avoid interaction with network cards. Appendix A shows the Click configuration that was used for these measurements. `RoundRobinUDPIPEncap` is initialized with a set of IP addresses that it traverses in round-robin fashion to use as IP source address on UDP/IP packets it generates. This simulates an IP spoofing attacker. `IPRateMonitor` is initialized with different values for `MEM_LIMIT`, and always with $Q = 0$, i.e., maximum unfolding.

The graph in Figure 4-7 shows the number of packets that `IPRateMonitor` can handle as a function of its imposed memory limit. The graph shows 5 lines, each representing the number of different IP source addresses on the packets flowing through `IPRateMonitor`. The actual addresses used on the UDP/IP packets are determined by the algorithm in section 4.7. For example, the line labeled "4096 addresses" shows that `IPRateMonitor` can handle roughly 240,000 packets per second when it has 10 MB of memory at its disposal. The packets come from the same 4096 different subnets as packets that are generated by the algorithm in section 4.7 with an initial value of 4096 for `max_addresses`.

From Figure 4-7 it is clear that `IPRateMonitor` can handle more packets when its available memory is less. A small MULTOPS fits in cache entirely and is, therefore, fast. As the amount of available memory grows, so does the size of the MULTOPS, which makes it too big to fit in cache entirely and cache misses result. The performance of `IPRateMonitor` for 256, 512, and 1024 addresses is roughly the same (270,000 packets/sec). In these cases, the tree is small enough to fit in cache entirely. For 2048 and 4096

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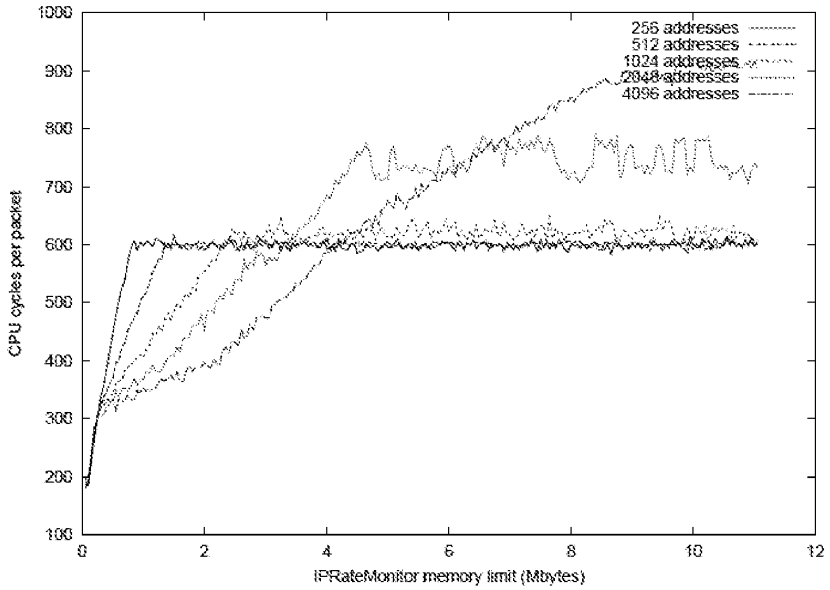


Figure 4-8: CPU cycles per packet as a function of memory limit

addresses, we observe that rates keep dropping up to a certain, stable point. In both cases, the tree grows past the capacity of the cache. As a result, its performance drops proportional to the amount of memory used by `IPRateMonitor`.

The graph in Figure 4-8 shows the number of CPU cycles that `IPRateMonitor` consumes per packet as a function of its imposed memory limit. The different lines have the same meaning as in Figure 4-7. An `IPRateMonitor` consumes more CPU cycles when it is given more memory. Most likely, most of these cycles are spent waiting for a memory fetch after a cache miss.

`IPRateMonitor`'s performance is better when it has little memory at its disposal. Unfortunately, its ability to unfold records and, therefore, to precisely determine the source(s) of the attack, is also limited. Improving the speed of `IPRateMonitor` can be achieved by making the tree consume less memory. Section 6 proposes a method to achieve this.

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Chapter 5

Detecting bandwidth attacks with MULTOPS

We explore the ability of a MULTOPS to detect bandwidth attacks using the attack classification presented in section 2.7.

Consider the setup in Figure 5-1. S is a Web server, A is a single attacker or a group of attackers on different networks—this will be specified per example. R is a router. The fat lines represent links with a higher capacity than the link that is represented by the thin line. R has some sort of packet dropping mechanism based on MULTOPS. C is a benign client or a group of benign clients on different networks.

5.1 Flood and D-Flood

In Flood and D-Flood bandwidth attacks, the attacker sends packets using an non adaptive protocol such as UDP or ICMP. The attacker does not spoof IP addresses.

Suppose that A starts her bandwidth attack by sending ICMP ECHO REQUEST packets to S at a rate that saturates the link between R and S. As a result, most packets coming back from S get dropped in R; C's browser freezes. R observes an asymmetry in the packet rates from A and to A, and an asymmetry in the packet rates from C and to C. Consequently, R concludes that both A and C are attackers and, therefore, drops their packets. In reaction to that, TCP in C backs down because it sees no ACKs coming from S. Because C is no longer sending packets, symmetry is re-established and R stops blocking packets from C. A, on the other hand, keeps sending packets and, with that, maintains the asymmetry.

If A is a distributed attacker launching a D-Flood from N different networks, then each client generates $1/N$ of the required bandwidth. R will observe asymmetries in the packet rates to and from each of those N networks. Consequently, packets from those networks are dropped. Conclusion: a MULTOPS is very well suited for stopping Flood and D-Flood bandwidth attacks. However, many factors play a role in detecting D-Flood attacks: the value of N, how much benign traffic there is from those N networks, and the value

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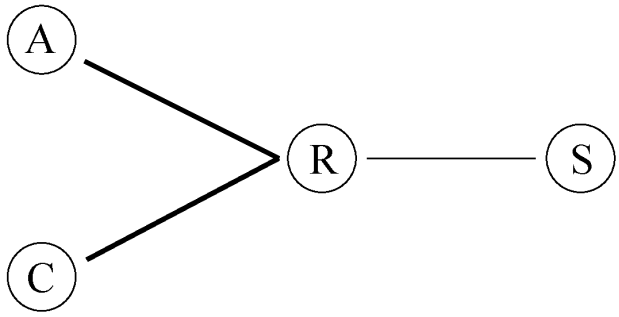


Figure 5-1: Example bandwidth attack setup

of R_{min}. If N is high, the relative volume of malicious traffic from that network is small, and, therefore, the asymmetry harder to detect. Similarly, if a relatively large share of traffic from a subnet is benign, it is hard to detect a maliciously caused asymmetry. The closer R_{min} is to 1, the more sensitive the router is to asymmetries, but the higher the chance for false positives.

5.2 Flood+

In Flood+ bandwidth attacks, the attacker sends packets using an non nadaptive protocol such as UDP or ICMP. The attacker spoofs IP addresses, which is only possible if she is not behind an ingress/egress filtering edge router.

The attacker can launch a successful Flood+ bandwidth attack if she uses C's address for spoofing. R observes an asymmetry from (what R thinks is) C and subsequently drops all packets coming from C, including packets that are really sent by C.

A router in outer-protection mode deployed on the edge of A's network will detect the attack on S because that router observes the asymmetry between packets going to S (many) and packets coming back from S (few or none at all). Conclusion: a MULTOPS-equipped router can only stop Flood+ attacks if deployed on (or close to) the attacker's network. More generally, a distributed approach, i.e., having MULTOPS-equipped routers spread out over the entire Internet, increases the ability of the system as a whole to detect distributed bandwidth attacks that use IP spoofing.

5.3 Stealth

In Stealth bandwidth attacks, the attacker sends packets using an adaptive protocol; most likely TCP. The design of MULTOPS makes it unsuitable to detect this type of attack.

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An attacker can open many normal TCP connections to a server and let each connection download a big file. If the resulting traffic constitutes an overload, then all TCP connections will slow down, including benign TCP connections to that server. Deploying MULTOPS-equipped routers on the attacker's network does not stop the attack either, since this attack causes no asymmetry.

There are several ways to adapt a system with a MULTOPS to make it more suitable for detecting Stealth bandwidth attacks.

- Rate-limit certain clients when total bandwidth nears threshold.

  Instead of looking at ratios only, a MULTOPS could easily keep track of the total bandwidth going through the router. As soon as the total bandwidth exceeds a certain threshold, the router can rate-limit clients that consume most bandwidth, the clients that have most connections, the clients that show most asymmetric behavior, or even based on the payload of packets. The aggressiveness of this rate-limiting can grow as the total bandwidth nears the maximum bandwidth. This strategy is similar to RED [19] and turns MULTOPS into a dropping policy based on packet rate (a)symmetry. Legitimate clients that use a high bandwidth will not like this, though.

- Create a server API.

  A router could ask a server how it is doing. In the event that the server lets the router know it cannot cope with all the traffic it receives, the router can rate-limit or completely drop traffic to that server. Of course, communication between routers and servers needs to go over a different link than the one under attack; a phone line, for example.

- Communication between routers.

  Whether or not a suspected victim is really under attack can be determined with greater precision if MULTOPS-equipped routers can send (parts of) their MULTOPS to other routers who compare this data to the contents of their own MULTOPS. This introduces several problems, though. Communication cannot be done through flooded links, and attackers can forge this data and send it to routers, too. Out-of-band communication provides a solution to both problems.

5.4 D-Stealth/Flashcrowd

In D-Stealth bandwidth attacks, the attacker sends packets using an adaptive protocol; most likely TCP. The attacker does not spoof IP addresses. Because a MULTOPS searches for asymmetries to detect attacks, it is not suitable to detect attacks that are mounted using an adaptive protocols such as TCP.

Unlike a Stealth attack, a MULTOPS-equipped router deployed on the victim's network cannot detect the attack, since traffic flows are symmetric and, therefore, inconspicuous. A Flashcrowd is similar to a D-Stealth attack, but more distributed than a D-Stealth attack.

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5.5 SYN flooding

SYN floods can be stopped by a router because each SYN requires a SYN/ACK to be sent back, which is the kind of symmetry a MULTOPS expects. If an attacker keeps sending SYN packets without any SYN/ACKs coming back, the attack becomes similar to a Flood. The capability of a MULTOPS to detect a SYN flood strongly depends on the values of R_{min} and R_{max}, though. A short explosion of SYN packets may be enough to run a server out of TCP control blocks, but may be too short for the MULTOPS to detect the asymmetry.

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Chapter 6

Future work

We suggest that the following issues are further explored.

Make unfolding R-triggered, not Q-triggered. Currently, a record unfolds if the packet rate exceeds threshold Q. A single packet rate is not an indication for an attack, though; asymmetry is. Thus, if packet rates are asymmetric, the relevant records should be unfolded. Care has to be taken, though, that this change does not make the MULTOPS more vulnerable to memory exhaustion attacks.

Look into application-dependent and level-dependent thresholds. By making Q, R_{min}, and R_{max} application dependent, a router's overall sensitivity to attacks can be improved. In addition, since average packet rates tend to be lower in deeper levels of the tree, making thresholds level-dependent is an obvious improvement.

Handle delayed ACKs correctly. TCP waits a short time between receiving a packet and sending an ACK. If, in that period, one or more packets come in, then TCP acknowledges only this last packet. This invalidates the assumption that traffic rates are symmetric. This problem can be solved by setting R_{min} and R_{max} such that the MULTOPS accepts asymmetric connections. Unfortunately this will also severely degrade the sensitivity to attacks.

Look into different folding strategies. Currently, the whole tree is searched for eligible records. Searching stops when a certain fraction f of memory is freed. If the attacker manages to blow up the tree faster than folding can reduce it, then memory exhaustion might result. Fraction f and threshold Q should increase as the total memory use gets closer to its imposed maximum to make folding more aggressive. Another (additional) method is to make the frequency of time-triggered folding increase as the total memory use gets closer to its imposed limit.

Do more on Stealth bombs. Stealth bombs are a MULTOPS' Achilles heel. Section 5.3 proposes several ideas to make MULTOPS better in detecting Stealth bombs, but more research is needed.

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Improve performance. To improve cache performance, level 0 and level 1 of the tree can be combined into a two dimensional array where the row is chosen based on the first byte of an IP address and the column based on the second byte of an IP address.

IPv6. With small adaptations, `IPRateMonitor` can be made suitable for IPv6. Its memory requirements are different, though.

Asymmetric routes. If routes are not symmetric, then routers need to exchange information to find asymmetries. For example, if a network has one router for all incoming traffic and one router for all outgoing traffic, then these routers need to exchange data to detect asymmetries.

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Chapter 7

Conclusion

This thesis proposes a bandwidth attack detection mechanism wherein routers monitor traffic and consider a subnet to be under attack when the packet rate coming from a subnet is disproportional to the packet rate going to that subnet. A MUlti-Level Tree for Online Packet Statistics (MULTOPS) is a data structure suitable for keeping track of packet rates to and from different subnets on different aggregation levels. A MULTOPS can be used to detect incoming or outgoing bandwidth attacks.

A MULTOPS is suitable for detecting bandwidth attacks that are mounted using unadaptive protocols such as UDP and ICMP. This covers all February 2000 attacks. To our knowledge, no such detection mechanism has been proposed yet. In some cases a MULTOPS is suitable to detect bandwidth attacks that are mounted using adaptive protocols such as TCP. Depending on the attack, a MULTOPS can point out the sources of the attack. It is exceedingly difficult to run a MULTOPS-equipped router out of memory.

Measurements show that the performance of a MULTOPS is primarily influenced by the size of the cache and the numbers of IP source addresses involved in the attack.

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Chapter 8

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Last, but certainly not least, I say murp to Lovely Lady "Twiga" Lisa, who fills me with happiness, joy, and pleasure. You turned Cambridge, Massachusetts into a place where true miracles happen. נס גדול היה פה. Thank you.

> Then he prayed, "... give me success today, and show kindness to my master Abraham. See, I am standing beside this spring, and the daughters of the townspeople are coming out to draw water. May it be that when I say to a girl, 'Please let down your jar that I may have a drink,' and she says, 'Drink, and I'll water your camels too'—let her be the one you have chosen for your servant Isaac. By this I will know that you have shown kindness to my master."
>
> Before he had finished praying, Rebekah came out with her jar on her shoulder. (Genesis 24:12-15)

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Appendix A

Click config file for performance measurement

```
is :: InfiniteSource(<00000000111111112222222233333333444444445555>,
      5000000, 1);
udpgen :: RoundRobinUDPIPEncap(
0.0.0.0 1234 1.0.0.2 1234 1,
1.0.0.0 1234 1.0.0.2 1234 1,
2.0.0.0 1234 1.0.0.2 1234 1,
...
254.0.0.0 1234 1.0.0.2 1234 1,
255.0.0.0 1234 1.0.0.2 1234 1,
0.1.0.0 1234 1.0.0.2 1234 1,
1.1.0.0 1234 1.0.0.2 1234 1,
2.1.0.0 1234 1.0.0.2 1234 1,
...
254.1.0.0 1234 1.0.0.2 1234 1,
255.1.0.0 1234 1.0.0.2 1234 1,
... etc...
);
is -> udpgen ->
CycleCount(0) ->
rm :: IPRateMonitor(PACKETS, 0, 1, 0, <MEM_LIMIT>) ->
CycleCount(1) ->
st :: StoreCycles(0,1) ->
co :: Counter -> Discard;
```


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Appendix B

Netmasks

There are two different notations for network prefixes. The first is $a.b.c.d/k.l.m.n$ where $a.b.c.d$ is an IP address, and $k.l.m.n$ is a netmask. The result of a logical AND operation between the IP address and the netmask is the prefix of all IP addresses on a network. For example, on network $18.24.123.69/255.255.0.0$, all addresses have prefix $18.24.0.0$.

The second notation—the one used in this thesis—is $a.b.c.d/x$, where $a.b.c.d$ is an IP address and x denotes the number of all-one-bits. If x is less than 32 (i.e., the total number of bits in an IP address) then it is right-padded with zeroes. The result of the a logical AND operation between $a.b.c.d$ and the zero-padded netmask is the prefix of all IP addresses on a network. For example, on network $18.24.123.69/16$, all addresses have prefix $18.24.0.0$.

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Declaration of Dr. Hall-Ellis

EXHIBIT 1043

P. Eronen, "Denial of service in public key protocols," Helsinki University of Technology, Telecommunications Software and Multimedia Laboratory, 2000

Denial of service in public key protocols

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Abstract

Network denial of service attacks have become a widespread problem on the Internet. However, denial of service is often considered to be an implementation issue by protocol designers. In this paper I present a survey of the literature on designing denial of service resistant communication protocols. I consider several different types of resources vulnerable to resource consumption attacks, and outline countermeasures against such attacks. I also describe how these countermeasures are used in the ISAKMP/IKE and Photuris protocols, and give overview of design recommendations for future protocols.

1 Introduction

Denial of service (DoS) means "the prevention of authorized access to resources or delaying of time-critical operations" [22]. During the last couple of years, network denial of service attacks—which deny or degrade access to some network service—have become a problem on the Internet. The most publicized attacks have been against well-known web sites such as Yahoo and Amazon [12, 37].

CERT's note on denial of service [9] identifies three different types of network DoS attacks. First, consumption of scarce, limited or non-renewable resources. Second, destruction or modification of configuration information, and third, physical destruction or modification of network components.

In this survey, I focus on resource consumption attacks, and how they could be prevented—or at least made more difficult—by taking availability into account in the design of communication protocols. In protecting the availability of actual systems, it is, of course, important to consider other attacks as well.

I also limit the study to what I consider to be a typical case on the Internet: protecting the availability of a server from attackers trying to deny service to legitimate clients. Thus, protecting clients from DoS, and protocols involving more than two parties, are beyond the scope of this paper.

The rest of the paper is organized as follows. The next section presents a couple of different resources vulnerable to DoS attacks, with examples in each category. Section 3 identifies a number of different countermeasures. Sections 4–6 describe how these countermeasures

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are used in two actual protocols, ISAKMP/IKE and Photuris. Section 7 presents some ideas how denial of service problem should be addressed in protocol design, and finally, Section 8 presents my conclusions and suggestions for further research.

2 Resource consumption attacks

Resource consumption attacks work by consuming some scarce, limited or non-renewable resources. Most of the widespread network DoS attacks have been of this type: for example, the TCP SYN flooding attacks and the distributed DoS attack on Yahoo, Amazon, and other popular web sites. The details of both of these attacks are discussed below.

Resource consumption attacks have become common because they are quite easy to mount, difficult to defend against, and hard to trace to their source. Furthermore, there are many types of resources which could be consumed. The next sections describe the most common resources used for denial of service attacks.

2.1 Memory

One of the earliest widespread DoS attacks was the TCP SYN flooding attack. It works by filling the table reserved for half-open TCP connections in the operating system's TCP/IP stack. When the table becomes full, new connection can't be opened until some entries are removed from the table (due to handshake timeout). The details are described in [7, 19, 44].

This attack can be done using fake IP addresses, so tracing it to its source is difficult. Of course, the table of connections can be filled without spoofing the source IP address. Often the space available for fixed tables, such as the half-open TCP connection table, is much less than the total RAM of the system. This makes the attacks even easier.

2.2 Network bandwidth

The distributed DoS attack carried out against Yahoo, Amazon, and other popular web sites worked by filling their network connection with junk traffic [12, 37]. The traffic was generated from hundreds of different sources—computers who had earlier been compromised by crackers, and had attack software installed on them.

In general, protecting systems from this type of attack is difficult, since it requires mechanisms distributed across the Internet. Some countermeasures to make tracing such attack easier are described in Section 3.2.

However, there are other types of network bandwidth attacks. In some protocols, the client sends only a small amount of data, but gets a large response from the server. This could be described as "traffic amplification" [8, 10]. This effect can be used to attack either the "amplifier" directly, or the amplifier can be used to attack some third party (by faking the source address, so that the amplified traffic is sent to the final target). This kind of attack could be made more difficult by server-side actions; e.g. designing services so that large responses aren't generated to untraceable requests.

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2.3 Computational resources

Some authors (e.g. Juels and Brainard in [25]) have suggested that strong authentication, based on a public-key infrastructure, could prevent or mitigate denial of service attacks such as SYN flooding.

However, using public key cryptography opens the possibility for another kind of attack. Public key cryptography usually involves expensive computations, such as modular exponentiation. If the attacker can convince the target to perform a large number of such computations, exhausting its CPU resources, legitimate connections won't get any CPU time.

There haven't been any widespread attacks of this type so far, but several protocols have been identified as being vulnerable [20, 21, 29, 30, 32].

2.4 Other resources

Although typically several orders of magnitude larger than RAM, disk space can also be subjected to denial of service. For example, the attacker can cause a large number of error messages to be written to a log, and fill the disk containing the log files. Or, user's mailbox can be filled with junk mail, thus preventing reception of important messages—this attack is usually even easier than filling disk with logs, since users often have mailbox "quotas" much smaller than typical disk capacities.

Disk (or other I/O than network) bandwidth can also be a bottleneck in a system. For example, in a server hosting a large database, queries for attributes which are not indexed probably result in lots of I/O activity. This could happen in a publicly available LDAP server, for instance.

In theory, any finite or non-renewable resource can be the target of a DoS attack, and providing a complete list is thus impossible. Other examples of resources that could be vulnerable are incoming telephone lines on a terminal server, paper at printers or fax machines, money spent buying another resource from a third party, and so forth.

3 Countermeasures

Reacting to a resource consumption attack usually involves at least detecting that an attack is going on, tracing it to (or nearer) its source, and taking administrative or legal action to end the attack.

In this paper I'm focusing only on countermeasures relevant in designing and implementing communications protocols. Thus administrative countermeasures are beyond the scope of this paper.

Countermeasures against DoS attacks can be either preventive or reactive. Preventive countermeasures can help in this by making attacks easier to detect, or trace, and also by making the system more resistant to attacks.

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3.1 Detecting attacks

Even detecting that a service is under a denial of service attack can sometimes be difficult. Clients which are denied of service naturally detect it, but the condition isn't always easily noticeable at the server (e.g. TCP SYN attack).

Even when it has been determined that the service is indeed under attack, detecting which part of the incoming traffic belongs to the attack, and which is legitimate traffic, can be difficult. This problem is made more difficult by spoofed IP addresses.

Intrusion detection and reaction systems aim to cut off denial of service attacks by identifying the part of traffic which belongs to the attack, and denying service only to that part while continuing to serve legitimate clients. Most such mechanisms are very ad hoc in nature; a determined attacker can fool them, and they can also produce false positives. For instance, a web proxy for a very large organization naturally produces a large number of traffic, which all looks like it's coming from a single or few IP addresses. To an intrusion detection system this might look like a flooding attack.

3.2 Tracing attacks

Cutting off an attack often requires tracing it to its source. The possibility of tracing probably also discourages attacks, since attackers know they are more likely to get caught. Thus, it can be thought as both preventive and reactive countermeasure.

Forging, or spoofing as it is usually called, of source IP address on the Internet is quite easy. Some techniques (such as cookies, described in the next section) can be used to get some degree of assurance about the source IP address. In analysis of mechanisms for protecting confidentiality and integrity of messages, it is usually assumed that the attacker can modify, replay, and block any packets sent. This naturally allows trivial denial of service, so somewhat weaker assumptions are used when analyzing availability.

There have been several proposals for mitigating the problem of IP spoofing. Ingress filtering [15] means filtering incoming IP addresses which should not occur on the correct link. For example, a central router at an university should filter out outgoing packets whose source address is not within the university's network. This makes the network less likely to be used as a launching pad for attacks, and if deployed widely, should reduce the problem of IP spoofing.

Another proposal, ICMP traceback messages [5], attempts to trace back flooding attacks, even if they have forged source addresses. Other authors have proposed mechanisms for recording the route traveled in the packets themselves [11, 43]. Unfortunately, all of these require modifications to router software, so it remains to be seen if any of them will ever be widely deployed.

3.3 Cookies

Cookie is a piece of data which is generated by the server and given to the client in the beginning of a protocol run. The client has to include this piece of data in the subsequent

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messages. The goal of cookies is to prevent attacks which employ IP spoofing. If the client doesn't receive the message containing the cookie, the server will reject further messages because they don't include a valid cookie.

More precisely, if the server receives a valid cookie from the client, it knows that:

- The attacker is using his real IP address. This address may, of course, belong to a third party computer the cracker has broken into.
- Or, the attacker has access to physical link on the route from the server to the spoofed IP. In reality, the attacker is probably quite "close" to either the server or the spoofed IP, making tracing easier.
- Or, the attacker is able to manipulate the IP routing infrastructure. This is beyond the capabilities of "script kids", and more sophisticated and motivated attackers probably focus on attacks on integrity and confidentiality.

In other words, the idea is to start the protocol with weak authentication (of IP addresses), and possibly later perform stronger authentication. This allows tracing of attacks (with some limitations, as described in the previous section), and probably discourages attacks on computational resources.

An early example of cookies are actually the TCP initial sequence numbers, though their original purpose was to prevent packets from old connections interfering with new connections. After the TCP SYN attacks, some TCP/IP stacks were modified to use the initial sequence numbers as "SYN cookies" to protect against the attack [19, 44].

The cookie approach was much refined during the design of the Photuris protocol. The Photuris specification [27] gives the following requirements for cookies (or "anti-clogging tokens"):

- The cookie must depend on the addresses of the communicating parties.
- Nobody else must be able to forge a cookie that will be accepted by the server.
- The cookie generation and verification must be fast enough so that they don't become subjects to DoS attacks.
- The server must not keep per-client state until the IP address has been verified (i.e. it has received a cookie it generated).

The last requirement is especially important in protecting against memory consumption attacks.

The recommended method for generating the cookies in Photuris is to use a keyed one way hash of both IP addresses, both UDP ports, some locally generated secret value (which must be same for all clients, and must be periodically changed), and some other context-dependent information (see [27] Section 3.3).

The properties of Photuris cookie exchange are described and analyzed by Oppliger in [38]. The idea of of gradually strengthening authentication are analyzed formally by Meadows in [35].

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3.4 Storing state in client

The cookie approach can be extended to include some state in the cookie. Any state that would be normally stored in the server is passed to the client. The client passes the state back to the server when sending the next message. The client doesn't have to interpret the state in any way, and can treat it simply as an arbitrary bit string. Encryption and message authentication codes can be used to prevent the client from tampering with the state.

This naturally doesn't work for protocols where the server might be required to take some action before the reception of next message, but is otherwise a quite general approach.

Stateless protocols have others advantages in addition to preventing memory consumption attacks. For example, in NFS recovering from server reboots is easy because no state is kept on the server (except for file locking, which complicates things). Stateless protocols also allows easier load balancing between servers.

The advantages of being stateless, at least in the beginning of a protocol run, were recognized in the security protocol context by Janson et al. [24]. The topic is further explored by Aura and Nikander in [2].

3.5 Re-ordering computations

In typical authenticated versions of the Diffie-Hellmann key agreement protocol, the server has to verify the client's signature in the first message. Since this requires expensive computation, the server can be potentially flooded with requests. In some cases, however, it is possible to modify the protocol so that client has to do some expensive computation first, and the server verifies the signature only after it has verified that the client has done so.

Thus, mounting an attack requires the client to invest the same amount of CPU resources as the server, and this hopefully will make DoS attacks at least somewhat harder. One such modification to the ISAKMP/IKE aggressive mode exchange is described in [32].

3.6 Pricing

Although cookies, stateless connections and re-ordering computations can give some protection against DoS attacks, in some cases more aggressive measures are required to allow service to legitimate users and deny it to attackers.

One such technique is "pricing". This means imposing some deliberate cost to the client, which is small for legitimate users making a small number of requests, but large for an attacker trying to flood the server.

Earliest use of this approach was a proposal by Dwork and Naor to combat junk e-mail [13, 14]. Before accepting an e-mail message, the recipient asks the sender to perform a small computation. The verification of the computation has to be quick, so this doesn't open possibilities for new DoS attacks. Another early use of this technique was against SYN flooding [25].

Usually this cost is in terms of processing time, since it is easy to implement, but other

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forms (such as paying with actual micropayment systems) are also possible. The computation can be just "junk computation" to prevent denial of service, or it can be "useful" computation for some other purpose [23]. This mechanism is generalized and analyzed by Aura, Leiwo, and Nikander in [3, 29] and formally described by Jakobsson in [23].

Interestingly, the idea of moderately hard computational problems has received other uses as well: e.g. uncheatable benchmarks [6], timed release of secrets [41, 17], partial key escrow [4], and auditable metering of web site use [16].

4 IPSEC architecture

IPSEC protocols provide security services at the IP layer in both IPv4 and IPv6 environments. At the lowest level of the IPSEC architecture are cryptographic algorithms for authentication and encryption, which are used by the Authentication Header (AH) and Encapsulating Security Payload (ESP) protocols.

The parameters required by AH and ESP, such as which algorithms are used and keys, are stored in Security Associations (SAs). Although the SAs can be specified manually, they are often negotiated using some key management protocol. The two most widely used protocols are ISAKMP/IKE and Photuris. Their main purpose is to create security associations with short-term keys from longer-term keys, refresh these keys when necessary, and negotiate other parameters required for the SAs.

The IPSEC architecture is described by Kent and Atkinson in [28].

5 ISAKMP/IKE

ISAKMP/IKE is actually a combination of two protocols, ISAKMP and IKE [33, 18]. ISAKMP provides a framework for authentication and key exchange. IKE, based on the Oakley protocol [39], specifies a key agreement protocol based on this framework.

The IKE negotiation has two phases. In the first phase, the parties negotiate an ISAKMP security association, which provides a secure communication channel between the ISAKMP daemons. In phase 2, this ISAKMP security association is used to negotiate an IPSEC security association for AH or ESP.

ISAKMP and IKE provide a large number of different modes and options, which can be considered to be different subprotocols. Meadows has identified a total of thirteen (!) different subprotocols [34]. This makes understanding, implementation, and analysis of ISAKMP/IKE very challenging.

5.1 Cookies in ISAKMP/IKE

ISAKMP uses cookies as a countermeasure against IP spoofing. The header of each packet contains two fields of 64 bits, the initiator and responder cookies. The initiator cookie is

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sent in the first message by the client, and the responder cookie is returned in the reply. All further messages contain both cookies.

The cookies are also used to identify a particular ISAKMP SA during phase 1 of the protocol. Since the cookie is also used to distinguish between different ISAKMP SAs, the protocol requires that the responder cookie is different for each initiator, and each protocol run. The method recommended by the ISAKMP specification is to use a one-way hash of IP addresses, UDP port numbers, locally generated secret value, and date and time.

Unfortunately, this requires a small amount of per-client state be stored on the server after the first message (at least the date and time). Simpson criticizes this harshly in [45].

5.2 Aggressive mode problem

ISAKMP contains two different modes which may be used in the phase 1 negotiation. These are called the "main mode" and "aggressive mode". The aggressive mode requires fewer messages than the main mode, but it doesn't usually provide protection of identities, and also has some other limitations.

The aggressive mode also has a known DoS vulnerability when using public key signatures for authentication [45, 31, 32]. The responder has to sign its response to the first message from the client. This expensive operation is done *before* the cookie has been verified, so it allows the possibility for DoS attack using spoofed IP addresses.

6 Photuris

The Photuris protocol is much simpler than ISAKMP/IKE, since it is not a combination of many layers of different subprotocols. The protocol has three phases: cookie exchange, value exchange, and identification exchange. After these phases, additional messages may be used to refresh the keys or modify other security parameters. [27, 26]

Like the ISAKMP header, the Photuris header also contains fields for initiator and responder cookies, each of 128 bits. In additional to the cookies, a "counter" field is included to distinguish between multiple parallel protocol runs. This removes the need to store any state on the responder after the first pair of messages.

Also, in Photuris the server never performs any expensive computations before receiving the second message (which must contain a valid cookie).

7 Protocol design principles

Based on the discussion in the previous sections, it should be clear that denial of service issues should considered in the design of new protocols. Without going to specific implementation issues, I feel that at least the following recommendations should be used as guidelines in the design.

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Recommendation 1: Protocol specifications should explicitly state what kind of DoS vulnerabilities exist, and not ignore denial of service as a mere implementation issue.

Recommendation 2: Protocols should verify the client's IP address before creating state or performing expensive computations. This is especially important for protocols which run over UDP, since they don't even have the weak protection offered by TCP sequence numbers.

Recommendation 3: Protocols should avoid creating state on the server at all if the state could be easily stored on the client instead [2].

Aura, Leiwo, and Nikander have written a couple of good papers about the design of DoS resistant protocols [29, 3]. Their earlier paper on stateless connections is also very relevant [2].

Simpson's harsh criticism of ISAKMP/IKE [45] presents some mistakes done in the design on ISAKMP/IKE which should prove helpful to the designers of future protocols. The design principles behind Photuris are described in the Photuris RFC [27] and [46].

The use of formal methods in protocol analysis has usually ignored denial of service. Some results are presented by Meadows in [35], and open issues in the field are discussed in [36].

This paper has addressed only the denial of service aspects in the design of protocols. Aura's dissertation [1] contains a good overview of other security-related aspects in protocol design. Other desirable properties of good Internet protocols, such as efficiency, extensibility, and simplicity are discussed in e.g. [40] and [42].

8 Conclusions

Often denial of service is considered to be an implementation issue by protocol designers. However, the resistance to DoS attacks can be improved by choices taken in the protocol design. In this paper I have presented an overview of resource consumption vulnerabilities, and countermeasures which could be used to defend systems.

Protocol design principles have been analyzed by several researchers, and Section 7 presents a short summary of their recommendations, with references to full publications. Although much of the work has focused on public key cryptographic protocols, many of the principles presented can be applied to other protocols as well.

There are many possibilities for further work. Modification of well known protocols to include better DoS protection, and experiments in the real world, could produce valuable information on the effectiveness of DoS protection mechanisms. Combining the techniques for pricing, tracing, and intrusion detection could also provide practical solutions for DoS protection.

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Exhibit 1026

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EDUCATION

Ph.D., University of Pittsburgh, Pittsburgh, Pennsylvania, 1985
M.P.S., University of Denver, Denver, Colorado, 2014
Post Graduate Studies, University of Texas – San Antonio, Texas, 1975-1976
M.L.S., University of North Texas, Denton, Texas, 1972
B.A., Rockford University, Rockford, Illinois, 1971

PROFESSIONAL EXPERIENCE

1981- **Consultant for higher education, non-profit organizations, and corporations.**

2002- **Adjunct Professor, School of Information, San José State University, San José, California.** Serve as part-time faculty member teaching graduate students in technical services (cataloging, bibliographic control, classification), "core courses," and special topics.

2014-2016 **Director, Grants and Resource Development, Colorado Community College System.** Provided leadership and vision to foster the continued growth of rigorous scholarship, innovative projects, and creative work for statewide system, 13 campuses, and 50 teaching sites serving 155,000 students. Responsible for leadership and ensured efficient functioning of contract and grants in compliance with state & federal requirements and successful implementation and management. Served as a subject matter expert and liaison for college Grant Directors for all issues relating to grants and subcontracts.

2010-2014 **Senior Grant Administrator, Morgridge College of Education, University of Denver (Colorado).** Provided leadership and vision to foster continued growth of rigorous scholarship, innovative research, and creative work in the Morgridge College of Education. Ensure that contract and grants processes function effectively and efficiently for 60 faculty and researchers with a focus on the successful progression and efficient management of grants totaling $13M. Worked effectively and collegially with Department Chairs and Program Coordinators on operational grant-related management activities and with a broad range of internal and external constituencies. Supported the dissemination and promotion of faculty research and scholarship to outside constituents at conferences and through publications. Assisted Principal Investigators and grant project teams by coaching, mentoring, and financial management.

2011-2013 **Interim Director & Assistant Dean, Westminster Law Library, Sturm College of Law, University of Denver.** Planned, organized, and directed all administrative activities for the library serving students, faculty, and alumni; oversaw the employment, retention, promotion, transfer and termination of library personnel; represented the library at professional conferences and public meetings; created and promoted a climate and culture of acceptance for new programs and services, a positive high-quality image of the law library, and that reflect the organization's values, encourage excellent performance, and reward high productivity and innovation; provided leadership and set strategic direction of the organization; ensured that the library provided excellent customer service through solution-oriented staff response to patron needs and by responsiveness and continuous improvement of the organization; promoted, developed, and maintained positive working relationships with colleagues and customers including key stakeholders and groups, higher education institutions, the legal community, other regional libraries and districts statewide, and national library organizations.

2007-2014 **Associate Professor, Library & Information Science, Morgridge College of Education, University of Denver (Colorado).** Served in leadership role and worked collaboratively in program, college, campus and community environments. Advised and supervised students, taught core and specialized courses at the graduate level in an integrative, student-centered learning environment. Served on LIS, College, and University committees, and maintained

working relationships with colleagues in other academic units and information professionals in the Rocky Mountain region and beyond. Served on and chair doctoral student dissertation committees. Oversaw and facilitated the College and LIS graduate student association.

2002-2007 **Assistant Professor, Library & Information Science, College of Education, University of Denver (Colorado).** Served as tenure-track faculty member teaching graduate students in "core courses," resource description and access, service learning, and independent studies. Advised graduate students, participate on LIS and College committees, and serve on doctoral student dissertation committees. Oversaw and facilitated the LIS graduate student association and alumni association.

2000-2002 **Affiliate Faculty, Library & Information Science, College of Education, University of Denver (Colorado).** Served as part-time faculty member teaching graduate students in technical services (cataloging, bibliographic control, classification), "core courses," and special topics. Oversaw and facilitated the LIS graduate student association and alumni association.

2000-2001 **Special Assistant to the Secretary's Regional Representative, U.S. Department of Education, Region VIII, Denver, Colorado.** Served as the principal advisor and representative of the U. S. Secretary of Education's Regional Representative (SRR). Ensured the implementation of major goals of the SRR and the Secretary. Provided leadership on behalf of the SRR in contacts with high-level officials in Region VIII requiring sensitive policy interpretation in communication with senior Department officials to solve problems and resolve issues raised by State and local education officials. Served as the primary contact for School-to-Work/Career, Children's Health Insurance Program, and Safe and Drug-Free Schools. Delivered technical assistance to local education agencies and institutions of higher education in technology, professional development, and school construction.

1999-2000 **Catalog Librarian, Jefferson County Public Library, Lakewood, Colorado.** Performed original, copy cataloging and classification of library materials (English and Spanish) using standard library protocols; completed original descriptive cataloging and subject analysis; enhanced brief catalog and authority records in III.

1997-1999 **Development Officer, McREL International, Aurora, Colorado.** Served as senior member of corporate management team in strategic planning, development of proposals and contracts, implementation, and evaluation of new services, products, and programs for educational agencies. Provided creative leadership to corporate committees to solicit ideas, identify goals and objectives, plan, develop, present, and evaluate professional development opportunities.

1995-1997 **Education Specialist, Education Service Center, Region One, Edinburg, Texas.** Served as member of Administrative Cabinet team in strategic planning, development of proposals and contracts, implementation, and evaluation of telecommunications capabilities, services, products, and programs for 40 school districts serving 283,000 students in 7 counties. Provided creative leadership to regional and state committees to solicit ideas, identify strategic goals and objectives, plan, develop, present, and evaluate funding opportunities and professional development for 400 librarians.

1993-1996 **Assistant Professor of Library Science, Sam Houston State University, Huntsville, Texas.** Served a faculty member teaching 400 graduate students in technical services (cataloging, bibliographic control, classification), automation, and networking. Participated in distance education program and coordinated annual conference. Conducted university and Texas Library Association-funded field research focused on library collection development and academic achievement.

1992-1993 **Head Librarian, Rocky Mountain College of Art & Design, Denver, Colorado.** Responsible for the daily operation, selection and acquisition of materials, formulation of policies for library operations, media center, and photography/slides archives. Designed and implemented library automation and delivery of electronic resources to college community.

1981-1985 **Development Officer, PRLC, Inc., Pittsburgh, Pennsylvania.** Served as senior member of corporate management team in strategic planning, development of proposals and contracts, implementation, and evaluation of new services, products, and programs for 100 institutional member organizations. Coordinated the development of proposals and contracts totaling $4,000,000 annually. Provided creative leadership to corporate committees to solicit ideas, identify goals and objectives, plan, develop, present, and evaluate professional development opportunities.

1981 **Director of Library Development, Pennsylvania Department of Education, Harrisburg, Pennsylvania.** Responsible for statewide development, technical assistance, professional development, resource sharing, children's services, institutional library services, networking, and state aid program for all libraries throughout the Commonwealth. Functioned as liaison to Governor's Advisory Council, LSCA Advisory Council, District Administrators, private colleges, universities, consortia managers, and network directors. Supervised $14,000,000 formula-based state aid program and $3,000,000 grant awards to individual libraries, consortia, and networks.

1978-1981 **Assistant Director, Southern Tier Library System, Corning, New York.** Coordinated operation of system-wide programs (technical assistance, professional development, resource sharing, technical services, outreach) to 40 public libraries in 5 counties serving 500,000 residents. Solicited ideas, identified goals, sponsored, and evaluated professional development opportunities and technical assistance sessions.

1976-1978 **Division Librarian for Technical Services, Corpus Christi Public Libraries, Corpus Christi, Texas.** Provided leadership in acquisitions, cataloging, serials control, and processing for main library and 4 branches serving 250,000 residents. Participated as senior member of library management team. Compiled and prepared technical evaluations, reports, and statistical analyses of Division operations to measure the achievement and cost of annual goals, objectives, and staff performance.

1975-1976 **System Coordinator, San Antonio Major Resource Center, San Antonio, Texas.** Served as senior member of the management team for District X Office, charged to provide technical assistance, resource sharing, media services, and professional development to librarians and staff representing 30 public library jurisdictions in 21 counties serving 1,500,000 residents. Functioned as liaison to System Director, staff, and members of governing bodies with the System Board of Directors and the Texas State Library and Historical Commission. Prepared LSCA grant applications and monitored awards totaling $1,100,000 annually.

1973-1975 **Bilingual Branch Librarian, San Antonio Public Library, San Antonio, Texas.** Worked as librarian providing reference, information, and readers' advisory services in branch serving 50,000 Spanish-speaking residents in southwest San Antonio. Participated in collection development and resource acquisition activities, specializing in children's work, Spanish language resources, and multicultural studies.

1972-1973 **Librarian, Holding Institute, Laredo, Texas.** Worked as high school librarian serving 500 boarding students in Spanish-speaking environment of private school. Provided reference, research assistance, and library instruction to students and 35 faculty members.

1966-1971 **Rockford Public Library, Rockford, Illinois.** Worked in branches as part-time as a Library Assistant, Clerk, and Page in city library serving 150,000 residents.

PUBLICATIONS

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Hall-Ellis, Sylvia D., and Mary Beth Weber. *Contemporary Cataloging in an RDA Environment: A Handbook for Students and Practitioners.* Chicago, IL: American Library Association. Under contract & In development.

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Hall-Ellis, Sylvia D. and Duan Zhang. *Project Homeless Connect 5 Event Evaluation.* Denver, Colo.: Center for Community Engagement and Service Learning, 2008.

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Hall-Ellis, Sylvia D. *Denver Public Library: Opportunities for Change.* Denver, Colo.: University of Denver, Colorado Community-Based Research Network & Metropolitan Organization of People, 2005.

Hall-Ellis, Sylvia D. *Resources in Grant Writing for Colorado Schools and Libraries.* Sponsored by the Colorado Department of Education, Educational Telecommunications Unit, 1999. Revised September 2000.

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Hall-Ellis, Sylvia D. *The Impact of Library Resource Centers on Academic Achievement in Selected Public Schools in Texas.* Huntsville, Tex.: Sam Houston State University, College of Education and Applied Science, 1997.

Hall-Ellis, Sylvia D. *Planning for Educational Technology: the Distance Education Implementation Phase: An Investigation of Technology and Telecommunication Needs for Region One Education Service Center, South Texas Community College, TCI Cablevision of South Texas, Inc., Tech Prep of the Rio Grande Valley, Inc., Texas State Technical College, Centro Cultural en el Valle de Texas, McAllen Independent School District, Harlingen Consolidated Independent School District, Donna Independent School District, Edinburg Consolidated Independent School District, La Joya Independent School District, Mercedes Independent School District, Pharr-San Juan-Alamo Independent School District, Sharyland Independent School District, Easter Seal Society of the Rio Grande Valley, Inc., and McAllen Memorial Library.* Harlingen, Tex.: Tech Prep of the Rio Grande Valley, 1996.

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Hall-Ellis, Sylvia D. *[et. al.] Planning for Educational Technology: A Study of Future Technology Needs for the Donna Independent School District, Region One Education Region Service Center, Tech Prep of the Rio Grande Valley, Inc. South Texas Community College, and the Department of Library Science, Sam Houston State University.* Research team: Sylvia D. Hall-Ellis, Ruth Ann Riggins, Noe Torres, Patricia G. Bubb, and Michael D. Bell. Harlingen, Tex.: Tech Prep of the Rio Grande Valley, 1994. Funded through a grant award from the Texas Education Agency.

Hall-Ellis, Sylvia D. and Mary Ann Berry. *The Impact of Library Resource Centers on Academic Achievement in Selected Public Schools in South Texas.* Huntsville, Tex.: Sam Houston State University, College of Education and Applied Science, 1993. Funded through a grant award from the Sam Houston State University Research Enhancement Fund.

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Hall-Ellis, Sylvia D. and Clarence L. Coffindaffer. *Partners in Progress: The 1992 Montana Library Federation Study Final Report*. Helena, Mont: Montana State Library and The Blue Bear Group, Inc., 1992.

Hall-Ellis, Sylvia D. and Clarence L. Coffindaffer. *Montana Federation Study Identification Paper*. Denver, Colo.: The Blue Bear Group, Inc., 1992.

Bruntjen, Scott and Sylvia D. Hall. *Recommendations on the Development of System-Wide Efforts of the Northern Waters Library Service.* Ashland, Wisc.: Northern Waters Library Service and The Blue Bear Group, Inc., 1989.

Hall, Sylvia D. *The Iowa Union List of Serials as A Part of The Iowa Locator: Planning Document*. Des Moines, Ia.: State Library of Iowa, 1988.

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Hall, Sylvia D. *Iowa Computer-Assisted Network (ICAN Users' Manual. IBM Compatible Edition: Version 5.0.* Des Moines, Ia.: State Library of Iowa, 1986.

Hall, Sylvia D. *Iowa Computer-Assisted Network (ICAN Users' Manual. Apple MacIntosh Edition: Version 5.0.* Des Moines, Ia.: State Library of Iowa, 1986.

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Bruntjen, Scott and Sylvia D. Hall. *The Iowa Locator: Final Report.* Central City, Colo.: The Blue Bear Group, Inc., 1986.

Bruntjen, Scott and Sylvia D. Hall. *Discovering Resource Sharing Treasures: Accessing Pennsylvania's High School Library Collections*. Harrisburg, Pa.: State Library of Pennsylvania, Bureau of School Library Media Resources, 1985.

Hall, Sylvia D. *Retrospective Conversion and the Completeness of Cataloging in Pennsylvania High School Libraries.* Pittsburgh, Pa.: PRLC, Inc., 1985.

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Other Publications

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Hall-Ellis, Sylvia D. "*Cataloger Competencies: Do the Employers Require What the Professors Teach?*" Presentation delivered to the ALCTS CCS Heads of Cataloging Discussion Group, 131st Annual Conference, American Library Association, New Orleans, Louisiana, June 26, 2006. http://dlist.sir.arizona.edu/

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Book Reviews

ALA Book of Library Grant Money. Ann Kepler, ed. 8th ed. Chicago, IL: American Library Association, 2011. 978-0-8389-1058-0, $175.00 [*Colorado Libraries,* June 2012]

Developing a Compensation Plan for Your Library. Paula M. Singer and Laura L. Francisco, comps. 2nd ed. Chicago, IL: American Library Association, 2009. 978-0-8389-0985-0, $57.00 [*Colorado Libraries,* March 2012]

Frugal Librarian. Carol Smallwood, ed. Chicago, IL: American Library Association, 2011. 978-0-83891-075-7, $42.00 [*Colorado Libraries,* February 2012]

Dowlin, Ken. *Getting the Money: How to Succeed in Fundraising for Public and Nonprofit Libraries.* Westport, Conn.: Libraries Unlimited, 2008. 978-1-59158-597-X, $50.00 [*Colorado Libraries,* February 2009]

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Keret, Etgar. Traducción de Ana María Bejarano. *Pizzería Kamikaze y Otras Relatos.* México, D.F.: Editorial Sexto Piso, 2008. 968-5679-29-0, no price given [*Críticas*, September 2008]

Littauer, Marita, and Florence Littauer. *Enriquece tu Comunicación. Miami, Fla.: Editorial Unilit, 2008.* 978-0-7899-1521-4, $11.99 [*Críticas*, August 2008]

Martínez, Guillermo. *La Muerte Lenta de Luciana B.* New York: Rayo Planeta, 2008. 978-0-06-156551-9, $14.95 [*Críticas*, May 2008]

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Gómez-Jurado, Juan. *A Masacre de Virginia Tech: Anatomía de una Mente Torturada.* Barcelona: Ediciones El Andén, 2007. 978-84-935789-4-7, €16.50 [*Críticas*, February, 2008]

Matthews, Joseph R. *Library Assessment in Higher Education.* Westport, Conn.: Libraries Unlimited, 2007. 978-1-59158-531-2, $45.00 [*Colorado Libraries,* February 2008]

Chacón, Inma. *La Princesa India: Cuando el Viento Azul.* México: Alfaguara, 2006. 970-770398-9, $19.95 [*Críticas*, June 2006]

Vargas Llosa, Mario. *Israel/Palestina: Paz o Guerra Santa.* fotogs. by Morgana Vargas Llosa. Spain/U.S.: Aguilar: Santillana, 2006. 84-03-09691-7, paper, $19.95 [*Críticas*, May 2006]

Findlay, Diane. *Digging into Dewey.* Fort Atkinson, Wisc.: Upstart Books, 2005. 978-1-932146-18-9, $16.95 [*Colorado Libraries,* May 2006]

Pequeñas Resistencias 4: Antología del Nuevo Cuento Norteamericano y Caribeño. Menéndez, Ronaldo, Ignacio Padilla & Enrique del Risco, eds. Madrid**:** Páginas de Espuma, 2005. 84-95642-59-X, paper, $36.95 [*Críticas*, April 2006]

Rueda, André. *Vengo a Salvar a España: Biografía de Un Franco Desconocido.* Madrid**:** Nowtilus (Investigación Abierta), 2005. photogs., bibliog. 84-9763-202-8, paper, $23.95 [*Críticas*, March 2006]

Becerra, Ángela. *El Penúltimo Sueño.* 1st ed. Barcelona: Planeta, 2005. 84-08-05795-2, $25.95. [*Críticas*, January 2006]

Aguilar Camín, Héctor. *La Conspiración de la Fortuna.* 1st ed. México: Planeta, 2005. 970-37-0368-2, $19.95 [*Críticas*, October 2005]

México en Sus Libros. Enrique Florescano with Pablo Mijangos, editors & compilers. 1st ed. México, D.F.: Taurus Aguilar, 2004. 968-19-0783-3, $16.95 [*Críticas*, September 2005]

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Abraham Lincoln. Colección Grandes Biografías. Madrid: Edimat Libros, 2003. 84-8403-858-0, €4.95 [*Críticas*, 2004]

Alponte, Juan María. *Colón: el Hombre, el Navegante, la Leyenda.* México, D.F.: Aguilar, 2003. 968-19-1260-8, $16.95 [*Críticas*, 2004]

Olcese Salvatecci, Alfieri. *Cómo Estudiar con Éxito: Téchnicas yHhábitos Para Aprender Major.* México, D.F.: Alfaomega Grupo Editor, 2002. 970-15-0764-9 [*Críticas*, 2003]

Mujeres Como Islas: Antología de Narradoras Cubanas, Dominicanas, Puertoriqueñas. Edición: Olga Marta Pérez, Thelma Jiménez, Andrés Blanco D., eds. Santo Domingo, República Dominicana: Ediciones Ferilibro, 2002. 959-209-419-5 [*Críticas*, 2003]

Tibol, Raquel. *Los Murales de Diego Rivera: Universidad Autónoma Chapingo.* México, D.F.: Editorial RM, Universidad Autónoma Chapingo, 2002. 968-5208-08-5 [*Críticas*, 2003]

Lindsay-Poland, John. *Emperors in the Jungle: the Hidden History of the U.S. in Panama.* Durham, N.C.: Duke University Press, 2003. 0-8223-3098-9, $18.95 [*Críticas*, 2003]

Kaplan, Allison G. and Ann Marlowe Riedling. *Catalog It! A Guide to Cataloging School Library Materials.* Worthington, Ohio: Linworth Pub., 2002. 1-58683-014-7, $44.95 [*Colorado Libraries,* 2002]

Bardach, Ann Louise. *Cuba Confidential: Love and Vengeance in Miami and Havana.* New York: Random, 2002. 0-375-50489-3, $25.95 [*Library Journal*, 2002]

Swan, James. *Fundraising for Libraries: 25 Proven Ways to Get More Money for Your Library.* New York: Neal Schuman, 2002. 1-55570-433-6, $69.95 [*Colorado Libraries,* 2002]

Puíg de Lange, Victoria. *Sol Con Agua.* Nashville, Tenn.: Editorial Vistazo/Ediciones Reio Negro, 2002. 0-9724506-0-2, $17.75 [*Críticas*, 2002]

The Encyclopedia of Latin American Politics. Edited by Diana Kapiszewski; assistant editor, Alexander Kazan. Westport, Conn.: Oryx Press, 2002. 1-57356-306-4, $74.95 [*Library Journal*, 2002]

Vargas Lizano, Isabel. *Y Si Quieres Saber de Mi Pasado.* Con la colaboración de J.C. Vales. Madrid: Santillana Ediciones Generales, S.L., 2002. 84-03-09278-4, $18.95 [*Críticas*, 2002]

Ruy Sánchez, Alberto. *Los Jardines Secretos de Mogador: Voces de Tierra.* México, D.F.: Alfaguara, S.A., 2001. 968-19-0879-1, $16.95 [*Críticas*, 2002]

Chávez, Ricardo and Celso Santajuliana. *El Final de las Nubes.* Barcelona: RBA Libros, S.A., 2001. 84-7901-760-0, $11.95 [*Críticas*, 2002]

The Power of Language / El Poder de la Palabra: Selected Papers from the Second REFORMA National Conference. Edited by Lillian Castillo-Speed and the REFORMA National Conference Publications Committee. Englewood, Colo.: Libraries Unlimited, 2001. 1-563089459, $35.00 [*Colorado Libraries,* 2001]

Martínez, Rubén. *Crossing Over: A Mexican Family on the Migrant Trail.* Metropolitan: Holt, 2001. 0-8050-4908-8, $26.00 [*Library Journal*, 2001]

Guevara, Ernesto "Che." *The African Dream: the Diaries of the Revolutionary War in the Congo.* Translated from the Spanish by Patrick Camiller. With an introduction by Richard Gott and a foreword by Aleida Guevara March. New York: Grove Press, 2001. 0-8021-3834-9, $13.00 [*Library Journal*, 2001]

Cooper, Gail and Garry Cooper. *New Virtual Field Trips.* Englewood, Colo.: Libraries Unlimited, 2001. 1-56308-887-8, $27.50 [*Colorado Libraries,* 2001]

NATIONAL SERVICE & PROFESSIONAL AFFILIATIONS

American Library Association
- Association for Library Collections & Technical Services
  - Cataloging, Classification, and Metadata Section
    - ALCTS Editorial Board, Member, 2015-2019
    - Committee on Cataloging: Description and Access, Member, 2008-2012
    - Test Site for RDA, Manager, 2009-2011
    - Nominating Committee, Member, 2007-2008
    - Committee for Education and Training of Catalogers, Chair, 2006-2007, Member, 2003-2007
    - Competencies & Education for a Career in Cataloging Interest Group, Chair, 2010-2012; Member, 2010-
  - President's Program Committee, 2015-2016
  - Education Committee, Member, 2005-2007
  - Task Force on Competencies and Education for a Career in Cataloging, Chair, 2007-2009
  - 2007 Annual Meeting Pre-conference, "What They Don't Teach in Library School: Competencies, Education and Employer Expectations for a Career in Cataloging," Steering Committee Chair
  - Fundraising Committee, Member, 2004-2006
- Office of Diversity
  - Committee on Diversity, Chair, 2010-2011
  - Diversity Research Advisory Committee, Member, 2009-2010
  - Spectrum Scholar Mentor, 2009
  - Diversity Grants Review Committee, Member, 2007, 2010, 2012
- Office of Statistics and Research
  - Research and Statistics Committee, Member, 2005-2007; Intern, 2003-2005
  - Library Research Round Table
    - Membership Committee, 2019-2021
    - Board of Directors, Member At-Large, 2009-2012
    - Member, 2003-
- Office of Accreditation
  - Accreditation Panel Member (training completed 2004)
  - Accreditation Review Panel Member (training completed 2004)

REFORMA
- National Board of Directors, 2005-2013
- National Fundraising Chair, 2005-2013
- National Recruiting and Mentoring Committee, 2008-2010
- Colorado Chapter, Secretary, 2004-2005
- Colorado Chapter Liaison to National Board of Directors, 2004-2013

Online Audiovisual Catalogers Association (OLAC)
American Association of Law Libraries (AALL)
Colorado Association of Law Librarians (CoALL)

American Association of University Women
Association for Library and Information Science Education (ALISE)
- University of Denver ALISE Representative, 2003-2008; 2010-2011
- Membership Advisory Committee, 2007-2010
- Technical Services Education Special Interest Group, 2003-
- Garfield Doctoral Dissertation Award Reviewer, 2012
- Garfield Doctoral Dissertation Scholarship Reviewer, 2014

American Association of University Professors (AAUP), 2006-

American Grant Writers Association, 2014-
Grant Professionals Institute, 2016-
National Grants Management Association, 2014-
Grant Reviewer (National and Regional Team Leader), U.S. Department of Education, 1998-
Grant Reviewer, Broadband Technologies Opportunity Program, U.S. Department of Commerce, 2009
Grant Reviewer, Institute of Museum and Library Services, 1998-2000
Grant Reviewer, Colorado Department of Education, 2014-
Grant Reviewer, Colorado State Library, 1998-
Grant Reviewer, American Association of Community Colleges *Working Connections* program, 1999
Peer Reviewer, *Journal for Library and Information Science Education,* 2005-
Peer Reviewer, *Journal of Library Metadata,* 2009
Peer Reviewer, *International Journal of Library and Information Science,* 2011
Regular Columnist, *The Bottom Line*, 2013-2016
Book Reviewer, *Library Journal*, 2001
Book Reviewer, *Criticas*, 2002-2009
Book Reviewer, *Colorado Libraries,* 2000-2012

REGIONAL SERVICE & PROFESSIONAL AFFILIATIONS

Mountain Plains Library Association
Professional Development Grants Committee, Member, 2005-2006
Professional Development Policy and Guidelines Sub-committee Chair, 2006

Colorado Association of Libraries
"Student Voices" Column Editor, *Colorado Libraries,* 2005-2006
Conference Planning Committee, Member, 2002
Technical Services and Automation Division, Chair, 2002-2003; Member, 2000-
Academic Libraries Division, Peer Review Conference Papers Committee, Member, 2007-2009
Education Committee, Member, 1988-1993
Diverse Populations Committee, Member, 2009-2013

SERVICE TO THE UNIVERSITY OF DENVER

Center for Teaching and Learning Faculty Advisory Board, 2007-2008; 2010-2012
Center for Community Engagement and Service Learning Advisory Board, 2007-2012
Faculty Senate
Executive Committee, 2008-2013
Nominations, Rules & Credentials Committee, Chair, 2008-2013; Member 2007-2013
Appointment, Promotion, and Tenure Revision Committee, 2010-2012
Grievance Policy Committee Member, 2007-2010
Law Library Director Search Committee Chair, 2012-2013
PROF Grant Review, College Representative to the University Review Team, 2006, 2008
Project Homeless Connect Evaluations, Principal Investigator, 2006-2009
University Technology Council, 2007-2009
University of Denver Hyde Interviews for Incoming Freshmen, 2003-2012

SERVICE TO THE MORGRIDGE COLLEGE OF EDUCATION

Appointment, Tenure & Review Committee
Member, voting, 2003-2005; 2007- 2009
Chair, Clinical Faculty Promotion & Tenure Policy Subcommittee, 2008-2009
Member, Community Engagement Subcommittee, 2007-2009
Member, Tenure Review Panel, 2003
Advancement and Alumni Relations Committee, Chair, 2003-2007; Member, 2002-2007
College Building Committee Member, 2004-2010
College of Education Student Association, Faculty Advisor, 2004-2007; 2009-2010
Faculty Senator, 2007-2013
Research and Scholarship Committee, Chair, 2008-2009; Member, 2002-2003, 2008-2009

Research and Grant Mentoring Committee, Chair, 2009-2010
Research Task Force Member, 2010-2012
Search Committee Member, Assistant Professor for Curriculum & Instruction, 2010-2011
Workload Task Force Member, 2010-2011

SERVICE TO THE LIBRARY & INFORMATION SCIENCE PROGRAM
Library and Information Science Student and Alumni Association, Faculty Advisor, 2002-2008
ALA Student Chapter, Faculty Advisor, 2005-2008
Beta Phi Mu Phi Chapter, Faculty Advisor, 2004-2014
Steering Committee Member, Accreditation by the American Library Association, 2001-2004
Search Committee Member, Associate Professor for LIS, 2006
Search Committee Chair, Assistant Professors for LIS, 2003, 2005, 2006, 2007
Search Committee Ex-Officio Member, Director for LIS, 2004

SERVICE TO SAM HOUSTON STATE UNIVERSITY
Rio Roundup: South Texas Literature Conference, Conference Coordinator, 1993
External Relations, Fund Raising, Grants Committee, Chair, 1993-1995
Advisory Council Committee, Chair, 1993-1995
Students, Admissions, and Advisement Committee, Chair, 1994
Institutional Effectiveness Committee, Member, 1993-1995

SERVICE TO THE COLLEGE OF EDUCATION AND APPLIED SCIENCE
Faculty Affairs Committee, Member, 1993-1995
Curriculum Committee, Member, 1993-1995
Continuing Education Committee, Member, 1993-1995

SERVICE TO THE COMMUNITY
French Teacher & Student Exchange with Laon, France, Monarch High School, Boulder Valley School District (Boulder, Colorado), 2017-
Denver/Boulder Games 2022, Board of Directors, Secretary-Treasurer, 2015-2018
United Way Campaign Committee, College of Education, 2006
Arapahoe County, Election Judge for the County Clerk and Recorder, 2000-2005
Arthritis Foundation, Rocky Mountain Chapter, Certified Educator & Trainer, 1999-2008
Bonfils Blood Center, Silver Level Donor, 2000-2016
Denver Museum of Natural History, Docent, 1992
Tech Prep of the Lower Rio Grande Valley, Inc. (Harlingen, Texas) Board of Directors, 1995-1997 Executive Committee, 1996-1997; Chair, Development Committee, 1995-1997; Chair, Fiscal Agency Committee, 1995-1996; Chair, Colleges and Universities Committee, 1996-1997
Gilpin County (Colorado) Public Library Board of Trustees, 1986-1989; Vice President, 1987-1989
City of Central (Colorado) Economic Development Committee, 1987-1989
Columbine Family Health Centers, Inc. (Nederland and Black Hawk, Colorado) Board of Directors, 1988-1989

CERTIFICATION
Permanent Public Librarian Certificate - Pennsylvania, New York, Texas
Westlaw Expert Witness, 2008-
Certified Grant Writer®, 2016-

AWARDS AND HONORS
Advanced Practitioner for Service Learning and Community Engagement, University of Denver, 2011
Platinum Star Alumnae, College of Information, Library Science & Technologies, University of North Texas, 2009
Commendation for Integration of Technologies in Teaching & Learning Environment, University of Denver, 2006
Outstanding Adjunct Faculty Member Award, College of Education, University of Denver, 2002
Beta Phi Mu, Pi, University of Pittsburgh, 1985
Alpha Lambda Sigma, University of North Texas, 1972

Albert Nelson Marquis Lifetime Achievement Award, Who's Who in America
Who's Who in American Women
Who's Who of Women Executives
Dictionary of International Biography
Who's Who in the East
Who's Who in the South and Southwest
Who's Who in the World
Who's Who of Online Professionals
Who's Who in Library and Information Science
2,000 Notable Women
Who's Who of Emerging Leaders
Who's Who in Professional and Executive Women
Who's Who in American Education
International Who's Who of Professional and Business Women
International Leaders in Achievement
International Educator of the Year
Who's Who in Finance and Industry
Who's Who in Finance and Business

Invited International and National Conference Presentations

Driscoll, Margaret, Christy Confetti Higgins, Scott Brown, and Sylvia D. Hall-Ellis. *A View from Within: Open House Tour of Three Canvas Core Courses.* Presentation to be delivered at the School of Information, San José State University Professional Development Seminar, San José, California, October 17, 2019.

Hall-Ellis, Sylvia D. *Invest in Me -- I'm Your Future: Succession Planning for Libraries.* Keynote presentation delivered at the ALCTS President's Symposium, Boston, Mass., January 8, 2016.

Seidel, Kent E. and Sylvia D. Hall-Ellis. *Making Grants Work for You: Strategies for Doctoral Students and Early Career Scholars.* Presentation delivered at the University Council for Educational Administration, Early Career Scholars Session, Indianapolis, Ind., November 9, 2013.

Hall-Ellis, Sylvia D. *So You Want to be a Manager; Leadership Skills and Competencies for Technical Services Managers and Administrators.* Presentation delivered at the 138th Annual Conference, American Library Association, Chicago, Ill., June 29, 2013.

Seidel, Kent E., Karen S. Riley, Lyndsay Agans, Susan Korach, and Sylvia D. Hall-Ellis. *Making Grants Work for You (Instead of Just Working for Grants).* A panel discussion delivered at the University Council for Educational Administration, Early Career Scholars Session, Denver, Colo., November 17, 2012.

Hall-Ellis, Sylvia D. *After the Great TS Reorganization: The Westminster Law Library.* Presentation delivered at the 137th Annual Conference, American Library Association, Anaheim, Calif., June 23, 2012.

Hall-Ellis, Sylvia D. *Conversations with Catalogers in the 21st Century.* A panel discussion sponsored by the ALCTS Competencies for a Career in Cataloging Interest Group, delivered at the 137th Annual Conference, American Library Association, Anaheim, Calif., June 22, 2012.

Hall-Ellis, Sylvia D., moderator. *Mid-Career Leaders Program.* A panel discussion sponsored by the ALA Committee on Diversity delivered at the 136th Annual Conference, American Library Association, New Orleans, La., June 26, 2011.

Hall-Ellis, Sylvia D., moderator. *Diversity Town Hall.* A community conversation sponsored by the ALA Committee on Diversity delivered at the 136th Annual Conference, American Library Association, New Orleans, La., June 24, 2011.

LaBarre, Kathryn, Sylvia D. Hall-Ellis, Karen Anderson, Rick Hasenyager, Christopher Cronin, and Penny Baker. *Briefings from RDA Test Participants.* A panel discussion delivered at the Midwinter Conference, American Library Association, San Diego, Calif., January 7, 2011.

Miksa, Shawne, Marjorie Bloss, and Sylvia D. Hall-Ellis. *Educating the Next Generation of Catalogers: Teaching RDA.* A panel discussion delivered at the 97th Annual Conference, Association for Library and Information Science Education, San Diego, Calif., January 7, 2011.

Hall-Ellis, Sylvia D., Robert Maxwell, John Hostage, and George Prager. *RDA Panel: What Cataloging Managers Need to Know.* Presentation delivered at the 103rd Annual Conference, American Association of Law Librarians, Denver, Colo., July 12, 2010.

Hall-Ellis, Sylvia D. and Stacey L. Bowers. *Catalogers in the RDA Environment: Skill Sets, Expectations and Challenges.* Presentation delivered at the 103rd Annual Conference, American Association of Law Librarians, Denver, Colo., July 11, 2010.

Hall-Ellis, Sylvia D. *Comfortable in Your Cataloging and Metadata Specialist Skin? Or, So You Want to Hire a Cataloger.* Presentation delivered to the ALCTS Research Group at the 134th Annual Conference, American Library Association, Chicago, Ill., July 11, 2009.

Perez, Megan, Sylvia D. Hall-Ellis, and Denise Anthony. *From Novice to Expert: Collaboration for Succession Planning.* A "hot topic" presentation delivered at the 14th ACRL Conference, Seattle, Wash., March 13, 2009.

Hall-Ellis, Sylvia D. *Cataloging in the RDA Environment: Skill Sets, Expectations and Challenges.* Presentation delivered to the ALCTS Research and Publications Committee at the Midwinter Conference, American Library Association, Denver, Colo., January 24, 2009.

Hall-Ellis, Sylvia D. *LIS Cataloging Education for the 21st Century: Expectations and Challenges.* A panel discussion held at the 95th Annual Conference, Association for Library and Information Science Education, Denver, Colo., January 23, 2009.

Chu, Clara, Sylvia D. Hall-Ellis, and Mark Winston. *The Doctoral Degree & Building a Career.* A panel discussion delivered at the ALA Office of Diversity Spectrum Doctoral Fellows E.J. Josey Leadership Institute, Midwinter Conference, American Library Association, Denver, Colo., January 20, 2009.

Hall-Ellis, Sylvia D. and Robert O. Ellett, Jr. *Fundamentals of Cataloging Course: An Overview of the ALCTS Online Course.* Presentation delivered to the ALCTS Big Heads Group, 133rd Annual Conference, American Library Association, Anaheim, Calif., June 30, 2008.

Hall-Ellis, Sylvia D. *Employers' Expectations for Technical Services Librarians: What We Don't Know.* Presentation delivered to the ALCTS Research and Publications Committee Program, 133rd Annual Conference, American Library Association, Anaheim, Calif., June 28, 2008.

Hall-Ellis, Sylvia D., Virginia R. Maloney, and Mary Stansbury. *Institutional Responses to Engaged Scholarship: The Carnegie Foundation Engaged University Classification at Two Universities.* Presentation delivered to the 94th Annual Conference, Association for Library and Information Science Education, Philadelphia, Pa., January 11, 2008.

Hall-Ellis, Sylvia D. *Puzzles, Problems, and Predicaments.* Presentation delivered to the ALCTS Research Discussion Group, 132nd Annual Conference, American Library Association, Washington, D.C., June 23, 2007.

Hall-Ellis, Sylvia D. *Cataloging Education: A New Emphasis for the Library and Information Science Curriculum.* Presentation delivered to the ALCTS Pre-conference, 132nd Annual Conference, American Library Association, Washington, D.C., June 22, 2007. http://www.loc.gov/catdir/cpso/careercat.html

Ellett, Jr., Robert O. and Sylvia D. Hall-Ellis. *Copy Cataloging Done Smarter.* Presentation delivered to the International Conference on Interdisciplinary Information Sciences and Technologies (InSciT2006), October 25-28, 2006.

Hall-Ellis, Sylvia D. and Robert O. Ellett, Jr. *Cooperative Cataloging: Challenges and Opportunities for Defense Libraries.* Presentation delivered to the 1st Annual Conference of Defense Libraries, Spanish Ministry of Defense, Madrid, Spain, July 7, 2006.

Hall-Ellis, Sylvia D. *Cataloger Competencies: Do the Employers Require What the Professors Teach?* Presentation delivered to the ALCTS CCS Heads of Cataloging Discussion Group, 131st Annual Conference, American Library Association, New Orleans, La., June 26, 2006.

Grealy, Deborah S. and Sylvia D. Hall-Ellis. *From Research to Practice: The Scholarship of Teaching and Learning in LIS Education.* Presentation delivered to the at the 92nd Annual Conference, Association for Library and Information Science Education, San Antonio, Tex., January 18, 2006.

Hall-Ellis, Sylvia D. *Employers' Expectations for Entry-Level Catalogers: What Position Announcement Data Indicate.* Research paper delivered to the Technical Services Special Interests Group, 91st Annual Conference, Association for Library and Information Science Education, Boston, Mass., January 12, 2005. http://dlist.sir.arizona.edu/

Hall-Ellis, Sylvia D. *Common Errors in MARC Records Prepared by LIS Students: What Does It Mean?* Research paper delivered to the ALCTS CCS Cataloging Norms Discussion Group, Mid-Winter Conference, 90th American Library Association, San Diego, Calif., January 10, 2004.

Hall-Ellis, Sylvia D. *Visual Arts as Foundation for Successful Library Automation: The Rocky Mountain College of Art & Design Experience.* Paper delivered at the 6th Annual Conference of Higher Education, Charleston, S. C., 1993.

Hall, Sylvia D. *Design Elements for Bibliographic Databases: An Overview.* Paper delivered at the 14th Online National Conference, New York, 1983.

Invited Regional Conference Presentations

Hall-Ellis, Sylvia D., Hudson, Christopher D., Brittany Cronin, and Kathryn Michaels. "The Colorado Law Project: Meeting the Public's Need for Legal Information." Panel discussion delivered at the Mountain Plains Library Association Conference, Billings, Mont., April 9, 2011.

Grealy, Deborah S. and Sylvia D. Hall-Ellis. *Education for Information Professionals in New Mexico: Library & Information Science Graduate Education at the University of Denver.* Presentation delivered at the New Mexico Library Education Summit, Las Vegas, N.M., September 26, 2005.

Hall-Ellis, Sylvia D. *Public Library-School Library Partnerships.* Presentation delivered at the 3rd Annual Colorado Association of Libraries Conference with the Mountain Plains Library Association, Denver, Colo., October 22, 2004.

Hall-Ellis, Sylvia D. *Learn All You Can – Educational Partnership Opportunities for the Lewis and Clark Bicentennial Commemoration.* Paper delivered at the 3rd Annual Lewis and Clark Bicentennial Council National Planning Conference, Bismarck, N.D., April 26, 1998.

Invited State Conference Presentations

Grealy, Deborah S. and Sylvia D. Hall-Ellis. *Academic Library Leadership Changes: Using Succession Planning and Mentoring*. Presentation delivered at the Minnesota Library Education Conference, St. Cloud, Minn., October 10, 2013.

Hall-Ellis, Sylvia D., Merrie Valliant, and Melissa Powell. *RDA: What Is It and What Do You Need To Do With It At Your Library?* Presentation delivered at the Colorado Library Consortium Spring Conference, Ft. Morgan, Colo., April 26, 2013.

Hall-Ellis, Sylvia D. *Service Learning and the Library & Information Science Graduate Education at the University of Denver.* Presentation delivered at the 4th LEADS Scholars Orientation, Denver, Colo., August 5, 2009.

Hall-Ellis, Sylvia D. *Service Learning: Enhancement to Library & Information Science Graduate Education at the University of Denver.* Presentation delivered at the 3rd LEADS Scholars Orientation, Denver, Colo., June 2008.

Hall-Ellis, Sylvia D. *Law Librarianship: A Community Conversation.* Sponsored by the Colorado Association of Law Libraries. Paper delivered at the Colorado Supreme Court Library, Denver, Colo., May 14, 2008.

Hall-Ellis, Sylvia D. *Opportunities and Challenges in Law Librarianship: A Community Conversation.* Presentation delivered at the Sturm College of Law, Denver, Colo., November 7, 2007.

Hall-Ellis, Sylvia D. *Grant Writing Resources for Nursing Professionals.* Presentation delivered at the Presbyterian / St. Luke's Health One Medical Center 1st Annual Research Symposium, Denver, Colo., October 17, 2007.

Hall-Ellis, Sylvia D. *Project Homeless Connect 4 Event Evaluation – Insights and Lessons Learned.* Presentation delivered at the Homelessness Research Symposium: What is DU Doing about Homelessness in Denver, Denver, Colo., September 14, 2007.

Hall-Ellis, Sylvia D. *Service Learning and the Library & Information Science Graduate Education at the University of Denver.* Presentation delivered at the 2nd LEADS Scholars Orientation, Denver, Colo., August 10, 2007.

Hall-Ellis, Sylvia D. *Education for Information Professionals in a Digital Environment: Library & Information Science Graduate Education at the University of Denver.* Presentation delivered at the 15th Spring Mountains and Plains Parapros Conference, Denver, Colo., February 24, 2007.

Hall-Ellis, Sylvia D. *Public Library Service to Spanish-Speaking and Latino Residents in Denver: A Case Study.* Presentation delivered at the 4th Annual Colorado Association of Libraries Conference, Denver, Colo., November 10, 2005.

Hall-Ellis, Sylvia D. *Education for Information Professionals in a Digital Environment: Library & Information Science Graduate Education at the University of Denver.* Presentation delivered at the 14th Annual Mountains and Plains Parapros Conference, Aurora, Colo., July 29, 2005.

Hall-Ellis, Sylvia D. *Educational Opportunities: Library & Information Science Graduate Education at the University of Denver.* Presentation delivered at the 13th Annual Mountains and Plains Parapros Conference, Centennial, Colo., August 6, 2004.

Hall-Ellis, Sylvia D. *Library Education & Training: Focus on the West: An LIS Faculty Member's Personal Response*. Presentation delivered at the 1st Annual Colorado Association of Libraries Conference, Keystone, Colo., October 18, 2002.

Hall-Ellis, Sylvia D. *Grant Writing for School Librarians.* Presentation delivered at the 2002 Annual Colorado Education Media Association Conference, Colorado Springs, Colo., February 15, 2002.

Hall-Ellis, Sylvia D. *Grants – Opportunities for the Future.* Paper delivered at the Southeast Regional Accountability Annual Conference, Lamar, Colo., November 12, 1998.

Hall-Ellis, Sylvia D. *The Texas Library Connection and Interlibrary Loan: An Experiment in Resource Sharing.* Paper delivered at the Texas Computer Educators' Association Annual Conference, Austin, Tex., February 6, 1997.

Hall-Ellis, Sylvia D. *Finding Grant Sources on the Internet: A Guide for Librarians.* Paper delivered at the 2nd Annual Institute for School Library Personnel, Pharr-San Juan-Alamo North High School, Pharr, Tex., July 29, 1996.

Hall-Ellis, Sylvia D. *Mathematical and Logical Thinking: A Critical Intelligence.* Paper delivered at the 3rd Annual Paraprofessional Conference at the University of Texas - Pan American, Edinburg, Tex., March 8, 1996.

Hall-Ellis, Sylvia D. *Cataloging Trends and Issues: Update Session.* Paper delivered at the 1st Annual Institute for School Library Personnel, South Texas Community College, McAllen, Tex., July 19, 1995.

Hall-Ellis, Sylvia D. *Grant Writing: Tips and Encouragement for School Librarians.* Paper delivered at the 1st Annual Institute for School Library Personnel, South Texas Community College, McAllen, Tex., July 18 and 19, 1995.

Hall-Ellis, Sylvia D. *How to Become an Expert Grant Writer.* Paper delivered at the 3rd Annual High School Principals' Academy, South Padre Island, Port Isabel, Tex., June 19, 1995.

Hall-Ellis, Sylvia D. *Texas Library Study: Results from Regions I and II.* Paper delivered at the 3rd Annual Technology Conference, Texas A&M University, College Station, Tex., November 18, 1994.

Hall-Ellis, Sylvia D. *Academic Achievement and Middle School Students.* Paper delivered at the 8th Annual Young Adult Conference, Sam Houston State University, Huntsville, Tex., November 5, 1994.

Hall-Ellis, Sylvia D. *Multimedia Resources for Library Leaders.* Paper delivered at the Institute for Librarians in A Multicultural Environment, Sam Houston State University, Huntsville, Tex., June 10, 1994.

Hall-Ellis, Sylvia D. *Finding the Resource: Empowering the User, or, the Case for Curriculum Based Subject Access to Learning Resource Center Collections.* Paper delivered at the 81st Annual Texas Library Association Conference, Corpus Christi, Tex., April 12-16, 1994.

Hall-Ellis, Sylvia D. and William H. Pichette. *Sam Houston State University Makes Use of OCLC/AMIGOS Collection Analysis CD.* Paper delivered at the 81st Annual Texas Library Association Conference, Corpus Christi, Tex., April 12-16, 1994.

Hall, Sylvia D. *Funding and Library Development in Pennsylvania: A Symbiotic Relationship.* Paper delivered at the Annual Graduate Student Colloquia, University of Pittsburgh, School of Library and Information Science, 1982.

Hall, Sylvia D. *Leadership for Public Library Trustees.* Paper delivered for the Trustees Division, Pennsylvania Library Association Annual Conference, Lancaster, Penn., 1981.

Seminar and Professional Development Presentations

Taylor, Meredith, and Sylvia D. Hall-Ellis. *Talent Management and Succession Planning.* ALCTS eForum, held March 22, 2017.

Hirsh, Sandra, Heather O'Brien, Michelle Holschuh Simmons, Michael Krasulski, and Sylvia D. Hall-Ellis. *Information Services Today: An Introduction. Part 3: Information Services: Roles in the Digital Age*. Rowan and Littlefield in partnership with Library Journal webinar, recorded February 5, 2015.

Hall-Ellis, Sylvia D. and Jennifer Sweda. *Copy Cataloging in an RDA Environment.* ALCTS eForum, held May 14 and 15, 2013.

Hall-Ellis, Sylvia D. *Law Librarianship: A Community Conversation.* Sponsored by the Colorado Association of Law Libraries, presented at the Colorado Supreme Court Library, Denver, Colo., May 14, 2008.

Hall-Ellis, Sylvia D. and Beatrice Z. Gerrish. *Reading and Libraries: Recent Research in Reading.* Presentation at the Ricks Center for Gifted Education, Denver, Colo., March 4, 2008.

Hall-Ellis, Sylvia D. *Cataloger Competencies: Do the Employers Require What the Professors Teach?* Presentation for the School of Library and Information Science, San José State University, February 12, 2008.

Hall-Ellis, Sylvia D. and Robert O. Ellett, Jr. *Cooperative Cataloging: Rules, Tools, and Conventions for Building a Multi-institutional Catalog.* Sponsored for the Spanish Ministry of Defense, Madrid, Spain, July 10, 2006.

Hall-Ellis, Sylvia D. *Cash for Kids: Grant Writing Opportunities for Youth Services Librarians.* Sponsored by the Colorado Young Adult Librarians; presented at Bemis Memorial Library, Littleton, Colo., November 13, 2002.

Hall-Ellis, Sylvia D. *MARC Records and Authority Control: Planning for Bibliographic Database Migration.* Sponsored and held at the Douglas County Public Library, Castle Rock, Colo., May 28, 2002.

Hall-Ellis, Sylvia D. *Grant Writing: A Refresher for Librarians.* Sponsored by Library and Information Science Program, College of Education, University of Denver; presented at University Center at Chaparral, August 12, 2000.

Hall-Ellis, Sylvia D. *Shaking the Money Tree – Basic Grant Writing for Colorado Educators.* Sponsored by the Office of Educational Telecommunications of the Colorado Department of Education.
Pikes Peak Community College, Colorado Springs, Colo., November 16, 1998.
Pueblo School District 60, Pueblo, Colo., November 12, 1998.
University of Northern Colorado, Greeley, Colo., November 10, 1998.
United Technology Educational Partnership, Grand Junction, Colo., November 9, 1998.

Hall-Ellis, Sylvia D. *Cataloging Multimedia, Kits, Globes and Map Materials in USMARC.* Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., April 24, 1997 and December 12, 1996.

Hall-Ellis, Sylvia D. *New Standards for School Library Media Centers.* Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., April 15, 1997.

Hall-Ellis, Sylvia D. *The School Library Media Specialist in the 21st Century: Visions for the Future.* Sponsored and hosted by Pharr-San Juan-Alamo Independent School District, Pharr, Tex., April 4, 1997.

Hall-Ellis, Sylvia D. *Cataloging Sound Recordings and Audio Materials in USMARC.* Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., March 20, 1997 and November 21, 1996.

Hall-Ellis, Sylvia D. *Evaluating and Selecting CD-ROMS for School Library Media Collections.* Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., March 18, 1997.

Hall-Ellis, Sylvia D. *Cataloging Audiovisual Materials in USMARC.* Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., February 27, 1997, November 7, 1996 and October 24, 1996.

Hall-Ellis, Sylvia D. *Introduction to Dialog: Basic Searching Strategies.* Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., February 14, 1997.

Hall-Ellis, Sylvia D. *Cataloging Books in USMARC.* Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., January 30, 1997, October 10, 1996, September 26, 1996 and August 8, 1996.

Hall-Ellis, Sylvia D. *Advanced Internet Searching Techniques for Librarians.* Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., January 21, 1997.

Hall-Ellis, Sylvia D. *Texas Library Connection Full-Text Searching.* Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., December 13, 1996 and October 25, 1996.

Hall-Ellis, Sylvia D. *Developing Evaluation Strategies for Grants and Proposals.* Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., December 10, 1996.

Hall-Ellis, Sylvia D. *Developing Needs Assessment for Grants and Proposals.* Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., November 12, 1996.

Hall-Ellis, Sylvia D. *Texas Library Connection Union Catalog Searching.* Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., November 8, 1996 and September 6, 1996.

Hall-Ellis, Sylvia D. *Grant Resources on the Internet.* Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., October 23, 1996.

Hall-Ellis, Sylvia D. *Preparing a Response to the Telecommunications Infrastructure Fund Board: Needs Assessment, Professional Development Framework, and Evaluation Strategies.* Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., October 16, 1996.

Hall-Ellis, Sylvia D. *Texas Library Connection: Building the Districtwide Bibliographic Database.* Sponsored and hosted by Mercedes Independent School District, Mercedes, Tex., September 13, 1996 and August 8, 1996. Sponsored and hosted by Los Fresnos Consolidated Independent School District, Los Fresnos, Tex., August 12, 1996.

Hall-Ellis, Sylvia D. *School-to-Work and Special Education: An Inclusive Partnership for Success.* Sponsored and hosted by the Office of Special Education, Region One Education Service Center, Edinburg, Tex., September 11, 1996.

Hall-Ellis, Sylvia D. *Telecommunications Infrastructure Fund Board: An Overview of Funding for Secondary Schools.* Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., August 31, 1996.

Hall-Ellis, Sylvia D. *Cataloging Books, Multimedia, and Realia in USMARC.* Sponsored and hosted by Edinburg Consolidated Independent School District, Edinburg, Tex., August 6, 1996.

Hall-Ellis, Sylvia D. *Internet Resources for Grant Writers.* Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., April 20, 1996.

Hall-Ellis, Sylvia D. *Enhanced Grant Writing Skills for Mathematics Educators: Writing Skills for Campus Teams.* Sponsored and hosted by the Office of General Education, Region One Education Service Center, Edinburg, Tex., March 22, 1996.

Hall-Ellis, Sylvia D. *Internet Resources for Grant Writers.* Sponsored and hosted by the College of Education and Applied Science, Sam Houston State University, Huntsville, Tex., March 9, 1996.

Hall-Ellis, Sylvia D. *Grant Writing for Mathematics Educators: A Development Process for Campus Teams.* Sponsored and hosted by the Office of General Education, Region One Education Service Center, Edinburg, Tex., March 4, 1996.

Hall-Ellis, Sylvia D. *Shaking the Money Tree: Preparing Successful Technology Grant Applications.* Sponsored and hosted by the Office of Technology and Media Services, Region One Education Service Center, Edinburg, Tex., February 29, 1996 and April 29, 1996.

Hall-Ellis, Sylvia D. *District-wide Technology Planning: Technical Assistance for the Texas Education Agency Initiative.* Sponsored and hosted by the Office of Technology and Media, Region One Education Service Center, Edinburg, Tex., February 2, 1996.

Hall-Ellis, Sylvia D. *Enhanced Grant Writing Skills.* Sponsored and hosted by Pharr-San Juan-Alamo Independent School District, Pharr, Tex., January 27, 1996.

Hall-Ellis, Sylvia D. *United States Copyright Act of 1976, Video Transmissions, Computer Software and the Internet.* Sponsored and hosted by the Office of Technology and Media, Region One Education Service Center, Edinburg, Tex., January 24, 1996.

Hall-Ellis, Sylvia D. *The Grant Writing Development Process.* Sponsored and hosted by Pharr-San Juan-Alamo Independent School District, Pharr, Tex., January 20, 1996.

Hall-Ellis, Sylvia D. *MARC Cataloging of Materials for Library Media Centers.* Sponsored and hosted by the Office of Media Services, Region One Education Service Center for the Donna Independent School District, Donna, Tex., August 17, 1995.

Hall-Ellis, Sylvia D. *Classification.* Sponsored by AJ Seminars, Rockville, Maryland; presented at University Hilton Hotel, Houston, Tex., May 10, 1995.

Hall-Ellis, Sylvia D. *Library Technical Services.* Sponsored by AJ Seminars, Rockville, Maryland; presented at University Hilton Hotel, Houston, Tex., April 26, 1995.

Hall-Ellis, Sylvia D. *Grant Writing: An Introduction for Public School Administrators.* Sponsored and hosted by the Office of Administrative Services, Region One Education Service Center, Edinburg, Tex., April 19, 1995.

Hall-Ellis, Sylvia D. *The School Library Media Specialist in the 21st Century: Visions for the Future.* Sponsored and hosted by the United Independent School District, Laredo, Tex., March 31, 1995.

Hall-Ellis, Sylvia D. *Using USMARC.* Sponsored by AJ Seminars, Rockville, Maryland; presented at University Hilton Hotel, Houston, Tex., March 29, 1995.

Hall-Ellis, Sylvia D. *Library Media Center Policies and Guidelines: How to Prepare for School Board Adoption.* Sponsored and hosted by the Office of Technology and Media Services, La Joya Independent School District, La Joya, Tex., March 10, 1995.

Hall-Ellis, Sylvia D. *Developing District-wide Policies and Guidelines for Library Media Centers.* Sponsored and hosted by the Office of Technology and Media Services, La Joya Independent School District, La Joya, Tex., January 10, 1995.

Hall-Ellis, Sylvia D. *MARC Cataloging of Audiovisual Materials for Library Media Centers.* Sponsored and hosted by the Office of Library Media and Technology Services, Cypress-Fairbanks Independent School District, Houston, Tex., December 1, 1994.

Hall-Ellis, Sylvia D. *The School Library Media Specialist in the 21st Century: Visions for the Future.* Sponsored and hosted by United Independent School District, Laredo, Tex., October 14, 1994.

Hall-Ellis, Sylvia D. *The School Library Media Specialist in the 21st Century: Visions for the Future.* Sponsored and hosted by the Laredo Independent School District, Laredo, Tex., October 7, 1994.

Hall-Ellis, Sylvia D. *MARC Cataloging for Library Media Centers.* Sponsored by the Office of Library Media and Technology Services, Cypress-Fairbanks Independent School District, Houston, Tex., October 5, 1994.

Hall-Ellis, Sylvia D. *Jump to the Head of the Class: Undergraduate Library Resources Available at Sam Houston State University.* Sponsored by the Office of the Associate Vice President for Student Services, Sam Houston State University, Huntsville, Tex., October 4, 1994.

Hall-Ellis, Sylvia D. *CD-ROMs - 1994's Newest and the Best for Secondary Level Media Centers.* Sponsored and hosted by Clear Lake Independent School District, Houston, Tex., June 3, 1994.

Hall-Ellis, Sylvia D. *Introduction to Classification.* Sponsored by AJ Seminars, Rockville, Maryland; presented at Holiday Inn, Market Center, Dallas, Tex., May 18, 1994.

Hall-Ellis, Sylvia D. *Basic Descriptive Cataloging.* Sponsored by AJ Seminars, Rockville, Maryland; presented at University Hilton Hotel, Houston, Tex., May 4, 1994.

Hall-Ellis, Sylvia D. *Shaking the Money Tree - Part II: Writing Successful Grant Applications.* Sponsored by Donna Independent School District, Donna, Texas, and Region One Education Service Center Edinburg, Texas; presented at South Texas Community College Library, McAllen, Tex., April 29, 1994.

Hall-Ellis, Sylvia D. *Using MARC.* Sponsored by AJ Seminars, Rockville, Maryland; presented at Holiday Inn, Market Center, Dallas, Tex., April 6, 1994.

Hall-Ellis, Sylvia D. *Automated Authority Control.* Sponsored by AJ Seminars, Rockville, Maryland; presented at University Hilton Hotel, Houston, Tex., March 23, 1994.

Hall-Ellis, Sylvia D. *Automating the District School Library Media Centers: Choices and Opportunities.* Sponsored and hosted by the Office of Technology and Library Media Services, Fort Bend Independent School District, Sugar Land, Tex., March 4, 1994.

Hall-Ellis, Sylvia D. *Shaking the Money Tree - Part I: Preparing Successful Grant Applications.* Sponsored and hosted by the Office of Library Media Services, Donna Independent School District, Donna, Tex., February 4, 1994.

GRADUATE COURSES TAUGHT

San José State University, School of Library and Information Science
INFO 249 – Advanced Cataloging and Classification (Fall 2015, 2016; Summer 2016)
INFO 287 – Special Topics in Cataloging and Classification (Spring 2017, 2018, 2019, 2020; Fall 2020)
LIBR 248 – Beginning Cataloging and Classification (Summer 2002, 2003, 2004, 2005, 2006)
LIBR 249 – Advanced Cataloging and Classification (Summer 2003; Fall 2014; Summer 2015)

University of Denver, University College
Grant Writing Certificate Seminar for Non-Profit Organizations (Fall 2020)

University of Denver, Morgridge College of Education
HED 5991 – Grant Writing in Higher Education (Spring 2011)
LIS 4010 – Organization of Information (Fall 2002, 2003, 2004, 2005, 2006, 2009; Winter 2005; Spring 2004, 2005, 2006)
LIS 4020 – Professional Principles and Ethics (Summer 2000)
LIS 4040 – Management of Libraries and Information Centers (Fall 2010; Spring 2003, 2009 (DS); Winter 2005)
LIS 4070 – Cataloging and Classification (Winter 2008, 2009, 2010, 2011, 2012; Fall 2009 (DS))
LIS 4321 – Collection Management (Spring 2005)
LIS 4326 – LIS Research (Winter 2009 (DS); Spring 2009 (DS))
LIS 4350 – Adult Materials and Services (Summer 2006, 2009)
LIS 4379 – Social Sciences Resources (Spring 2009)
LIS 4400 – Cataloging and Classification (Spring 2000, 2001; Winter 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009; Summer 2005, 2006 – course renumbered LIS 4070, September 2007)
LIS 4401 – Descriptive Cataloging (Winter 2001; Spring 2002, 2003, 2006, 2007, 2008, 2009; Summer 2005)
LIS 4402 – Subject Cataloging (Spring 2001, 2009; Summer 2005, 2006, 2007, 2008)
LIS 4403 – Classification Schemes (Fall 2007, 2008, 2009 (DS))
LIS 4405 – Authority Control (Winter 2009)
LIS 4510 – Materials and Services for Children (Winter 2004; Summer 2005)
LIS 4620 – Grant Writing and Fundraising (Summer 2000, 2002, 2004, 2010; Winter 2006; Fall 2006, 2007, 2008, 2009)
LIS 4700 – Seminar in Technical Services (Fall 2001)
LIS 4700 – Seminar in Public Libraries (Summer 2002)
LIS 4804 – Management of Electronic Records (Spring 2004; Fall 2005)
LIS 4902 – Capstone Projects (Winter 2003, Spring 2008, 2009, 2011)
LIS 4910 – Independent Study (every quarter Winter 2000 through Spring 2011)
LIS 4920 – Service Learning (every quarter Summer 2004 through Spring 2011)
RMS 4954 – Grant Writing (Summer 2013, 2014)
RMS 4959 – Content Analysis Methodology (Spring 2015)
QRM 4978 – Grant Writing (Summer 2011, 2012)

Rutgers University, School of Communication and Information
SC&I 522 – Cataloging and Classification (Summer 2013)

University of Arizona, College of Behavioral and Social Sciences
LIS 602 – Cataloging and Classification (Summer 1995)
LIS 612 – Advanced Online Search and Retrieval (Summer 1995)

Sam Houston State University, College of Education & Applied Science
LIS 532 - Cataloging and Classification (Fall 1993, 1994, 1995)
LIS 563 - Advanced Cataloging and Classification (Summer 1994)
LIS 567 - Research Methods (Spring 1994, Spring 1995)
LIS 591 - Educational Technology (Spring 1994, 1995)
LIS 596 - Networking and Computer Technologies in Education (Fall 1993, Summer 1994, Fall 1995)

Dissertations at the University of Denver

Bowers, Stacey L. *Library Anxiety of Law School Students: A Study Utilizing the Multidimensional Library Anxiety Scale.* Chair, May 5, 2010.

Fattor, Melissa M. *Student Engagement Differences by Ethnicity and Scale for Ninth Grade Students.* Chair, November 1, 2010.

Fulton, Roseanne. *A Case Study of Culturally Responsive Teaching in Middle School Mathematics.* Kent Seidel, Chair, June 18, 2009, Outside Chair.

Grealy, Deborah S. *Tribes and Territories in Library and Information Studies Education.* Bruce Uhrmacher, Chair, June 10, 2008, Committee Member.

McCord, J. Michael. *Developing a Standard of Care for Educational Malpractice.* Chair, April 15, 2011.

Priebe, Sarah J. *Distinguishing Effects of Domain and General Knowledge on Passage Fluency and Comprehension.* Jan Keenan, Chair. July 21, 2011, Outside Chair.

Snyder-Mondragon, Sandra M. *Institutional Factors that Impact the Retention of Graduate Students of Color in Schools of Library and Information Science: A Metaregression of Accredited Library School Statistics on Student Retention and Graduation Rates.* Kathy Green, Chair, July 24, 2009, Committee Member.

Taylor, Karen Pickles. *Effective Teaching.* Elinor Katz, Chair, July 15, 2009, Outside Chair.

Thompson, Jennifer. *Distinguishing a Western Women's College: A History of the Curriculum and Student Experience at Colorado Women's College.* Edith W. King, Chair, July 16, 2010, Committee Member.

Walker, Emelda. *Influence of Organizational Factors on Job Satisfaction of Disability Service Providers at Postsecondary Institutions.* Chair, April 29, 2010.

Dissertation Proposals at the University of Denver

Bowers, Stacey L. *Library Anxiety of Law School Students: A Study Utilizing the Multidimensional Library Anxiety Scale.* Chair, November 5, 2009.

McCord, J. Michael. *Developing a Standard of Care for Educational Malpractice.* Edith W. King, Chair. April 23, 2010.

Thompson, Jennifer. *History of Colorado Women's College.* Edith W. King, Chair, October 30, 2008. Committee Member.

Walker, Emelda. *Influence of Organizational Factors on Job Satisfaction of Disability Service Providers at Postsecondary Institutions.* Chair, July 21, 2009.

Dissertations at Other Institutions

Rodríguez-Mori, Howard. *The Information Behavior of Puerto Rican Immigrants to Central Florida, 2003-2009: Grounded Analysis of Six Case Studies Use of Social Networks during the Migration Process.* Kathleen Burnett, Chair, April 10, 2009, Florida State University, Committee Member.

Schwartz, Brian *More than a Look-up Skill: Medical Information Literacy Education in Osteopathic Medical Schools.* D. Mirah Dow, Chair, July 18, 2017. Emporia State University, Committee Member.

Snow, Karen. *A Study of the Perception of Cataloging Quality among Catalogers.* Shawne D. Miksa, Chair, August 1, 2011. University of North Texas, Committee Member.

Dissertation Proposals at Other Institutions

Schwartz, Brian *More than a Look-up Skill: Medical Information Literacy Education in Osteopathic Medical Schools.* D. Mirah Dow, Chair, December 4, 2015. Emporia State University, Committee Member.

Snow, Karen. *A Study of the Perception of Cataloging Quality among Catalogers.* Shawne D. Miksa, Chair, May 11, 2010. University of North Texas, Committee Member.

Master's Thesis at the University of Denver

Hemingson, Jeff. *Recital Paper.* Lamont School of Music, February 2010, Outside Chair.

Capstones at the University of Denver

Anthony, Alisa. *Correlation of Library and Information Science Program outcomes and Vacant Position Qualifications Listed on the Colorado State Library Jobline by Employers During the Period September 1, 2000 through August 31, 2002.* Chair, Winter Quarter, 2003.

Borden, Donna M. *Improving Emergency Communications Systems: Is a Radio Communications Network the Answer?* Fall Quarter, 2014.

Bowden, Heather L.M. *Exploring Biological Models for Long-term Data Preservation.* Chair, Spring Quarter, 2008.

Casenada, Cassandra Y. *Challenges to the Recruitment, Education, and Retention of Librarians of Color*. Chair, Spring Quarter, 2008.

Chang, Jennifer C. *Legal Research Practice and Preference: A Law Firm Perspective.* Chair, Spring Quarter 2011.

Ellis, Megan S. Fitzgerald. *Design of a Public Library Adult Volunteer Recruitment Program and Training Curriculum.* Chair, Winter Quarter, 2003.

Kircher, Kathy. *Development of a Library Pathfinder for Exobiology and Posting it on the Internet.* Chair, Winter Quarter, 2003.

Melhado, Loretta. *Design of St. John's Episcopal Church Library.* Chair, Spring Quarter, 2008.

Radcliff, Kathy. *Original Cataloging of Archival materials in the HERS Collection in Penrose Library.* Chair, Winter Quarter, 2003.

Sass, Carol Ann. *ACT Periodical Index: Access to Catholic Thinking Periodical Index: Web Index to Select Catholic Periodicals.* Spring Quarter 2000.

Stone, Sergio D. *Conducting Community Analysis for the Bemis Public Library (Littleton, Colorado) Using 2002 U.S. Census Data and the Online Outcome-Based Evaluation Toolkit.* Chair, Winter Quarter, 2003.

Tureson, Tamara. *Design and Use of an Information Audit Tool for Use in a Law Library.* Chair, Winter Quarter, 2003.

Tweed, Beth. *Evaluation of Email Reference Service in a Consumer Health Library Environment.* Chair, Winter Quarter, 2003.

GRANTS AND CONTRACTS

Student Learning in Agriculture STEM through Teacher Professional Development. Research team: Stanton Gartin (PI) and Cyndi Hofmeister, Northeast Junior College; Jeff Cash, Cheryl Sánchez, Anne-Marie Crampton, Lamar Community College; Suzanna Spears, Morgan Community College; Jack Wiley, Kerry Gabrielson, Trinidad State Junior College; Michael J. Miller, Colorado State University; Michael Womochil (Co-PI), Casey Sacks, and Sylvia D. Hall-Ellis, Colorado Community College System. U.S. Department of Agriculture, Agriculture and Food Research Initiative, Food, Agriculture, Natural Resources and Human Sciences Education and Literacy Initiative, $404,460 (2017-2020)

Leading and Achieving: the Colorado Agriculture Regional Consortium. Research team: Jack Wiley (PI), Kerry Gabrielson, Trinidad State Junior College; Jeff Cash (PI), Cheryl Sánchez, Anne-Marie Crampton, Lamar Community College; Suzanna Spears, Morgan Community College; Cyndi Hofmeister, Northeast Junior College; Michael Womochil (Co-PI), Casey Sacks, and Sylvia D. Hall-Ellis, Colorado Community College System. U.S. Department of Agriculture, Hispanic Serving Institutions Education Grants Program, $504,414 (2017-2020)

Cyber Prep Program Planning Grant. Research team: Debbie Sagen (PI), Brenda Lauer, Pikes Peak Community College; Gretchen Martin, Koiosa Insights; and, Sylvia D. Hall-Ellis, Colorado Community College System. U.S. Department of Commerce, Regional Alliances and Multi-stakeholder Partnerships to Stimulate (RAMPS) Cybersecurity Education and Workforce Development, $199,681 (2016-2018)

Career and Technical Education in Colorado: Pathways to Education and Employment. Research team: Heather McKay (PI), Rutgers University; Sarah Heath, Casey Sacks, Sylvia D. Hall-Ellis, Colorado Community College System. U.S. Department of Education, Institute of Education Sciences, $1,400,000 (2017-2021)

Pre-Alliance Planning Grant Colorado Community College Alliance. Research team: Victor Vialpondo (PI) and Janel Highfill, Community College of Aurora; Heidi Loshbaugh (Co-PI), Community College of Denver; Rick Reeves, Bill McGreevy, Liz Cox, and Kristin Aslin, Red Rocks Community College; Cathy Pellish, Front Range Community College; Samuel DeVries, Arapahoe Community College; Sylvia D. Hall-Ellis, Colorado Community College System. National Science Foundation, Louis Stokes Alliance for Minority Participation (LSAMP), $86,817 (2016-2017)

Towards Scalable Differentiated Instruction Using Technology-enabled, Competency-based, Dynamic Scaffolding. Research team: Karen Wilcox (PI) and Vijay Kumar, Center for Computational Engineering, Massachusetts Institute of Technology; Flora McMartin, Broad-based Knowledge; Quinsigamond Community College; and, Casey Sacks, and Sylvia D. Hall-Ellis, Colorado Community College System. U.S. Department of Education, First in the World Developmental Grant, $2,891,882 (2015-2019)

Colorado Strategic Partnerships Emergency Grant. Research team: Elise Lowe-Vaughn (PI), Amy Hodson, Celia Hardin, Barbara McBride, James Newby, Christopher Dewhurst, Nina Holland, Kate Anderson, MaryAnn Roe, Chrystalynn Chrystalynn, Elaine Edon, Mona Barnes, Tom Morgan, Rob Hanni, and Marie Valenzuela, Colorado Department of Labor and Employment; Steve Anton, Joelle Brouner, and, Katie Griego, Colorado Department of Human Services; Rebecca Holmes, Judith Martinez, and Jennifer Jirous, Colorado Department of Education; Emily Templin Lesh, Colorado Workforce Development Council; Cory Everett, Colorado Department of Regulatory Agencies; and, Casey Sacks and Sylvia D. Hall-Ellis, Colorado Community College System. U.S. Department of Labor, Strategic Partnerships Emergency Grant, $5,000,000 (2015-2017)

CAEL Jump Start Program: Competency-Based Education. Research team: Jerry Migler (PI), Casey Sacks, Debra Cohn, Thomas Hartman, and Sylvia D. Hall-Ellis, Colorado Community College System; Matt Jamison, Front Range Community College; Mike Coste, Red Rocks Community College; Amanda Corum, Pueblo Community College; Janet Colvin, Pikes Peak Community College; and, MaryAnn Matheny, Community College of Denver. Council for Adult and Experiential Learning, $15,000 (2015)

Summit on the Redesign of Developmental Education. Research team: Jerry Migler (PI), Casey Sacks, and Sylvia D. Hall-Ellis, Colorado Community College System; Chip Nava, Pueblo Community College; Kim Moultney,

Arapahoe Community College; Debbie Ulibarri, Trinidad State Junior College; and, Kris Bernard, Front Range Community College. American Association of Community Colleges, $15,000 (2015-2016)

Equity in Excellence at Colorado Community Colleges. Research team: Keith Howard (PI) and Sylvia D. Hall-Ellis, Colorado Community College System; Estela Mata Bensimon, Center for Urban Education, University of Southern California; and Kerry Gabrielson, Trinidad State Junior College. Colorado Department of Higher Education, Colorado Opportunity Scholarship Program, $150,000 (2015-2016)

MBA High School of Business in Colorado. Research team: Laurie Urich (PI) and Sylvia D. Hall-Ellis, Colorado Community College System; Rudolph Sumpter and Beatrice Gerrish, Boulder Valley Schools; Keith Curry Lance, RSL Research Group. Colorado Department of Higher Education, Colorado Opportunity Scholarship Program, $501,295 (2015-2016)

Fullbridge Program in Colorado. Research team: Keith Howard (PI) and Sylvia D. Hall-Ellis, Colorado Community College System; Suzanna Spears, Fort Morgan Community College; and, Cheryl Sánchez and Anne-Marie Compton, Lamar Community College. Colorado Department of Higher Education, Colorado Opportunity Scholarship Program, $300,000 (2015-2017)

Colorado Community College System Alternative Credit Program. Research team: Jerry Migler (PI), Keith Howard, and Sylvia D. Hall-Ellis, Colorado Community College System. American Council on Education, $13,000 (2015)

Internationalization in Higher Education. Researcher: Samuel D. Museus. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Office of Internationalization, $8,000 (2014-2015)

International Perspectives on Bilingual Education. Researcher: Sharolyn Pollard-Durodola. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Office of Internationalization, $3,700 (2014-2015)

Cultivating Culturally Relevant and Responsive Curriculum and Pedagogy in College. Researcher: Samuel Museus. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, iRise Grant, $5,000 (2014-2015)

Project EMERGE (Educational Model for Evaluation and Replicability in Gifted Environments). Research team: Norma Hafenstein (PI) and Bruce Uhrmacher. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Lynde and Harry Bradley Foundation, $235,000 (2014-2015)

Collecting Asian American Refugee Stories. Researcher: Samuel Museus. Technical reviewer for MCE: Sylvia D. Hall-Ellis. American Educational Research Association, Research Grant, $5,000 (2014-2015)

Developing Expertise in Teaching K-5 Mathematics. Research team: Julie Sarama (PI) and Douglas H. Clements (Co-PI), in partnership with the School of Education at the University of Michigan. Technical reviewer for MCE: Sylvia D. Hall-Ellis. National Science Foundation, $130,344 (2013-2015)

Investigation of the Long-Term Outcomes for Special Education Students. Researcher: Antonio Olmos-Gallos. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Jefferson County School District, Office of Assessment, $40,000 (2014)

Refugee Community Collaboration. Researcher: Vicki Tomlin (PI) in partnership with the African Community Center and Jewish Family Service. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Center for Community Engagement and Service Learning, $14,854 (2014-2015)

Access to Mathematics for All. Research team: Richard S. Kitchen (PI), Nicole M. Russell (Co-PI), and Terrence Blackman (Co-PI), Curriculum Studies and Teaching Program, Morgridge College of Education; Álvaro Árias (Co-PI, Department of Mathematics); and, James Gray (Co-PI), Department of Mathematics, Community

College of Aurora. Technical reviewer for MCE: Sylvia D. Hall-Ellis. National Science Foundation, The Robert Noyce Scholarship Program, Capacity Building Project, $349,926 (2014-2016)

Cognitive Test Battery for Intellectual Disabilities. Research team: Karen Riley (PI), Lyndsay Agans, Jessica Lerner, and Karin Dittrick-Nathan in partnership with David Hessl (PI), The MIND Institute at the University of California – Davis, and Elizabeth Berry-Kravis, Rush University Medical Center. Technical reviewer for MCE: Sylvia D. Hall-Ellis. National Institutes of Health, Outcome Measures for Use in Treatment Trials for Individuals with Intellectual and Developmental Disabilities (R01), $2,499,996 ($588,672 at DU) (2014-2019)

Broadening Participation in Engineering among Women and Latino/as: A Longitudinal, Multi-Site Study. Researcher: Patton Garriott (PI) in partnership with the University of North Dakota and the University of Missouri. Technical reviewer for MCE: Sylvia D. Hall-Ellis. National Science Foundation, HER Core Research, $677,390 ($69,992 at DU) (2014-2019)

Designing a Teacher Evaluation System to Improve Teacher Effectiveness for Culturally and Linguistically Diverse Learners. Research team: María del Carmen Sálazar (PI), Jessica Lerner, and Kathy Green. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Professional Research Opportunities for Faculty, $29,988 (2014-2016)

Developing a College-Going Culture in Latina/O Families: Exploring the Influence of Funds of Knowledge on Family Outreach Programs. Researcher: Judy Marquez Kiyama. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Professional Research Opportunities for Faculty, $18,720 (2014-2016)

Assessment of Quality of Life in Neutral Implantation Surgery for the Treatment of Parkinson's Disease. Researcher: Cynthia McRae. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Office of Internationalization, $3,967 (2014-2015)

Pura Vida: Cloud Forest, Curriculum and Cross-Cultural Study. Research team: Norma Hafenstein (PI) and Bruce Uhrmacher (Co-PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Office of Internationalization, $8,000 (2014-2015)

Online Course Development for Curriculum and Instruction. Researcher: Ruth Chao. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Office of Teaching and Learning, $3,000 (2014)

Online Course Development for Curriculum and Instruction. Researcher: María del Carmen Sálazar. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Office of Teaching and Learning, $3,000 (2014)

Online Course Development for Curriculum and Instruction. Researcher: Jessica Lerner. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Office of Teaching and Learning, $3,000 (2014)

Online Course Development for Curriculum and Instruction. Researcher: Duan Zhang. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Office of Teaching and Learning, $3,000 (2014)

The Mathematics Education of African Americans, 1866 – 1954. Researcher: Nicole M. Russell. Technical reviewer for MCE: Sylvia D. Hall-Ellis. National Academy of Education, Spencer Foundation Postdoctoral Fellowship, $55,000 (2014-2016)

Early Childhood Care and Education Study. Research team: Carrie Germeroth (PI), Melissa Mincic, and Douglas H. Clements. Technical reviewer for MCE: Sylvia D. Hall-Ellis. State of North Dakota, Department of Public Instruction, $73,500 (2013-2014)

Graduate Level Specialty in Addiction Counselor Training with Emphasis on Integration of Native American Specific Content. Research team: Ruth Chao (PI) and Michael J. Faragher (Co-PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. The Galena Foundation, $289,732 (2013-2016)

The Collecting Asian American and Pacific Islander Refugee Stories (CARS) Project. Researcher: Samuel Museus. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Center for Community Engagement and Service Learning, $15,000 (2014)

Parents in Transition: A Multiple Case Study of Parent and Family Orientation Programs. Researcher: Judy Marquéz Kiyama. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Faculty Research Fund, $1,500 (2014-2015)

The Sistah Network: Black Women Graduate Students Supporting and Retaining Each Other. Researcher; Nicole M. Russell. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Faculty Research Fund, $2,708 (2014-2015)

Evaluation of the Northeast Denver Babies Ready for College Program. Research team: Carrie Germeroth (PI), Melissa Mincic, and Douglas H. Clements. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Mile High Montessori, $9,922 (2013-2014)

Developing Teaching Expertise in K-5 Mathematics. Research team: Julie Sarama (PI) and Douglas Clements (University of Denver), in partnership with Timothy Boerst (PI), Meghan Shaughnessy, Deborah Ball, Hyman Bass (School of Education at the University of Michigan). Technical reviewer for MCE: Sylvia D. Hall-Ellis. National Science Foundation, $449,827 ($130,344 at the University of Denver (2013-2015)

Early Learning Care and Education Study Program Grant for the State of North Dakota. Research team: Carrie Germeroth (PI), Melissa Mincic, and Sheridan Green. Technical reviewer for MCE: Sylvia D. Hall-Ellis. State of North Dakota Department of Public Instruction, $73,500 (2013-2014)

Local Professional Learning Community for School Leaders. Research team: Susan Korach (PI), Kristina Hesbol, and Rebecca McClure. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Education Development Center, $10,950 (2013)

Healthy Eaters, Lifelong Movers 2: Implementing Evidence-Based School Environment, Policy, and Curricular Changes to Increase Opportunities for Healthy Eating and Physical Activity in Low Income, Rural Colorado. Research team: Elaine Berlansky, University of Colorado at Denver (PI), Nicholas Cutforth, University of Denver (Co-PI), and Allison Reeds. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Colorado Health Foundation, $3,103,108 (2013-2017)

Hughes Rare Books Library Room Renovation in the Sturm College of Law. Project team: Patti H. Marks, Sylvia D. Hall-Ellis, and Leigh Elliott. Mabel T. Hughes Charitable Trust, $34,000 (2013-2014)

The Promise Center Partnership with the Marsico Institute for Early Learning and Literacy and the City and County of Denver. Research team: Karen Riley (PI), Douglas H. Clements (Co-PI), and Sheridan Green. Technical reviewer for MCE: Sylvia D. Hall-Ellis. The Piton Foundation, $223,468 (2013-2014)

Center of Excellence for Problem Gambling. Research team: Ruth Chao (PI) and J. Mike Faragher. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Colorado Department of Behavioral Health, $68,021 (2012-2013)

United Way Implementation and Validation Review. Research team: Douglas H. Clements (PI), Amanda Moreno, and Sheridan Green. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Mile High United Way, $19,737 (2013)

Math/Science Partnership in Rural Districts. Research team: Kristen Bunn (PI, Eagle County Schools), Paul Michalec (Co-PI), and Alegra Reiber. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Colorado Department of Education, Colorado's Mathematics and Science Partnership Program, $750,000 (2013-2014)

Mathematics and Science Education of African Americans. Research team: Nicole Russell (PI), Sylvia D. Hall-Ellis, Steve Fisher (Penrose Library). Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Professional Research Opportunities for Faculty, $29,994 (2013-2015)

Online Course Development for Curriculum and Instruction. Researcher: Nicole Russell. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Office of Teaching and Learning, $3,000 (2013)

Discourse and Opportunity: Undocumented Students and Higher Education Policy. Researcher: Ryan Gildersleeve. Technical reviewer for MCE: Sylvia D. Hall-Ellis. National Academy of Education, Spencer Foundation Postdoctoral Fellowship, $55,000 (2012-2014)

An Anthropological Study of the Latino Graduation Ceremony. Researcher: Ryan Gildersleeve. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Spencer Foundation, $39,900 (2012-2013)

Fragile-X and Pharmaceutical Company: Clinical Trial of AFQ056. University of California – Davis Children's Hospital MIND Institute (Sacramento), Children's Hospital Denver, and Rush Children's Hospital at Rush University Medical Center (Chicago). Karen Riley, PI. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Novartis Pharmaceuticals Corporation, $394,206 (2012-2014)

Project Engage, Phase 2, a DAPRA Grant in partnership with Total Immersion Systems, Inc., and Texas A&M University. Research team: Karen Riley (PI) and Lyndsay Agans (Co-PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. U.S. Department of Defense, $60,000 (2011-2013)

International School Psychology Practicum Exchange. Researcher: Gloria L. Miller. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Center for Community Engagement and Service Learning, $14,951 (2012-2013)

Online Course Development for Curriculum and Instruction. Research team: Bruce Uhrmacher (PI) and Norma Hafenstein (Co-PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Office of Teaching and Learning, $18,193 (2012-2014)

Writers in the Schools. Research team: Karen Riley (PI) and Amanda Moreno (Co-PI).Technical reviewer for MCE: Sylvia D. Hall-Ellis. Colorado Humanities, $4,965 (2012-2013)

Learning Ecosystem Validation Grant. Research team: Karen Riley (PI), Lyndsay Agans, Kent Seidel, and Shimelis Assefa. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Bill & Melinda Gates Foundation, $315,000 (2012-2013)

Project Words of Oral Reading and Language Development (WORLD). Research team: Jorge E. Gonzalez (PI), Texas A&M University; Laura Saenz (Co-PI), University of Texas – Pan American; and, Sharolyn Pollard-Durodola (Co-PI), University of Denver. Technical reviewer for MCE: Sylvia D. Hall-Ellis. U.S. Department of Education, Institute of Education Sciences, $53,354 (2012-2015); award $640,718, transfer from Texas A&M University

Increasing the Efficacy of an Early Mathematics Curriculum with Scaffolding Designed to Promote Self-Regulation. Research team: Douglas H. Clements (PI) and Julie Sarama (Co-PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. U.S. Department of Education, Institute of Education Sciences, $1,445,315 (2008-2014); award $4,541,975, transfer from University at Buffalo, The State University of New York

Using Rule Space and Poset-based Adaptive Testing Methodologies to Identify Ability Patterns in Early Mathematics and Create a Comprehensive Mathematics Ability Test. Research team: Douglas H. Clements (PI) and Julie Sarama (Co-PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. National Science Foundation, $323,791 (2010-2014); award $1,194,944, transfer from University at Buffalo, The State University of New York

Comprehensive Postdoctoral Training in Scientific Education Research. Researcher: Julie Sarama (PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. U.S. Department of Education, Institute of Education Sciences, $133,458 (2010-2014); award $613,353, transfer from University at Buffalo, The State University of New York

Longitudinal Study of a Successful Scaling Up Project: Extending TRIAD. Research team: Douglas H. Clements (PI), Julie Sarama (Co-PI), and Abt Associates (Carolyn Layzer, Fatih Unlu, Laurie Bozzi, Lily Fesler, Alina Martinez, Cristofer Price, James van Orden). Technical reviewer for MCE: Sylvia D. Hall-Ellis. Institute of Education Sciences, $384,940 (2011-2015; award $1,250,286, transfer from University at Buffalo, The State University of New York

Early Childhood Education in the Context of Mathematics, Science, and Literacy. Research team: Julie Sarama (PI), Douglas H. Clements (Co-PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. National Science Foundation, $990,020 (2010-2014; award $2,285,228, transfer from University at Buffalo, The State University of New York

Early Childhood Clearinghouse Information Center Redesign. Research team: Karen Riley (PI) and Amanda Moreno (Co-PI).Technical reviewer for MCE: Sylvia D. Hall-Ellis. Office of the Lt. Governor of Colorado, $12,000 (2012-2013)

Morgridge Rural Educational Leadership Initiative. Research team: Lyndsay Agans (PI), Linda Brookhart (Co-PI), Susan Korach, and Rebecca McClure. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Morgridge Family Foundation, $100,000 (2012-2014)

Center of Excellence for Problem Gambling. Research team: Patrick Sherry (PI) and J. Mike Faragher. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Colorado Department of Behavioral Health, $55,000 (2012-2013)

Intermodal Transportation Institute Research Initiatives. Researcher: Patrick Sherry. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University Transportation Centers Program, Research and Innovative Technology Administration, U.S. Department of Transportation. $600,000 (2012-2014)

Mile High United Way Social Innovation Fund Early Literacy Initiative. Gloria L. Miller, PI, Amanda Moreano, Kim Hartnett-Edwards, and Sheridan Green. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Mile High United Way, $89,992 (2012-2013)

International School Psychology Practicum Exchange. Researcher: Gloria L. Miller. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Center for Community Engagement and Service Learning, $1,000 (2012-2013)

Refugee Student Art Outreach. Researcher: Karin Dittrick-Nathan. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Faculty Research Fund, $3,000 (2012-2013)

Resistance, Resilience, and Reciprocity: Centering the Voices of Black Doctoral Women with Faculty Aspirations. Researcher: Nicole M. Russell. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Faculty Research Fund, $2,965 (2012-2013)

Assessing Learning through Student Notebooks. Research team: Keith Miller, Nancy Sasaki, and Kathy Green. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Professional Research Opportunities for Faculty, $30,000 (2012-2014)

International School Psychology Practicum Exchange. Researcher: Gloria L. Miller. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Office of Internationalization, $2,000 (2012-2013)

ELO in Colorado. Research team: Cynthia Hazel and Duan Zhang. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Colorado Legacy Foundation, $150,000 (2012-2013)

Creating Online LIS Courses. Research team: Mary C. Stansbury (PI), Shimelis Assefa, Denise Anthony, Xiao Hu, and Krystyna Matusiak. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Center for Teaching and Learning, $15,000 (2011-2013)

Maritime Piracy Seminar. Researcher: Ved Nanda, The Nanda Center, Sturm College of Law. Technical reviewer for Sturm College of Law: Sylvia D. Hall-Ellis. Arsenault Family Foundation, $15,000 (2012-2013).

Early Childhood Librarianship: An Interdisciplinary, Experiential Learning MLIS. Researcher: Mary C. Stansbury (PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. Laura Bush's 21st Century Librarians Program, Institute for Museums and Library Services, $249,066 (2012-2014)

Learning Ecosystem Planning Grant. Research team: Karen Riley (PI), Lyndsay Agans, Kent Seidel, and Shimelis Assefa. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Bill & Melinda Gates Foundation, $281,217 (2011-2012)

Advanced Service Learning Practitioner Faculty Grant, Sylvia D. Hall-Ellis, University of Denver, Center for Community Engagement and Service Learning, $400 (2011)

Evaluating and Enhancing the EspeciallyMe Program. Research team: Lori D. Patton and Nicole Russell. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Center for Community Engagement and Service Learning, Public Good Fellowship Grant, $24,780 (2012)

Choosing Excellence: Let Every Child Bloom. Research team: Shimelis Assefa (PI) and Mary C. Stansbury (Co-PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Center for Community Engagement and Service Learning, Public Good Grant, $7,657 (2012)

K-8 STEM Content Specific Professional Development to Improve Elementary Student Achievement. Research team: Kent Seidel (PI), Nicole Russell (Co-PI), Kimberly Hartnett-Edwards, Paul Michalec, Jeff Farmer, Keith Miller, Alegra Reiber, and Nancy Sasaki. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Colorado Department of Education, Improving Teacher Quality Grant, (Title II ESEA), $307,299 (2011-2012)

Building a Better Principal Pipeline to Boost Student Achievement. Researcher: Susan Korach. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Denver Public Schools; a subcontract from the Wallace Foundation Grant, $170,000 (2011-2017)

Center of Excellence for Problem Gambling. Research team: J. Mike Faragher (Co-PI) and Bobbie Vollmer (PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. Colorado Department of Behavioral Health, $79,999 (2011-2012)

An Exploration of Novice Teachers' Core Competencies: Impacts on Student Achievement, and Effectiveness of Preparation. Research team: Kent Seidel (PI), Kathy Green (Co-PI), Kimberly Hartnett-Edwards, and Duan Zhang. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Institute of Education Sciences, Effective Teachers and Effective Teaching, $990,987 (2012-2015)

Project Engage, a DAPRA Grant in partnership with Total Immersion Systems, Inc., and Texas A&M University. Research team: Karen Riley (PI) and Lyndsay Agans (Co-PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. U.S. Department of Defense, $49,964 (2011-2014)

User-centered Evaluation of Music Search Engines. Researcher: Xiao Hu. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Faculty Research Fund, $2,931 (2011-2012)

Educational Practicum in Vietnam and China to Promote the Inclusion of Young Children with Disabilities. Researcher: Gloria L. Miller. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Office of Internationalization, $5,000 (2011-2012)

Evaluation of Colorado's Enhancing Quality in Infant-Toddler (EQIT) Initiative. Research team: Virginia R. Maloney and Amanda Moreno. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Buell Foundation, $395,884 (2011-2013)

Creating Engaging Environments to Teach Pre-Algebra Mathematics to Elementary Students. Research team: Álvaro Arias, Mario López, María del Carmen Salazar, and Lyndsay Agans. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver Interdisciplinary Grant, $60,000 (2011-2012)

Morgridge Education Technology Accessible (META) Resource Project. Research team: Lyndsay Agans (PI) and Shimelis Assefa (Co-PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. Morgridge Family Foundation, $36,000 (2011)

MCE Connect: A 21st Century Framework for Faculty Development. Research team: Bruce Uhrmacher (PI), Shimelis Assefa (Co-PI), Lyndsay Agans (Co-PI), Kimberly Hartnett-Edwards, Norma Hafenstein, Xiao Hu, Paul Michalec (Co-PI), María del Carmen Salazar (Co-PI), and Sandra Snyder-Mondragon. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Center for Teaching and Learning, $22,355 (2011-2012)

Parent Education and Parent Leadership and Advocacy. Research team: Virginia Maloney (PI) and Amanda Moreno, Marsico Institute for Early Learning and Literacy. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Colorado Health Foundation, $27,358 (2010-2011)

Intentional School Culture. Researcher: Cynthia Hazel. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Denver Public Schools, $38,040 (2010-2011)

Healthy Eaters, Lifelong Movers: Implementing Evidence-Based School Environment, Policy, and Curricular Changes to Increase Opportunities for Healthy Eating and Physical Activity in Low Income, Rural Colorado. Research team: Elaine Berlansky, University of Colorado at Denver (PI), Nicholas Cutforth, University of Denver (Co-PI), and Allison Reeds. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Colorado Health Foundation, $1,683,277 (2011-2014)

Second Life Learning Community. Research team: Don McCubbrey (PI), Sylvia D. Hall-Ellis (Co-PI), Walter LaMendola, and Paul Novak. University of Denver, Center for Teaching and Learning, $13,000 (2010-2011)

Reintroducing the Value of Law Librarians to Academic and Public Librarians in Colorado through the Identification and Use of Emerging Technologies. Research team: Sylvia D. Hall-Ellis (Co-PI), Stacey L. Bowers (PI), and Christopher Hudson, in partnership with Denver Public Library, Arapahoe Library District, and the Colorado State Supreme Court Library. University of Denver, Center for Community Engagement and Service Learning, $5,773 (2010-11)

Reintroducing the Value of Law Librarians to Public Librarians through the Identification and Use of Emerging Technologies and Resources. Research team: Stacey Bowers (PI) and Sylvia D. Hall-Ellis (Co-PI). American Association of Libraries, Wolters Kluwer Law & Business Grant Program, $2,725 (2010-2011)

Faculty Service Learning Pod. Research team: María del Carmen Salazar and Nicholas Cutforth (Curriculum and Instruction Program), Frank Tuitt (Higher Education Program), Cynthia Hazel and Gloria Miller (Child, Family, and School Psychology Program), and Sylvia D. Hall-Ellis (Library and Information Science Program). University of Denver, Center for Community Engagement and Service Learning, $8,000 (2010-2011)

Lincoln Collaborative. Research team: Antonio Esquibel (Principal, Lincoln High School), María del Carmen Salazar (Curriculum and Instruction Program), and. Sylvia D. Hall-Ellis. School Improvement Grant, Denver Public Schools, $375,000 (2010-2012)

Future LEADers of America: Leaders III. Research team: Denver Public Library (Kristen Svendson, PI), the University of Denver (Sylvia D. Hall-Ellis), the Colorado Chapter of REFORMA (Orlando Archibeque), and the Colorado Association of Libraries (Martin Garnar). Laura Bush's Recruiting Librarians for the 21st Century Program, Institute for Museums and Library Services, $988,366 (2009-2012)

Teaching for Success in the Library Environment: LIS 4030 in Library 2.0. Research team: Deborah S. Grealy (PI) and Sylvia D. Hall-Ellis (Co-PI). University of Denver, Center for Teaching and Learning, $ 9,350 (2009-10)

Writing Group Faculty Grant, Sylvia D. Hall-Ellis, University of Denver, Center for Community Engagement and Service Learning, $750 (2008-2009)

Collaborative Learning Faculty Grant, Sylvia D. Hall-Ellis, University of Denver, Center for Teaching and Learning, $1,500 (2008)

Connecting Information Literacy to Learning. Research team: Lori Micho, Merrie Valliant, Amanda Samland, and Sylvia D. Hall-Ellis. Colorado State Library, LSTA Discretionary Grant Program, $19,548 (2008-2009)

Law Librarianship Fellows Program. Research team: Sylvia D. Hall-Ellis (PI), Stacey Bowers (Co-PI), and Christopher Hudson, Westminster Law Library. Laura Bush's 21st Century Librarians Program, Institute for Museums and Library Services, $999,370 (2008-2012)

Grant Writing in a Cooperative Learning Environment. Sylvia D. Hall-Ellis. University of Denver, Center for Teaching and Learning, $2,000 (2008-2009)

Project Homeless Connect 6 Event Evaluation. Research team: Sylvia D. Hall-Ellis and Duan Zhang. University of Denver Center for Community Engagement and Service Learning, $9,785 (2008)

Project Ecuador: International Learning Service Libraries – A Faculty Development Experience in Ecuador. Sylvia D. Hall-Ellis, Office of Internationalization, University of Denver, $600 (2007)

Project Ecuador: International Learning Service Libraries – A Faculty Development Experience in Ecuador. Sylvia D. Hall-Ellis, International Service Learning Office, University of Denver, $400 (2007)

Project Homeless Connect 5 Event Evaluation. Research team: Sylvia D. Hall-Ellis and Duan Zhang. University of Denver Center for Community Engagement and Service Learning, $1,000 (2007)

Project Homeless Connect 4 Event Evaluation. Research team: Sylvia D. Hall-Ellis and Duan Zhang. University of Denver Center for Community Engagement and Service Learning, $4,595 (2007)

Future LEADers of America: Leaders II. Research team: Denver Public Library (Kristen Svendson, PI), the University of Denver (Sylvia D. Hall-Ellis), and the Colorado Chapter of REFORMA (Orlando Archibeque). Laura Bush's Recruiting Librarians for the 21st Century Program, Institute for Museums and Library Services, $988,518 (2007-2010)

Strategic Planning Assistance for the Denver Medical Library. Sylvia D. Hall-Ellis. Denver Medical Library, Inc., $30,000 (2006-2007)

Destiny Software for JMAC Student Lab. Sylvia D. Hall-Ellis, gift from the Sagebrush Corporation, Minneapolis, Minnesota, $10,000 (2006)

Libraries: Tools for Education and Development Worldwide: A Faculty Development Experience in France. Sylvia D. Hall-Ellis, Office of Internationalization, University of Denver, $800 (2005)

Denver Public Library: Opportunities for Change. Sylvia D. Hall-Ellis, Colorado Community Based Research Network, $2,000 (2005)

Future LEADers of America. Research team: Denver Public Library (Letty Icolari and Steve Taylor, PIs), Emporia State University (Jim Agee), and the University of Denver (Sylvia D. Hall-Ellis). Recruiting Librarians for the 21st Century Program, Institute for Museums and Library Services, $670,315 (2005-2008)

American Association of University Professors Summer Institute Professional Development Grant. Sylvia D. Hall-Ellis, American Association of University Professors, $300 (2005)

Beta Phi Mu Alumni Tea. Sylvia D. Hall-Ellis, gift from the Office of Alumni and Parent and Relations, University of Denver, $2,000 (2005)

Spectrum Software for LIS Student Lab. Sylvia D. Hall-Ellis, gift from the Sagebrush Corporation, Minneapolis, Minnesota, $5,000 (2005)

Developing Research Capacity in Community Organizations and Residents through Training and Technical Assistance. Nicholas J. Cutforth (PI) and Sylvia D. Hall-Ellis. Piton Foundation, $25,000 (2005-2006)

Libraries: Tools for Education and Development Worldwide: A Faculty Development Experience in Argentina. Sylvia D. Hall-Ellis, Office of Internationalization, University of Denver, $500 (2004)

Developing Research Capacity in Community Organizations and Residents through Training and Technical Assistance. Research team: Nicholas J. Cutforth (PI), Gary Lichtenstein and Sylvia D. Hall-Ellis, Piton Foundation, $25,000 (2003-2004)

Increasing Spanish-Speaking and Hispanic Diversity among Library and Information Science Students at the University of Denver: Development of a Student Recruitment Model. Researcher: Sylvia D. Hall-Ellis (PI), Office of Multicultural Excellence, University of Denver, $2,750 (2003-2004)

Collection Development Enrichment to Support the Cataloging & Classification Specialization and School Librarianship within the Library & Information Science Program at the University of Denver. Research team: Sylvia D. Hall-Ellis (PI) and Deborah S. Grealy. Women's Library Association, University of Denver, $4,000 (2003)

Collection Development Enrichment to Support the Library & Information Science Program at the University of Denver. Research team: Deborah S. Grealy (PI) and Sylvia D. Hall-Ellis. Women's Library Association, University of Denver, $4,000 (2001)

Wireless LAN for Library Education. Research team: Deborah S. Grealy (PI) and Sylvia Hall-Ellis. University of Denver, Center for Teaching and Learning, $24,000 (2001-2002)

Upward Bound – A Program for South Texas Youth. Research team: Monte Churchill, Executive Director of Community Relations; Gary R. Sauceda, Outreach Coordinator; Raymond Hernandez, (PI) Associate Dean for Student Success; and Sylvia D. Hall-Ellis, South Texas Community College (McAllen, Texas). U.S. Department of Education, Office of Postsecondary Education, $2,672,003 (1999-2003)

Write Now! Improving Elementary Students' Writing Skills. Research team: Caryl G. Thomason, Assistant Superintendent (PI); Karen Tankersley, Principal; and, Hal Anderson, Director of Technology, Cheyenne Mountain School District 12 (Colorado Springs, Colorado); and Sylvia D. Hall-Ellis. Colorado Department of Education, Educational Telecommunications Unit, $189,453 (1999-2001)

Operation Quick Start -- Distance Learning in Rural Colorado. Research team: Randal Weigum, Technology Coordinator (PI); Bonnie Barns, Director of Federal Programs and Staff Development; and, Adam "Joe" Raskop, Executive Director, Southeastern Board of Cooperative Educational Services (Lamar, Colorado); and Sylvia D. Hall-Ellis. Colorado Department of Education, Educational Telecommunications Unit, $400,000 (1999-2001)

Advanced Technological Training for Information Professionals for the 21st Century. Research team: Mario Reyna, Division of Business Director (PI) and Sylvia D. Hall-Ellis, South Texas Community College (McAllen, Texas). Phi Delta Kappa and the National Science Foundation, $250,000 (1999-2001)

Working Connections – Training Information Technologies Professionals for the 21st Century. Research team: Mario Reyna, Division of Business Director (PI) and Sylvia D. Hall-Ellis, South Texas Community College

(McAllen, Texas). Microsoft Corporation and the American Association of Community Colleges, $1,147,775 (1999-2001)

The ROAD (Research Oriented Amplification of Development to Literacy) Program. Research team: Deborah J. Leong (PI), Metropolitan State University; Elena Bodrova, Metropolitan State University; Dmitri Semenov, Robert J. Marzano, and Sylvia D. Hall-Ellis, Mid-continent Regional Educational Laboratory (Aurora, Colorado). Hewlett-Packard Foundation, $25,000 (1998-1999)

Press to Literacy. Research team: Deborah J. Leong (PI), Metropolitan State University; Elena Bodrova, Metropolitan State University; Dmitri Semenov, Robert J. Marzano, and Sylvia D. Hall-Ellis, Mid-continent Regional Educational Laboratory (Aurora, Colorado). The Denver Post and the Robert S. McCormick Foundation, $49,818 (1998-1999)

International Telementor Center. Research team: David Neils, David B. Frost (PI), and Sylvia D. Hall-Ellis, Mid-continent Regional Educational Laboratory (Aurora, Colorado). Hewlett-Packard Philanthropy, $100,000 (1998-1999)

America Reads: Providing Tutor Training for the America Reads Challenge. Research team: Louis F. Cicchinelli (PI) and Sylvia D. Hall-Ellis, Mid-continent Regional Educational Laboratory (Aurora, Colorado). U.S. Department of Education, Office of Educational Research and Improvement, $306,000 (1998-1999)

Comprehensive School Reform. Research team: Louis F. Cicchinelli (PI), J. Timothy Waters, and Sylvia D. Hall-Ellis, Mid-continent Regional Educational Laboratory (Aurora, Colorado). U.S. Department of Education, Office of Educational Research and Improvement, $285,000 (1998-1999)

Sustainable Energy Education (SEE) Program for Grades 4-8: Preparing Today's Youth for Lifelong Learning and Responsible Actions in Energy Conservation. Research team: Mary Gromko, Colorado Department of Education; Gene McCarthy, Rocky Flats Field Office, U.S. Department of Energy; Gina Kissell, National Renewable Energy Laboratory; and Barbara L. McCombs (PI), Janet L. Bishop, and Sylvia D. Hall-Ellis, Mid-continent Regional Educational Laboratory (Aurora, Colorado). State of Colorado Governor's Office for Energy Conservation, $499,936 (1997-1999)

Review of Kansas Curriculum Standards in Mathematics and Language Arts. Research team: Robert J. Marzano (PI), John S. Kendall, David B. Frost, and Sylvia D. Hall-Ellis, Mid-continent Regional Educational Laboratory (Aurora, Colorado). Submitted to the Kansas State Department of Education, $25,903 (1998)

International Telementor Center. Research team: David Neils, John Kuglin, Chris Rapp, David B. Frost (PI), and Sylvia D. Hall-Ellis, Mid-continent Regional Educational Laboratory (Aurora, Colorado). Hewlett-Packard Company, $54,752 (1998)

Genesis Mission: Education Public Outreach. Developed in partnership by the Jet Propulsion Laboratory, California Institute of Technology, Los Alamos National Laboratory, Lockheed Martin Astronautics, and the Mid-continent Regional Educational Laboratory (Aurora, Colorado). Research team: John T. Sutton (PI), Alice Krueger, Martha Henry, Greg Rawls, Shae Isaacs, Jeff Johnson, Deb Jordan, Arlene Mitchell, David B. Frost, Jana Caldwell, J. Timothy Waters, and Sylvia D. Hall-Ellis. National Aeronautics and Space Administration, $139,700,000; subcontract award, $4,750,000 (1997-2007)

North Dakota Mathematics Assessment Project. Developed in partnership by the North Dakota Department of Education and Mid-continent Regional Educational Laboratory (Mid-continent Regional Educational Laboratory). Research team: Ann Clapper, Clarence Bina, Greg Gallagher, North Dakota Department of Education; Don Burger (PI), Hillary Michaels, and Sylvia D. Hall-Ellis, Mid-continent Regional Educational Laboratory (Aurora, Colorado). U.S. Office of Education, $1,618,214; subcontract award, $389,076 (1997-2001)

Pacific Resources for Education and Learning Distance Education: Project Evaluation. Developed in partnership by the Pacific Educational Community, the Pacific Resources for Education and Learning (PREL), and Mid-continent Regional Educational Laboratory (McREL). Research team: John W. Kofel (PI), Executive Director, PREL; J. Timothy Waters, Executive Director; Joan Buttram, Robert Keller, and Sylvia D. Hall-Ellis, Mid-continent Regional Educational Laboratory (Aurora, Colorado). U.S. Office of Education, Star Schools Program, $10,000,000; subcontract award, $500,000 (1997-2002)

Identification of Bilingual Gifted and Talented Children: A Comprehensive School Grants for Bilingual Education. Developed in partnership by Hidalgo (Texas) ISD, Los Fresnos (Texas) CISD, Progreso (Texas) ISD, University of Texas – Pan American (Edinburg, Texas), and Education Service Center, Region One (Edinburg, Texas). Research team: Hilda Medrano, Dean, College of Education, University of Texas – Pan American; Linda Phemister (PI), Janie Navarro, and Sylvia D. Hall-Ellis, Education Service Center, Region One. U.S. Department of Education, Office of Bilingual Education and Minority Languages Affairs, $1,670,633 (1997-2002)

Academics 2000: First Things First -- The Texas Goals 2000. Developed for Jim Hogg (Hebbronville, Texas) County ISD, Mirando City (Texas) ISD, and San Isidro (Texas) ISD. Research team: Hilda Medrano, Dean, College of Education, University of Texas - Pan American (Edinburg, Texas); Angie Lehmann, Amy Mares, Ellen Gonzalez (PI), and Sylvia D. Hall-Ellis, Education Service Center, Region One (Edinburg, Texas). Texas Education Agency, $339,987 (1997-2000)

Southwestern Bell's Learning Communities Initiative. Developed for Tech Prep of the Rio Grande Valley, Inc. (Harlingen, Texas); the Center for Professional Teacher Development, University of Texas – Brownsville; Teach for America – Rio Grande Valley (McAllen, Texas); and Education Service Center, Region One (Edinburg, Texas). Research team: Patricia G. Bubb, Executive Director (PI), Tech Prep of the Rio Grande Valley; Martin Winchester, Executive Director, Teach for America – Rio Grande Valley; Aileen Johnson, Director, School of Education, University of Texas – Brownsville; and Sylvia D. Hall-Ellis. Southwestern Bell Foundation, $100,000 (1997-1998)

Texas School to Work: Regional Implementation. Developed for Tech Prep of the Rio Grande Valley, Inc. (Harlingen), South Texas Community College (McAllen), Texas State Technical College (Harlingen), Texas Southmost College (Brownsville), Empowerment Zone of the Rio Grande Valley (Mercedes), Project VIDA (Weslaco), Youth Fair Chance (McAllen), and Education Service Center, Region One (Edinburg). Research team: Patricia G. Bubb (PI), Tech Prep of the Rio Grande Valley; Stephen Vassberg, Texas State Technical College; Ellen Trevino, Youth Fair Chance; Wanda Garza, Project VIDA; Leonardo Olivares, University of Texas – Pan American; Michael Bell, South Texas Community College; and Sylvia D. Hall-Ellis. Texas Workforce Commission, $4,250,000 (1997-2002).

Comprehensive Bilingual Education Grant for Hidalgo ISD and Roma ISD. Developed for Hidalgo (Texas) ISD, Roma (Texas) ISD, College of Education, University of Texas – Pan American (Edinburg, Texas), and Education Service Center, Region One (Edinburg, Texas). Research team: Tomas Thomas (PI), Director, Office of Bilingual Education and Sylvia D. Hall-Ellis. U.S. Department of Education, Office of Bilingual Education and Minority Languages Affairs, $1,531,361 (1997-2002)

Lopez High School, Porter High School, Rivera High School, Central Middle School, and Perkins Middle School, Brownsville (Texas) Independent School District. Telecommunications Infrastructure Fund Board, $1,473,611 (1997-1998)

Donna High School, Todd Middle School, and Solis Middle School, Donna (Texas) Independent School District. Telecommunications Infrastructure Fund Board, $704,052 (1997-1998)

Memorial Middle School and Nellie Schunior Middle School, La Joya Independent School District (Texas). Telecommunications Infrastructure Fund Board, $293,641 (1997-1998)

Martin High School, Christen Middle School, Cigarroa Middle School, Lamar Middle School, Laredo (Texas) Independent School District. Telecommunications Infrastructure Fund Board, $1,200,000 (1997-1998).

Lasara Middle School, Lasara (Texas) Independent School District. Telecommunications Infrastructure Fund Board, $246,210 (1997-1998)

Los Fresnos High School and Resaca Middle School, Los Fresnos (Texas) Consolidated Independent School District. Telecommunications Infrastructure Fund Board, $500,000 (1997-1998)

Lyford Junior High School, Lyford (Texas) Independent School District. Telecommunications Infrastructure Fund Board, $354,997 (1997-1998)

Travis Middle School, McAllen (Texas) Independent School District. Telecommunications Infrastructure Fund Board, $269,139 (1997-1998)

Mission High School, Mission (Texas) Independent School District. Telecommunications Infrastructure Fund Board, $297,010 (1997-1998)

Progreso High School, Progreso (Texas) Independent School District. Telecommunications Infrastructure Fund Board, $300,000 (1997-1998)

San Perlita High School, San Perlita (Texas) Independent School District. Telecommunications Infrastructure Fund Board, $293,490 (1997-1998)

Myra Green Junior High School, Raymondville (Texas) Independent School District. Telecommunications Infrastructure Fund Board, $225,000 (1997-1998)

Rio Grande City High School, Ringgold Middle School, Gruella Middle School, Rio Grande City (Texas) Independent School District. Telecommunications Infrastructure Fund Board, $809,934 (1997-1998)

Rio Hondo Junior High School, Rio Hondo (Texas) Independent School District. Telecommunications Infrastructure Fund Board, $297,024 (1997-1998)

Roma High School, Roma (Texas) Independent School District. Telecommunications Infrastructure Fund Board, $333,178 (1997-1998)

San Benito High School, Miller Jordan Junior High School, San Benito (Texas) Consolidated Independent School District. Telecommunications Infrastructure Fund Board, $547,000 (1997-1998)

Santa Maria High School and Santa Maria Middle School, Santa Maria (Texas) Independent School District. Telecommunications Infrastructure Fund Board, $400,000 (1997-1998)

Salvador High School, United Independent School District (Laredo, Texas). Telecommunications Infrastructure Fund Board, $250,879 (1997-1998)

Weslaco High School, Cabaza Middle School, Cuellar Middle School, Weslaco (Texas) Independent School District. Telecommunications Infrastructure Fund Board, $874,242 (1997-1998)

Principals' Assessment and Training Center. Developed for Education Service Center, Region One (Edinburg, Texas). Research team: Roberto Zamora, Leonel Barrera, William H. Parry, and Sylvia D. Hall-Ellis. Texas Principals' Leadership Initiative, Texas Association of Secondary School Principals, Texas Association of Elementary School Principals, and the Sid Richardson Foundation. $461,439 (1996-1998)

The Texas Library Connection -- Integrating and Sharing Resources. Developed for Hidalgo County Library System (McAllen), Cameron County Library System (Brownsville), South Texas Community College (McAllen), the

University of Texas - Pan American (Edinburg), University of Texas – Brownsville, and Education Service Center, Region One (Edinburg). Research team: William R. McGee, Coordinator, Hidalgo County Library System; Joe Garcia, Director, Cameron County Library System; Michael D. Bell, Library Director, South Texas Community College; Eleanor Folger Foster, University Library, University of Texas - Pan American; Jaime Vela (PI), Director of Instructional Technology and Media Services, Ron Pontius, Instructional Technology, and Fabiola Fuentes, Media Services, Education Service Center, Region One; and Sylvia D. Hall-Ellis. Office of Library Media Services, Technology Services, Texas Education Agency. $8,000 (1996-1997)

Developing Leadership Communities for Improving Algebra I for All Students. Developed for a partnership of the Region One Statewide Systemic Initiative Team. Research team: Noel Villarreal (PI), Eduardo Cancino, and Sylvia D. Hall-Ellis, Education Service Center, Region One (Edinburg). Texas Statewide Systemic Initiative for Reform in Mathematics, Science and Technology Education to The Charles A. Dana Center for Mathematics and Science Education, The University of Texas at Austin. $25,000 (1996-1997)

Academics 2000: First Things First -- The Texas Goals 2000. Developed for Edinburg (Texas) CISD. Research team: Hilda Medrano, Dean, College of Education, University of Texas - Pan American (Edinburg); Helen Jones, Director (PI), Gifted and Talented Education, Edinburg CISD; and Sylvia D. Hall-Ellis, Education Service Center, Region One (Edinburg). Texas Education Agency, $750,000 (1996-2001)

Texas Teachers Empowered for Achievement in Mathematics (TEXTEAM) Institute for Algebra I. Developed for Hidalgo ISD, Jim Hogg (Hebbronville) County ISD, La Joya ISD, La Villa ISD, Lyford ISD, Mission CISD, Pharr-San Juan-Alamo ISD, Rio Hondo ISD, San Isidro ISD, San Perlita ISD, Santa Maria ISD, Santa Rosa, Sharyland ISD, Valley View ISD, Webb (Laredo) CISD, Weslaco ISD, and Zapata County (Zapata) ISD. Research team: Noel Villarreal (PI), Chuck McInteer, Ellen M. Gonzalez, Education Service Center, Region One (Edinburg); and Sylvia D. Hall-Ellis. Charles A. Dana Center for Mathematics and Science Education, University of Texas - Austin, $15,975 (1996)

Community Learning Center for La Villa, Texas. Developed for Edcouch-Elsa Independent School District. Research team: Noe Gonzalez (PI), Assistant Superintendent, Edcouch-Elsa Independent School District, and Sylvia D. Hall-Ellis. Delta Region Subzone, Rio Grande Valley (Texas) Rural Empowerment Zone, $325,000 (1996-1997)

Monte Alto (Texas) Community Learning Center. Developed for Monte Alto Independent School District. Research team: Homero A. Diaz (PI), Superintendent, Monte Alto Independent School District, and Sylvia D. Hall-Ellis. Delta Region Subzone, Rio Grande Valley (Texas) Rural Empowerment Zone, $300,000 (1996-1997)

Community Learning Center for La Villa, Texas. Developed for La Villa Independent School District. Research team: Sam Gonzalez (PI), Assistant Superintendent, La Villa Independent School District; and Sylvia D. Hall-Ellis. Delta Region Subzone, Rio Grande Valley (Texas) Rural Empowerment Zone, $325,000 (1996-1997)

Building Project for Taylor Elementary. Developed for Mercedes (Texas) Independent School District. Research team: Mrs. Denise Rivera, Librarian, and Eduardo Infante, Principal, Taylor Elementary School; Ismael S. Cantu (PI), Federal Programs Director, Mercedes Independent School District; and Sylvia D. Hall-Ellis. Delta Region Subzone, Rio Grande Valley (Texas) Rural Empowerment Zone, $375,000 (1996-1997)

Border Education Network (BEN) - Distance Education through Cable Television. Developed for Edinburg (Texas) Consolidated Independent School District. Research team: Noe Torres (PI), Library Media Specialist, Magdalena Rosas, Library Media and Technology Coordinator, Edinburg Consolidated Independent School District; and Sylvia D. Hall-Ellis, Education Service Center, Region One (Edinburg). Edinburg (Texas) Consolidated School District, $250,000 (1996-1997)

Multiservice One-Stop Open Enrollment Charter School. Developed for the Information Referral Resource Assistance, Inc. (McAllen, Texas). Research team: Pablo Perez and Aguie Pena (PI), Executive Director, Information Referral Resource Assistance, Inc.; Roberto Zamora and Sylvia D. Hall-Ellis, Education Service Center, Region One (Edinburg). Texas Education Agency, $3,066,000 (1996-2001)

Project OK: A Community Youth Opportunities Grant for Summer, 1996. Developed for McAllen (Texas) Independent School District, St. Joseph the Worker Catholic Church, and the Office of Adult Education, Education Service Center, Region One. Research team: Father Bart Flatt, St. Joseph the Worker Catholic Church; Noe Calvillo (PI), Office of Adult Education; Maria Louisa Garcia, McAllen Independent School District; and Sylvia D. Hall-Ellis, Education Service Center, Region One (Edinburg). Texas Protective and Regulatory Agency through the Office of the Mayor, City of McAllen, $350,000 (1996-2001).

Early Childhood: a Time of Discovery. Developed for a partnership of Lasara ISD, Rio Hondo ISD, San Perlita ISD, the School of Education, University of Texas - Brownsville, and Education Service Center, Region One (Edinburg). Research team: Hugo Rodriguez, Dean, School of Education, University of Texas - Pan American; Leonel Barrera and Jack Damron, Field Service Agents, Ellen M. Gonzalez (PI), Administrator for Student Instructional Services, Ruth Solis, Education Specialist in Special Education, and Sylvia D. Hall-Ellis, Education Service Center, Region One (Edinburg). Texas Education Agency, $722,090 (1996-2001)

Innovative Gifted and Talented Programs for Early Childhood and Elementary Education Students. Developed for a partnership of Edinburg (Texas) CISD, the School of Education, University of Texas - Pan American (Edinburg), and Education Service Center, Region One (Edinburg). Research team: Hilda Medrano, Dean, School of Education, University of Texas - Pan American; Helen de la Garza (PI), Director of Elementary Curriculum and Instruction, Edinburg CISD; and Sylvia D. Hall-Ellis. Texas Education Agency, $750,000 (1996-2001)

Reading Recovery in Early Elementary Grades. Developed for a partnership of La Villa (Texas) ISD the School of Education, University of Texas - Pan American (Edinburg), and Education Service Center, Region One (Edinburg). Research team: Hilda Medrano, Dean, School of Education, University of Texas - Pan American; Marcario Salinas (PI), Supervisor of Elementary Curriculum and Instruction, La Villa ISD; and Sylvia D. Hall-Ellis, Education Service Center, Region One. Texas Education Agency, $750,000 (1996-2001)

Connected Mathematics Project for Middle and Junior High Students. Developed for a partnership of Michigan State University, The Charles A. Dana Center for Mathematics and Science Education, The University of Texas at Austin and Region One Statewide Systemic Initiative Team. Research team: Jack Damron, Chuck McInteer, Noel Villarreal (PI), and Sylvia D. Hall-Ellis, Education Service Center, Region One (Edinburg). National Science Foundation through Michigan State University to the Charles A. Dana Center at the University of Texas - Austin, $539,610 (1996-1999)

Sharing Resources: Testing the Interlibrary Loan Potential of the Texas Library Connection -- Integrating Media Resources. Developed under the sponsorship of the Hidalgo County Library System (McAllen) and Education Service Center, Region One (Edinburg). Research team: William H. McGee, Hidalgo County System Coordinator; Fabiola Fuentes, Library Media; Ronald Pontius (PI), Instructional Technology, Education Service Center, Region One; and Sylvia D. Hall-Ellis. Library Media Services Program, Office of Technology Services, Texas Education Agency, $25,000 (1996-1997)

State and Federal Adult Education JOBS Program. Developed for Education Service Center, Region One (Edinburg). Research team: Noe Calvillo (PI), Director, Adult Education Program, and Sylvia D. Hall-Ellis. Adult Education Program, Texas Education Agency, $532,846 (1995-1996)

Creating Safe and Drug-Free Schools and Communities. Developed for a partnership of the Region One Consortium for Safe and Drug-Free Education Environments. Research team: Clara Contreras (PI), Health Specialist, and Sylvia D. Hall-Ellis, Education Service Center, Region One (Edinburg). Texas Education Agency, $150,000 (1995-1996)

Developing Leadership Communities for Improving Mathematics Performance for All Students on Title I Campuses. Developed for a partnership of the Region One Statewide Systemic Initiative Team. Research team: Jack Damron, Chuck McInteer, Noel Villarreal (PI), and Sylvia D. Hall-Ellis, Education Service Center, Region One (Edinburg). Texas Statewide Systemic Initiative for Reform in Mathematics, Science and Technology Education to The Charles A. Dana Center for Mathematics and Science Education, The University of Texas at Austin, $50,669 (1995-1996)

The Impact of Library Resource Centers on Academic Achievement in Selected Public Schools in South Texas. Sylvia D. Hall-Ellis (PI). Developed under the sponsorship of the Department of Library Science, College of Education and Applied Science, Sam Houston State University (Huntsville). Texas Association of School Librarians, Children's Services Round Table, and Young Adults Round Table (Austin, Texas), $2,500 (1995)

School Library Media Specialists Fellowship Program. Sylvia D. Hall-Ellis (PI). Developed under the sponsorship of the Department of Library Science, College of Education and Applied Science, Sam Houston State University (Huntsville, Texas). U.S. Department of Education, HEA Title II-B, Library Education and Human Resource Development Program, $44,000 (1995-1996)

Planning for Educational Technology. Research team: Ruth Ann Riggins (PI), Director of Library Media and Technology Services, Donna (Texas) Independent School District; Noe Torres, Education Service Center, Region One; Patricia G. Bubb, Tech Prep of the Rio Grande Calley, Inc; Michael D. Bell, South Texas Community College; and Sylvia D. Hall-Ellis, Sam Houston State University. Developed under the sponsorship of Donna (Texas) Independent School District, Education Service Center, Region One (Edinburg), Tech Prep of the Rio Grande Valley, Inc. (Harlingen), South Texas Community College (McAllen), and the Department of Library Science, Sam Houston State University (Huntsville). Funded through Infusion of Educational Technology Planning Grant Program (H.B. 18: Models). Texas Education Agency, $18,000 (1993-1994)

The Impact of Library Resource Centers on Academic Achievement in Selected Public Schools in South Texas. Sylvia D. Hall-Ellis (PI) and Mary Ann Berry. Developed under the sponsorship of the Department of Library Science, College of Education and Applied Science, Sam Houston State University (Huntsville). Sam Houston State University Research Enhancement Fund, $7,500 (1993-1994)

Electronic Mail Resource Sharing System: Management and Operation of the Iowa Computer-Assisted Network. State Library of Iowa, $294,000 (1986-1993)

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Exhibit 1027

U.S. Patent 6,789,190 by Donald N. Cohen

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(12) **United States Patent**
Cohen

(10) **Patent No.: US 6,789,190 B1**
(45) **Date of Patent: Sep. 7, 2004**

(54) **PACKET FLOODING DEFENSE SYSTEM**

(75) Inventor: **Donald N. Cohen**, Los Angeles, CA (US)

(73) Assignee: **Computing Services Support Solutions, Inc.**, Los Angeles, CA (US)

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(22) Filed: **Nov. 16, 2000**

(51) **Int. Cl.**[7] **G06F 11/30**
(52) **U.S. Cl.** **713/160**; 709/238
(58) **Field of Search** 713/201; 709/238–244; 370/229–240

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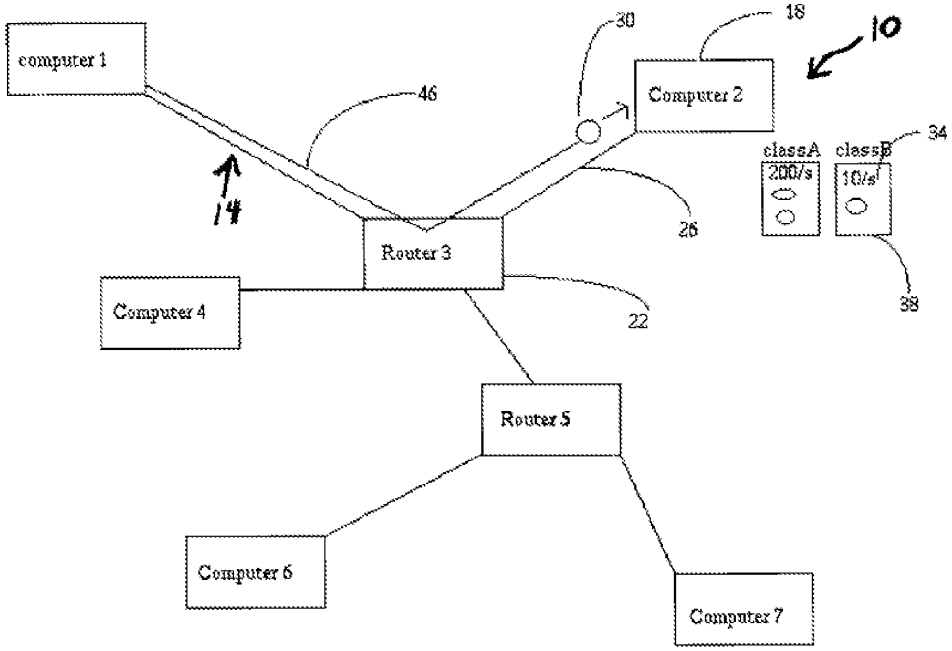
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Assistant Examiner—Ronald Baum
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(57) **ABSTRACT**

The invention prevents "packet flooding", where an attacker uses up all available bandwidth to a victim with useless data. It can also be used to prevent some other related denial of service attacks. The defense is distributed among cooperating sites and routers. The sites identify data they don't want. The routers help sites to determine which routers forward that data. The sites then ask these routers to reduce the rate at which such data is forwarded. Variations of the defense protect against packet flooding attacks on routers and attacks in which an attacker tries to use up some service offered by a site.

3 Claims, 9 Drawing Sheets



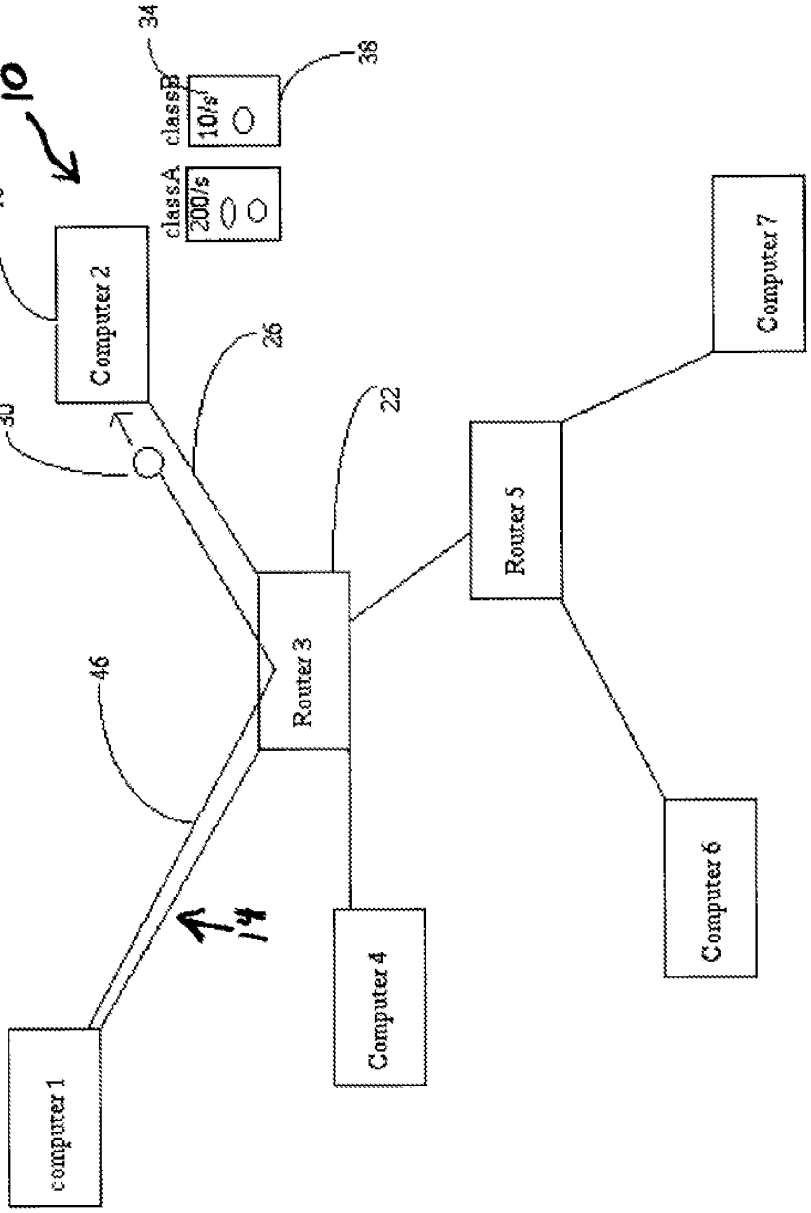

10
34
38
classB
10/s
classA
200/s
18
Computer 2
26
30
22
Router 5
Computer 7
Router 3
46
14
Computer 4
Computer 6
computer 1

Figure 1

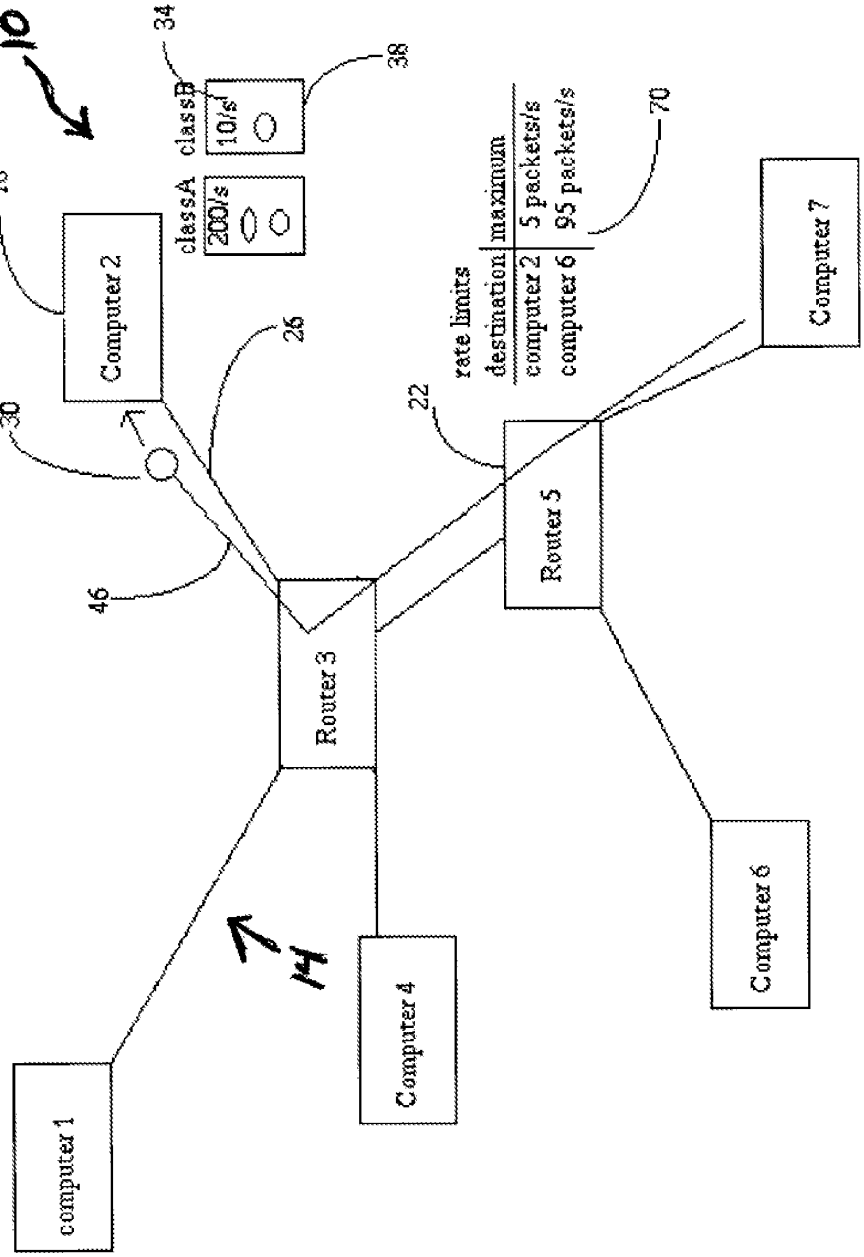

10
34
classB
10/s
38
18
Computer 2
classA
200/s
26
30
46
rate limits
destination | maximum
computer 2 | 5 packets/s
computer 6 | 95 packets/s
70
22
Router 5
Computer 7
Router 3
14
Computer 4
Computer 6
computer 1

Figure 2

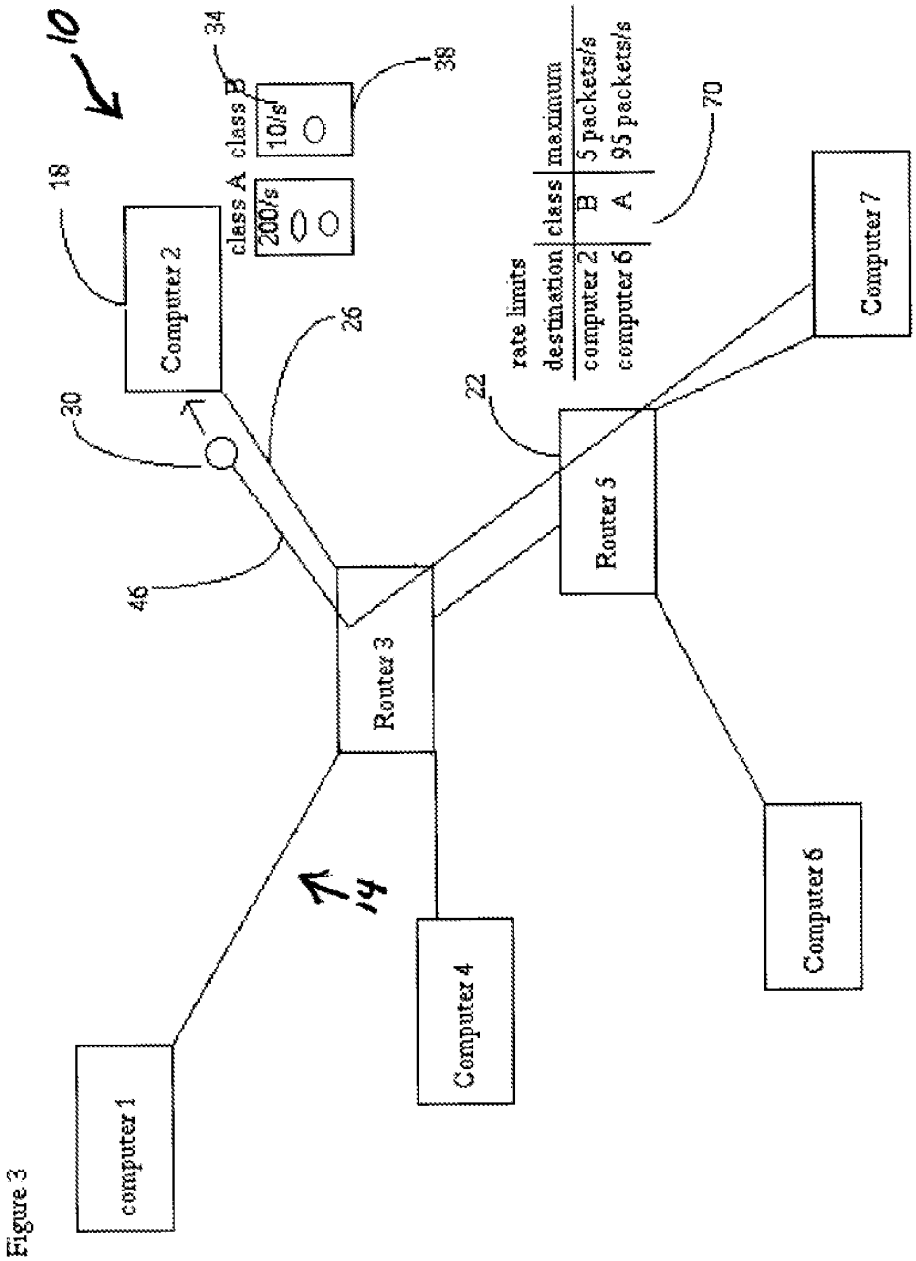

10
34
class B
10/s
38
class A
200/s
18
Computer 2
26
30
46
22
rate limits
destination | class | maximum
computer 2 | B | 5 packets/s
computer 6 | A | 95 packets/s
70
Computer 7
Router 5
Router 3
14
Computer 4
Computer 6
computer 1

Figure 3

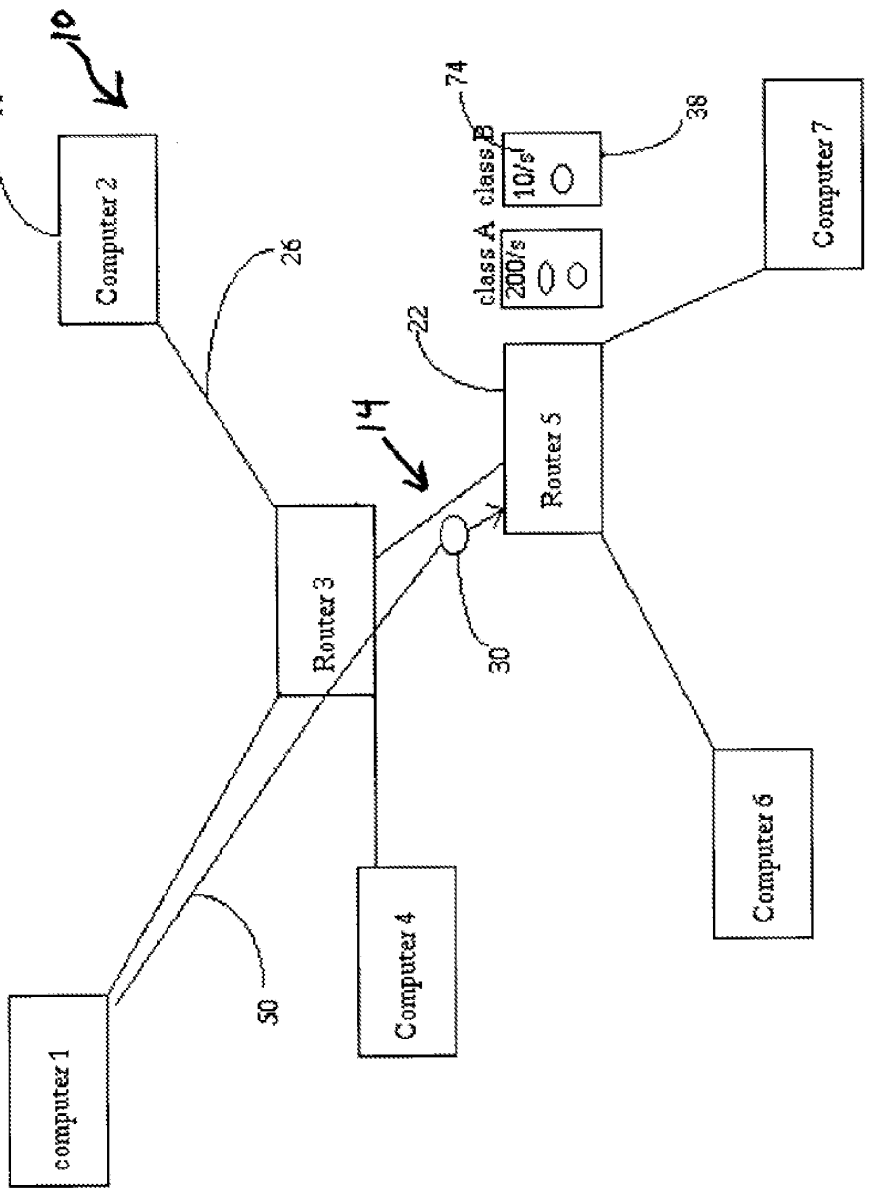

10
18
Computer 2
26
74
class B
10/s
38
class A
200/s
Computer 7
22
Router 5
14
Router 3
30
Computer 6
Computer 4
50
computer 1

Figure 4

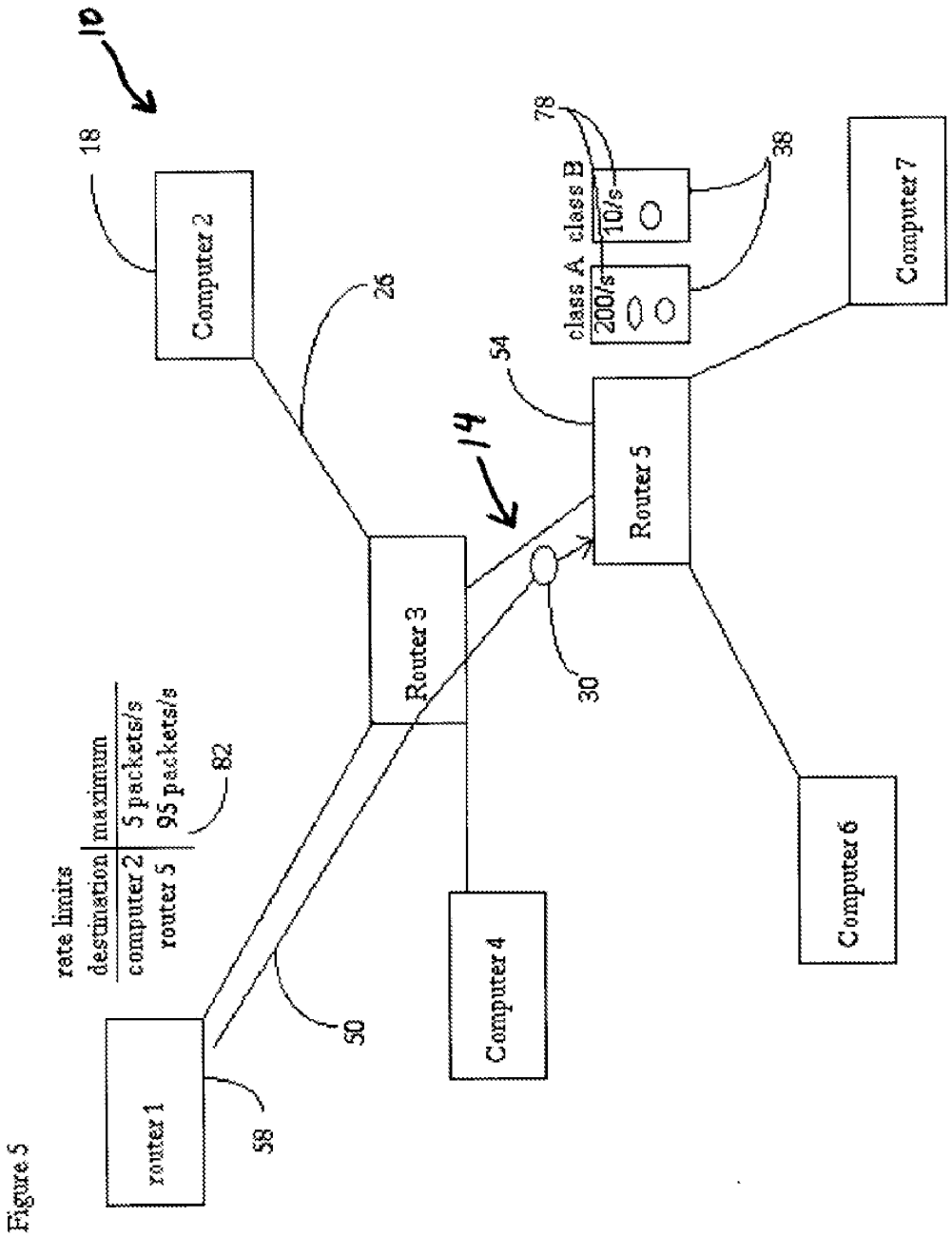

10
18
Computer 2
26
78
class A
200/s
class B
10/s
38
Computer 7
54
Router 5
14
Router 3
30
rate limits
destination
maximum
computer 2
5 packets/s
router 5
95 packets/s
82
Computer 4
Computer 6
50
58
router 1

Figure 5

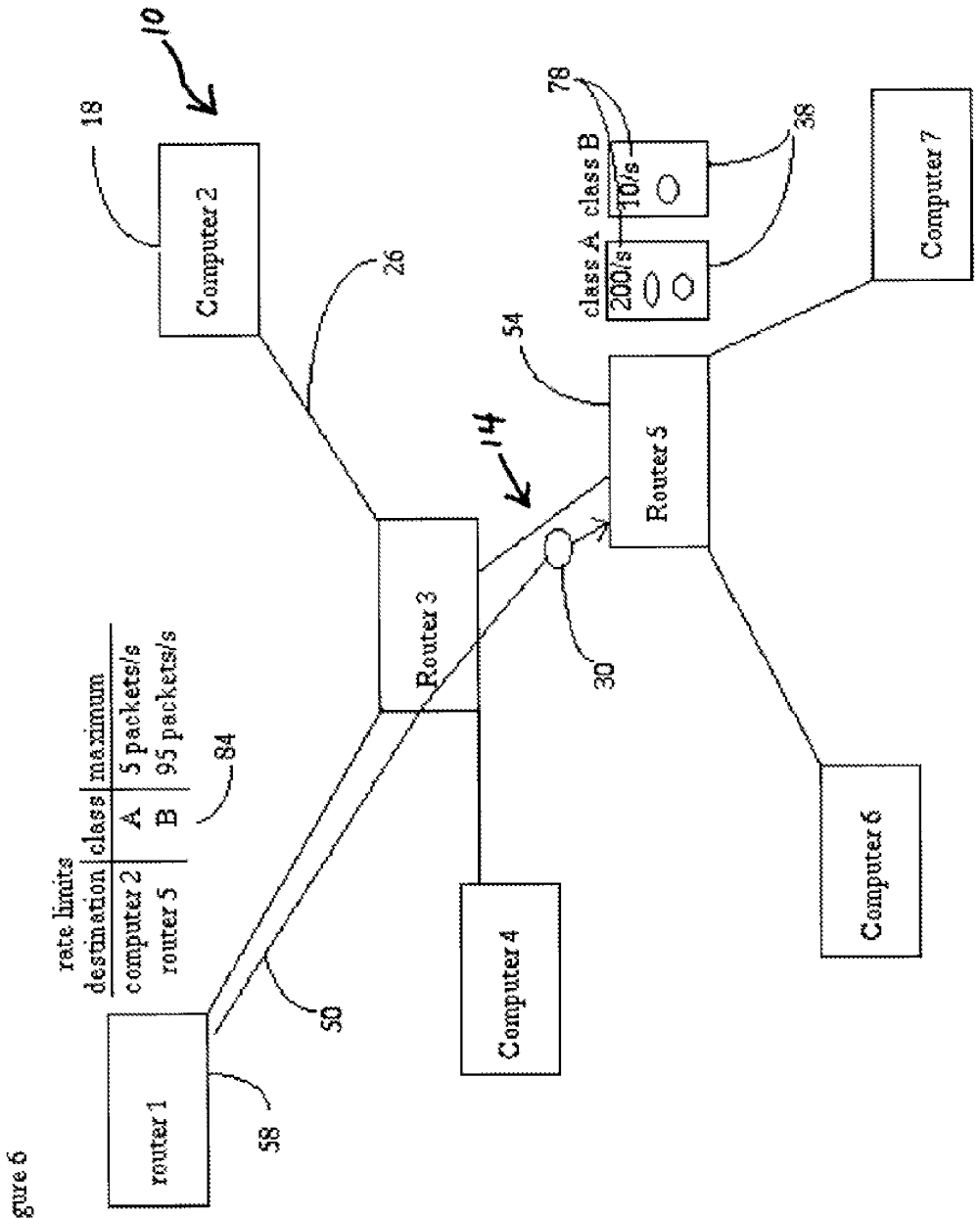

10
18
Computer 2
26
78
class A
200/s
class B
10/s
38
Computer 7
54
Router 5
14
Router 3
30
Computer 4
Computer 6
50
58
router 1
rate limits
destination
class
maximum
computer 2
A
5 packets/s
router 5
B
95 packets/s
84

Figure 6

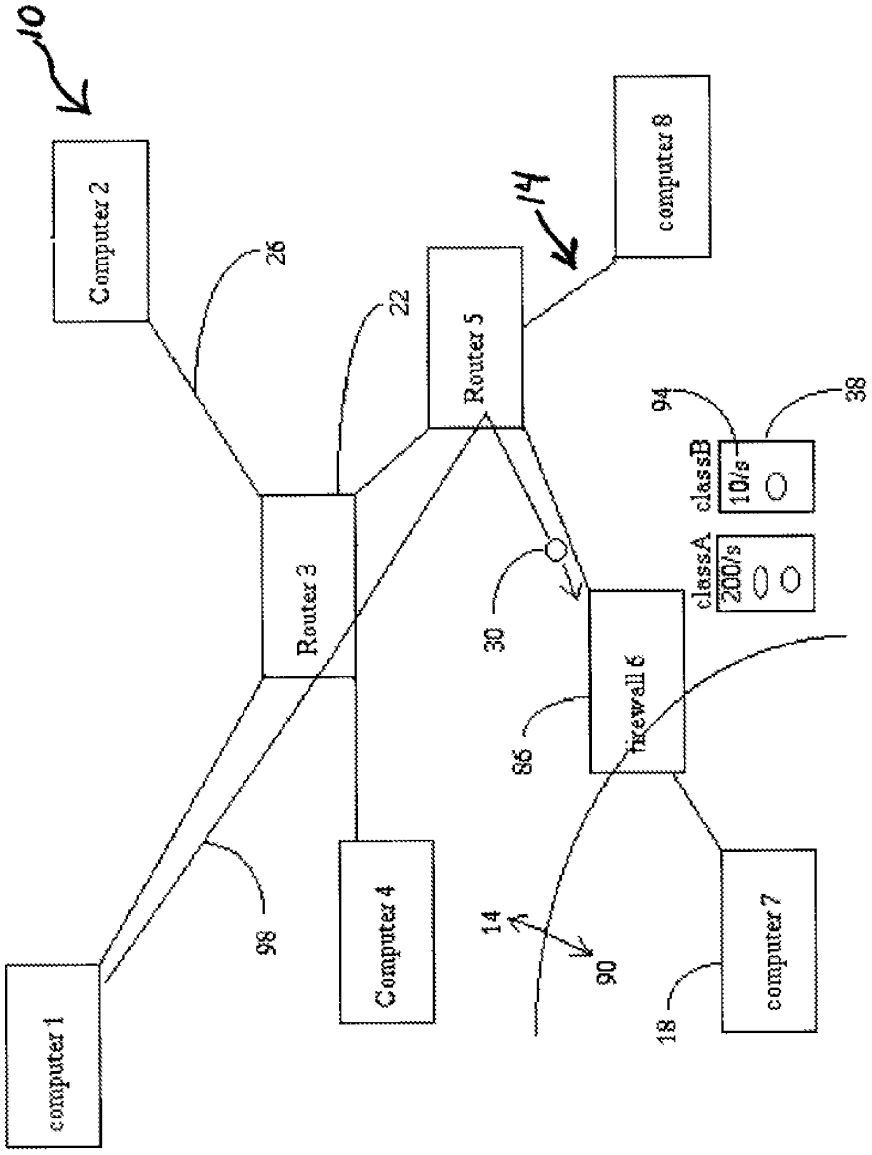

10
Computer 2
26
22
Router 5
14
computer 8
94
38
classB
10/s
classA
200/s
30
Router 3
firewall 6
86
98
Computer 4
14
90
18
computer 7
computer 1

Figure 7

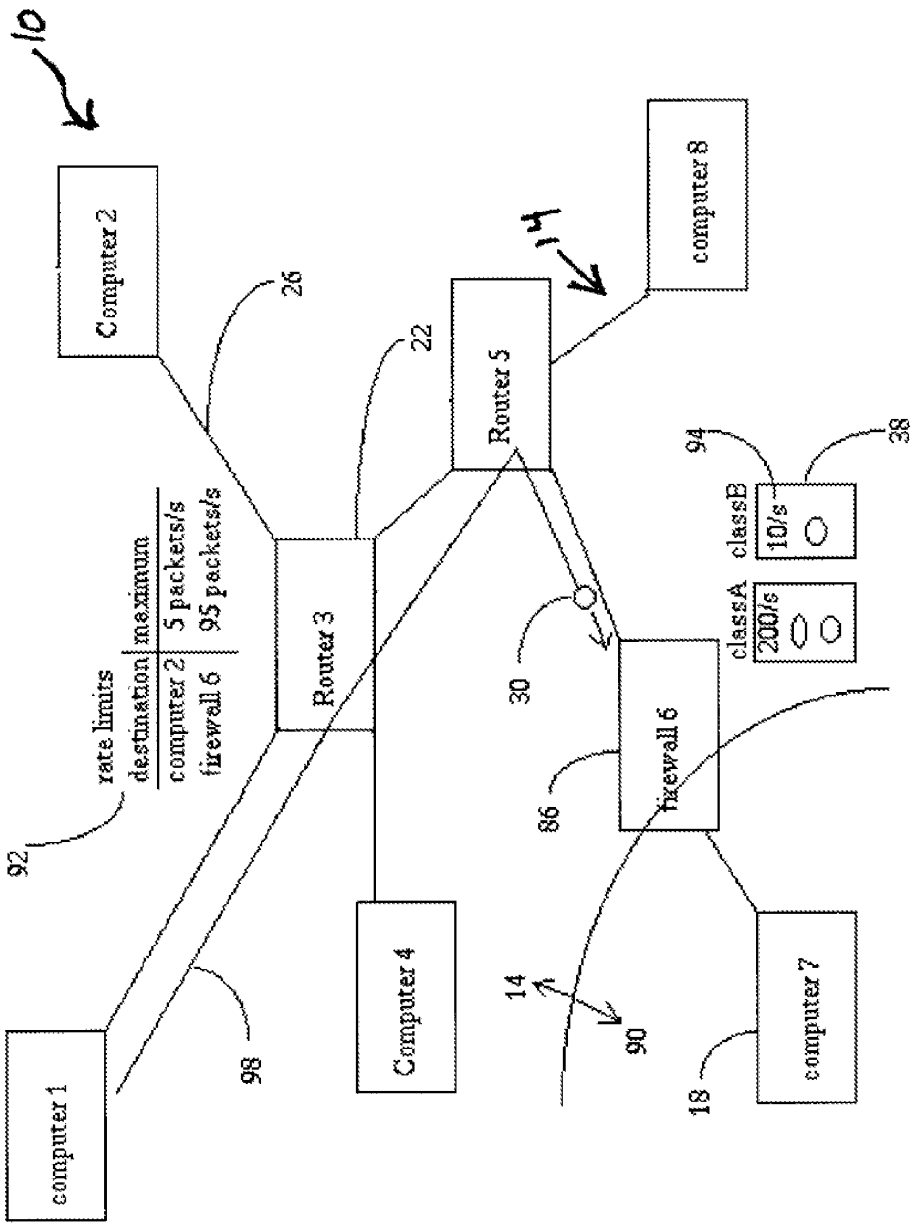

10
Computer 2
26
22
Router 5
14
computer 8
94
38
classB
10/s
classA
200/s
rate limits
destination | maximum
computer 2 | 5 packets/s
firewall 6 | 95 packets/s
92
Router 3
30
86
firewall 6
98
Computer 4
14
90
18
computer 7
computer 1

Figure 8

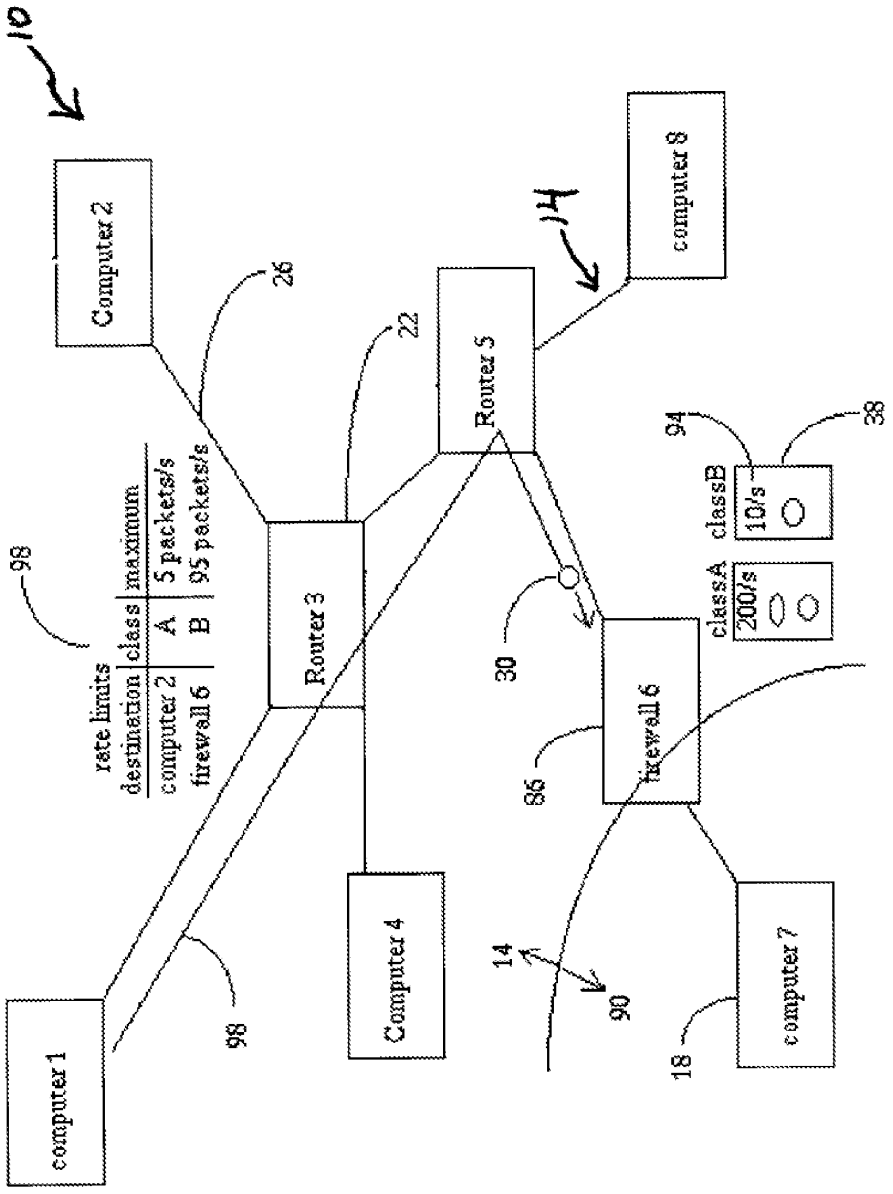

10
Computer 2
26
22
Router 5
14
computer 8
94
38
classB
10/s
classA
200/s
rate limits
destination | class | maximum
computer 2 | A | 5 packets/s
firewall 6 | B | 95 packets/s
98
Router 3
30
86
firewall 6
Computer 4
14
90
computer 7
18
98
computer 1

Figure 9

PACKET FLOODING DEFENSE SYSTEM

This invention was made with Government support under Contract # DAAH01-00-C-R211 awarded by U.S. Army Aviation and Missile Command. The Government has certain rights in the invention.

FIELD OF THE INVENTION

The invention pertains to network data transmission controls. More particularly, the invention relates to systems for minimizing the effects of packet flooding attacks directed against computers or routers connected to a network.

BACKGROUND OF THE INVENTION

Various types of systems have been developed for handling unwanted network data transmission incorporating a number of different technologies. U.S. Pat. No. 5,581,559 issued to Crayford et al. discloses a method that verifies the integrity of data transmitted over a network by comparing the destination address for a data packet with end station addresses stored on network repeaters. Where the destination address fails to match the stored end station addresses, the data packet will be disrupted.

U.S. Pat. No. 6,044,402 issued to Jacobson et al., describes a system in which the only data packets that are transmitted between source and destination network addresses are those that satisfy the blocking policies stored by the blocking data structure. Thus only, "pre-approved" data can flow through such a control mechanism. U.S. Pat. No. 5,455,865, issued to Perlman discloses a system that relies upon a stored list of acceptable packet identifiers at each node in the network. U.S. Pat. No. 5,353,353 issued to Vijeh et al. describes a system that determines the acceptability of data packets based upon a destination address/source address match and will disrupt any packet not satisfying these criteria. U.S. Pat. No. 5,850,515 issued to Lo et al. discloses a system that uses source and destination address matching to determine if packets should be transmitted to an end station or the end station disabled from participating in the network. It also employs a system where an end station can be disabled by a program that determines that a certain number of unauthorized packets have been detected. While other variations exist, the above-described designs for handling unwanted network data transmissions are typical of those encountered in the prior art.

The primary objective of the present invention is to defend against "packet flooding attacks" in which an attacker tries to use up all the bandwidth to the victim by sending data of little or no value (at least to the victim), thereby making more valuable communication with the victim slow or unreliable. A secondary objective is to defend against a related class of attacks in which the attacker tries to use up some other resource by sending more requests of some particular type to the victim than the victim can handle.

One way to view all these attacks is that a resource is being allocated in an unfair way. Well-behaved users request reasonable amounts, while attackers request unreasonable amounts. The most straight-forward allocation mechanism, which might be called "first come first served", ends up allocating almost all of the resource to the attackers. A more "fair" allocation would reduce the impact of an attacker to that of a normal user.

There are two obvious impediments to the "fair service" goal above. One is lack of a reliable way to associate incoming packets with those users among whom bandwidth should be fairly allocated. The other is lack of control over what packets arrive. The solution described here to both of these problems requires help from the routers that forward packets to the victim.

The defense is distributed among cooperating sites and routers. A set of transitively connected cooperating machines is called a "cooperating neighborhood". The quality of the defense is related to the size of the cooperating neighborhood, a larger neighborhood providing better defense. Within the neighborhood it is possible to trace the forwarding path of packets. The association of packets with the "users" is approximated by associating packets with "places" in the cooperating neighborhood from which those packets are forwarded. That is, service will be allocated in a fair (or otherwise reasonable) manner among these places. A "place" in this sense is typically a particular interface from which a packet arrived at a cooperating router.

One such place is likely to be shared by many actual users. An attack will deny service to those users sharing the same place. The advantage of a large number of such places is that each place is shared by fewer users, so an attack will deny service to fewer users. It is advantageous to a user who wants to communicate with a particular machine, to be in the cooperating neighborhood of that machine, since no attacker from another machine can deny him service. Conversely, an attacker wishing to deny service to as many users as possible prefers to share an entry point into the cooperating neighborhood with as many users as possible.

Routers will supply data about the forwarding path of the packets that arrive at a site. The site can use this data to allocate service as described above among the packets that arrive. This would solve the problem of unfair service if the packets that arrived were a fair sample of those that were sent to the site. This may not be the case, however, if routers are unable to forward all the packets they receive. To some extent fair service is limited by network topology, i.e., too many legitimate users trying to share parts of the same path will inevitably suffer relative to users of uncrowded paths. However another potential cause for this problem is a flooding attack against a router. That problem is solved by letting routers allocate their services in a similar way to that described above for sites. That is, they allocate the limited resource of forwarding bandwidth along any given output in a reasonable way among some set of places in the cooperating neighborhood.

The final step in the defense is that cooperating routers will limit the rate at which they forward packets to places that so request. This may not be essential in the allocation of service, but it is useful for limiting the bandwidth used by "unwanted" packets. The rate-limiting request is to be made when a site detects a high rate of unwanted packets coming from one place. This helps the site because it no longer has to process as many unwanted packets. It helps the network by freeing some of the bandwidth for other use.

Even if the traffic is not reduced, the distinction between "wanted" and "unwanted" packets plays an important role in "reasonable" allocation. For a site there are normally some packets (in fact, the great majority) that are expected in a very strong sense. It is reasonable to process these at the highest possible rate. All other packets are not exactly unwanted, but the site is willing to process them at only a limited rate. A reasonable approach is to schedule these as described above (using the places from which they were forwarded) at a limited rate, and regard as "unwanted" those that end up being significantly delayed (or discarded).

SUMMARY OF THE INVENTION

The present invention addresses many of the deficiencies of prior network defense systems and satisfies all of the objectives described above.

A packet flooding defense system for a network providing the desired features may be constructed from the following components. The network includes a plurality of host computers, routers, communication lines and transmitted data packets. Means are provided for classifying data packets received at a host computer as are means for associating a maximum acceptable processing rate with each class of data packet received at the computer. Means are also provided for the computer to find information for packets it receives regarding the path by which the packets came to the computer. Thus, the computer can use the information to allocate the processing rate available for packets of each class in a desired way.

In another variant, a packet flooding defense system for a network including a plurality of host computers, routers, communication lines and transmitted data packets includes means for classifying data packets received at a host computer and means for associating a maximum acceptable processing rate with each class of data packet received at the computer. Means are provided for the computer to determine the rate at which data packets of each class are transmitted from a router to the computer as are means for the router to receive information regarding maximum acceptable transmission rate for data packets being transmitted to the computer. Means are provided for the router to control the rate of transmission of data packets from the router to the computer. Thus, the rate of data packet transmissions received at the computer is kept below the maximum acceptable processing rate for each data packet class by the control of the rate of transmission of data packets from the router, thereby freeing a portion of the network providing data packet transmission to the computer.

In yet another variant, the router is capable of receiving information regarding maximum acceptable transmission rate for each class of data packet being transmitted to the computer and the router is capable of controlling the rate of transmission of each class of data packets to the computer.

In still another variant, a packet flooding defense system for a network including a plurality of host computers, routers, communication lines and transmitted data packets includes means for classifying data packets received at a router and means for associating a maximum acceptable transmission rate with each class of data packet received at the router. Means are provided for the router to find information for packets it receives regarding the path by which the packets came to the router. Thus, the router can use the information to allocate the transmission rate for each class in a desired way.

In a further variant of the invention, a packet flooding defense system for a network including a plurality of host computers, routers, communication lines and transmitted data packets includes means for classifying data packets received at a first router and means for associating a maximum acceptable transmission rate with each class of data packet received at the first router. Means are provided for the first router to determine the rate at which data packets of each class are transmitted from a second router to the first router as are means for the second router to receive information regarding maximum acceptable transmission rate for data packets being transmitted to the first router. Means are provided for the second router to control the rate of transmission of data packets from the second router to the first router. Thus, the rate of data packet transmissions received at the first router is kept below the maximum acceptable transmission rate for each data packet class by the control of the rate of transmission of data packets from the second router, thereby freeing a portion of the network providing data packet transmission to the first router.

In yet a further variant, the second router is capable of receiving information regarding maximum acceptable transmission rate for each class of data packet being transmitted to the first router and the second router is capable of controlling the rate of transmission of each class of data packets to the first router.

In another variant, a packet flooding defense system for a network including a plurality of host computers, routers, communication lines and transmitted data packets includes at least one firewall. The firewall includes hardware and software serving to control packet transmission between the network and a host computer connected to an internal network. Means are provided for classifying data packets received at the firewall as are means for associating a maximum acceptable transmission rate with each class of data packet received at the firewall. Means are provided for the firewall to find information for packets it receives regarding the path by which the packets came to the firewall. Thus, the firewall can use the information to allocate the transmission rate for each class in a desired way.

In still another variant of the invention, a packet flooding defense system for a network including a plurality of host computers, routers, communication lines and transmitted data packets includes at least one firewall. The firewall includes hardware and software serving to control packet transmission between the network and a host computer connected to an internal network and means for classifying data packets received at the firewall. Means are provided for associating a maximum acceptable transmission rate with each class of data packet received at the firewall as are means for the firewall to determine the rate at which data packets of each class are transmitted from a router to the firewall. Means are provided for the router to receive information regarding maximum acceptable transmission rate for data packets being transmitted to the firewall as are means for the router to control the rate of transmission of data packets from the router to the firewall. Thus, the rate of data packet transmissions received at the firewall is kept below the maximum acceptable transmission rate for each data packet class by the control of the rate of transmission of data packets from the router, thereby freeing a portion of the network providing data packet transmission to the firewall.

In a final variant of the invention, the router is capable of receiving information regarding maximum acceptable transmission rate for each class of data packet being transmitted to the firewall and the router is capable of controlling the rate of transmission of each class of data packets to the firewall.

An appreciation of the other aims and objectives of the present invention and an understanding of it may be achieved by referring to the accompanying drawings and the detailed description of a preferred embodiment.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of a first embodiment of the invention illustrating the association of maximum acceptable processing rates for each class of packet received at a computer and a path by which the packets came to the computer;

FIG. 2 is a schematic view of a second embodiment illustrating the association of maximum acceptable processing rates for each class of packet received at a computer, a path by which the packets came to the computer and illustrating information received at a router regarding maximum acceptable transmission rate for data packets being transmitted to the computer;

FIG. 3 is a schematic view of a third embodiment illustrating information received at a router regarding maximum

acceptable transmission rate for each class of data packets being transmitted to the computer;

FIG. **4** is a schematic view of a fourth embodiment illustrating association of maximum acceptable transmission rates for each class of packet received at a router and a path by which the packets came to the router;

FIG. **5** is a schematic view of a fifth embodiment illustrating the association of maximum acceptable transmission rates for each class of packet received at a first router, a path by which the packets came to the first router and illustrating information received at a second router regarding maximum acceptable transmission rate for data packets being transmitted to the first router;

FIG. **6** is a schematic view of a sixth embodiment illustrating information received at the second router regarding maximum acceptable transmission rate for each class of data packets being transmitted to the first router;

FIG. **7** is a schematic view of a seventh embodiment of the invention illustrating the association of maximum acceptable transmission rates for each class of packet received at a firewall and a path by which the packets came to the firewall;

FIG. **8** is a schematic view of an eighth embodiment illustrating the association of maximum acceptable transmission rates for each class of packet received at the firewall, a path by which the packets came to the firewall and illustrating information received at a router regarding maximum acceptable transmission rate for data packets being transmitted to the firewall; and

FIG. **9** is a schematic view of a ninth embodiment illustrating information received at a router regarding maximum acceptable transmission rate for each class of data packets being transmitted to the firewall.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. **1** illustrates a packet flooding defense system **10** for a network **14** providing the desired features that may be constructed from the following components. The network **14** includes a plurality of host computers **18**, routers **22**, communication lines **26** and transmitted data packets **30**. Means are provided for classifying data packets **30** received at a host computer **18** as are means for associating a maximum acceptable processing rate **34** with each class **38** of data packet **30** received at the computer **18**. Means are also provided for the computer **18** to find information for packets **30** it receives regarding the path **46** by which the packets **30** came to the computer **18**. Thus, the computer **18** can use the information to allocate the processing rate for each class **38** in a desired way among the places from which packets **30** are transmitted.

In another variant, as illustrated in FIG. **2**, a packet flooding defense system **10** for a network **14** including a plurality of host computers **18**, routers **22**, communication lines **26** and transmitted data packets **30** includes means for classifying data packets **30** received at a host computer **18** and means for associating a maximum acceptable processing rate **34** with each class **38** of data packet **30** received at the computer **18**. Means are provided for the computer **18** to determine the rate at which data packets **30** of each class **38** are transmitted from a router **22** to the computer **18** as are means for the router **22** to receive information regarding maximum acceptable transmission rate **70** for data packets **30** being transmitted to the computer **18**. Means are provided for the router **22** to control the rate of transmission of data packets **30** from the router **22** to the computer **18**. Thus, the rate of data packet transmissions received at the computer **18** is kept below the maximum acceptable processing rate **34** for each data packet class **38** by the control of the rate of transmission of data packets **30** from the router **22**, thereby freeing a portion of the network **14** providing data packet transmission to the computer **18**.

In yet another variant, as illustrated in FIG. **3**, the router **22** is capable of receiving information regarding maximum acceptable transmission rate **70** for each class **38** of data packet **30** being transmitted to the computer **18** and the router **22** is capable of controlling the rate of transmission of each class **38** of data packets **30** to the computer **18**.

In still another variant, as illustrated in FIG. **4**, a packet flooding defense system **10** for a network **14** including a plurality of host computers **18**, routers **22**, communication lines **26** and transmitted data packets **30**, includes means for classifying data packets **30** received at a router **22** and means for associating a maximum acceptable transmission rate **74** with each class **38** of data packet **30** received at the router **22**. Means are provided for the router **22** to find information for packets **30** it receives regarding the path **50** by which the packets **30** came to the router **22**. Thus, the router **22** can use the information to allocate the transmission rate for each class **38** in a desired way.

In a further variant of the invention, as illustrated in FIG. **5**, a packet flooding defense system **10** for a network **14** including a plurality of host computers **18**, routers **22**, communication lines **26** and transmitted data packets **30** includes means for classifying data packets **30** received at a first router **54** and means for associating a maximum acceptable transmission rate **78** with each class **38** of data packet **30** received at the first router **54**. Means are provided for the first router **54** to determine the rate at which data packets **30** of each class **38** are transmitted from a second router **58** to the first router **54** as are means for the second router **58** to receive information regarding maximum acceptable transmission rate **82** for data packets **30** being transmitted to the first router **54**. Means are provided for the second router **58** to control the rate of transmission of data packets **30** from the second router **58** to the first router **54**. Thus, the rate of data packet transmissions received at the first router **54** is kept below the maximum acceptable transmission rate **78** for each data packet class **38** by the control of the rate of transmission of data packets **30** from the second router **58**, thereby freeing a portion of the network **14** providing data packet transmission to the first router **54**.

In yet a further variant, as illustrated in FIG. **6**, the second router **58** is capable of receiving information regarding maximum acceptable transmission rate **84** for each class **38** of data packet **30** being transmitted to the first router **54** and the second router **58** is capable of controlling the rate of transmission of each class **38** of data packets **30** to the first router **54**.

In another variant, as illustrated in FIG. **7**, a packet flooding defense system **10** for a network **14** including a plurality of host computers **18**, routers **22**, communication lines **26** and transmitted data packets **30** includes at least one firewall **86**. The firewall **86** includes hardware and software serving to control packet transmission between the network **14** and a host computer **18** connected to an internal network **90**. Means are provided for classifying data packets **30** received at the firewall **86** as are means for associating a maximum acceptable transmission rate **94** with each class **38** of data packet **30** received at the firewall **86**. Means are provided for the firewall **86** to find information for packets **30** it receives regarding the path **98** by which the packets **30**

came to the firewall **86**. Thus, the firewall **86** can use the information to allocate the transmission rate for each class **38** in a desired way.

In still another variant of the invention, as illustrated in FIG. **8**, a packet flooding defense system **10** for a network **14** including a plurality of host computers **18**, routers **22**, communication lines **26** and transmitted data packets **30** includes at least one firewall **86**. The firewall **86** includes hardware and software serving to control packet transmission between the network **14** and a host computer **18** connected to an internal network **90** and means for classifying data packets **30** received at the firewall **86**. Means are provided for associating a maximum acceptable transmission rate **94** with each class **38** of data packet **30** received at the firewall **86** as are means for the firewall **86** to determine the rate at which data packets **30** of each class **38** are transmitted from a router **22** to the firewall **86**. Means are provided for the router **22** to receive information regarding maximum acceptable transmission rate **92** for data packets **30** being transmitted to the firewall **86** as are means for the router **22** to control the rate of transmission of data packets **30** from the router **22** to the firewall **86**. Thus, the rate of data packet transmissions received at the firewall **86** is kept below the maximum acceptable transmission rate **94** for each data packet class **38** by the control of the rate of transmission of data packets **30** from the router **22**, thereby freeing a portion of the network **14** providing data packet transmission to the firewall **86**.

In a final variant of the invention, as illustrated in FIG. **9**, the router **22** is capable of receiving information regarding maximum acceptable transmission rate **98** for each class **38** of data packet **30** being transmitted to the firewall **86** and the router **22** is capable of controlling the rate of transmission of each class **38** of data packets **30** to the firewall **86**.

The packet flooding defense system **10** has been described with reference to particular embodiments. Other modifications and enhancements can be made without departing from the spirit and scope of the claims that follow.

What is claimed is:

1. A packet flooding defense system for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets, said system comprising: at least one firewall, said firewall comprising:

hardware and software serving to control packet transmission between said network and a host computer connected to an internal network;

means for classifying data packets received at said firewall;

means for associating a maximum acceptable transmission rate with each class of data packet received at said firewall;

means for said firewall to find information for packets it receives regarding the path by which said packets came to said firewall; and

whereby, said firewall can use said information to allocate the transmission rate for each class in a desired way.

2. A packet flooding defense system for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets, said system comprising:

at least one firewall, said firewall comprising:

hardware and software serving to control packet transmission between said network and a host computer connected to an internal network;

means for classifying data packets received at said firewall;

means for associating a maximum acceptable transmission rate with each class of data packet received at said firewall;

means for said firewall to determine the rate at which data packets of each class are transmitted from a router to said firewall;

means for said router to receive information regarding maximum acceptable transmission rate for data packets being transmitted to said firewall;

means for said router to control the rate of transmission of data packets from said router to said firewall; and

whereby, the rate of data packet transmissions received at said firewall is kept below the maximum acceptable transmission rate for each data packet class by said control of the rate of transmission of data packets from said router, thereby freeing a portion of the network providing data packet transmission to said firewall.

3. A packet flooding defense system as described in claim **2**, wherein:

said router is capable of receiving information regarding maximum acceptable transmission rate for each class of data packet being transmitted to said firewall; and

said router is capable of controlling the rate of transmission of each class of data packets to said firewall.

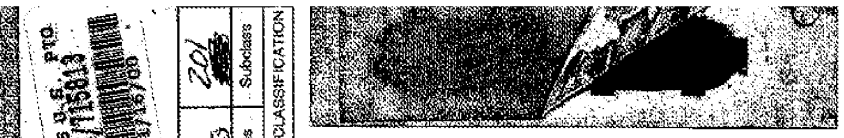
* * * * *

Exhibit 1028

Prosecution History of U.S. Patent 6,789,190

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PATENT NUMBER

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U.S. **UTILITY** Patent Application

ISSUE CLASSIFICATION	Class	Subclass
	713	201

O.I.P.E.	PATENT DATE
SCANNED 380 G.A. CFH	SEP 07 2004

APPLICATION NO.	CONT/PRIOR	CLASS	SUBCLASS	ART UNIT	EXAMINER
09/715813		380	161	~~2735~~ 2135	Baum

APPLICANTS: Donald Cohen

TITLE: Packet flooding defense system

PTO-2040 12/98

ISSUING CLASSIFICATION

ORIGINAL CLASS	ORIGINAL SUBCLASS	CROSS REFERENCE(S) CLASS	CROSS REFERENCE(S) SUBCLASS (ONE SUBCLASS PER BLOCK)
713	160	709	238

INTERNATIONAL CLASSIFICATION: G06F 11/30

☐ Continued on Issue Slip Inside File Jacket

8/10/04 Formal Drawings (9 sht(s)) rec'd 11/16/00

☐ TERMINAL DISCLAIMER	DRAWINGS Sheets Drwg.	Figs. Drwg.	Print Fig.	CLAIMS ALLOWED Total Claims	Print Claim for O.G.
	9	9	1	3	1

☐ The term of this patent subsequent to _____ (date) has been disclaimed.

RONALD BAUM (Assistant Examiner) 6/1/04 (Date)

NOTICE OF ALLOWANCE MAILED: 06/08/04

☐ The term of this patent shall not extend beyond the expiration date of U.S Patent. No. _____

AYAZ SHEIKH
SUPERVISORY PATENT EXAMINER
TECHNOLOGY CENTER 2100
(Primary Examiner) 6/3/04 (Date)

ISSUE FEE

Amount Due	Date Paid
$665	8/2/04 JRN

☐ The terminal ____months of this patent have been disclaimed.

(Legal Instruments Examiner) 6/7/04 (Date)

ISSUE BATCH NUMBER

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PATENT APPLICATION SERIAL NO. 09-715813

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE
FEE RECORD SHEET

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(5/87)

*U.S. GPO: 1999-459-082/19144

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Bib Data Sheet

SERIAL NUMBER	FILING DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
09/715,813	11/16/2000 RULE	380	2131	Q982-DB

APPLICANTS
Donald N. Cohen, Los Angeles, CA ;

** CONTINUING DATA *********

** FOREIGN APPLICATIONS *********

IF REQUIRED, FOREIGN FILING LICENSE GRANTED ** 02/22/2001

** SMALL ENTITY **

Foreign Priority claimed	STATE OR COUNTRY	SHEETS DRAWING	TOTAL CLAIMS	INDEPENDENT CLAIMS
☐ yes ☑ no 35 USC 119 (a-d) conditions met ☐ yes ☑ no ☐ Met after Allowance Verified and Acknowledged _____ Examiner's Signature _____ Initials	CA	9	9	6

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TITLE

Packet flooding defense system

FILING FEE RECEIVED	FEES: Authority has been given in Paper
475	No. _____ to charge/credit DEPOSIT ACCOUNT No. _____ for following:

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PATENT APPLICATION TRANSMITTAL LETTER (Small Entity)	Docket No. Q982-DB

TO THE ASSISTANT COMMISSIONER FOR PATENTS

Transmitted herewith for filing under 35 U.S.C. 111 and 37 C.F.R. 1.53 is the patent application of:

DONALD N. COHEN

For: **PACKET FLOODING DEFENSE SYSTEM**

Enclosed are:

- ☒ Certificate of Mailing with Express Mail Mailing Label No. **EL680358285**
- ☒ 9 sheets of drawings.
- ☐ A certified copy of a application.
- ☒ Declaration ☒ Signed. ☐ Unsigned.
- ☒ Power of Attorney
- ☐ Information Disclosure Statement
- ☐ Preliminary Amendment
- ☐ Small Entity Status declared by Attorney for Applicant
  Verified Statement(s) to Establish Small Entity Status Under 37 C.F.R. 1.9 and 1.27.
- ☒ Other: **Assignment of Rights, Title and Interest in Invention, and check in the sum of $40.00**

CLAIMS AS FILED

For	#Filed	#Allowed	#Extra	Rate	Fee
Total Claims	9	- 20 =	0	x $9.00	$0.00
Indep. Claims	6	- 3 =	3	x $40.00	$120.00
Multiple Dependent Claims (check if applicable) ☐					$0.00
				BASIC FEE	$355.00
				TOTAL FILING FEE	$475.00

- ☒ A check in the amount of **$475.00** to cover the filing fee is enclosed.
- ☒ The Commissioner is hereby authorized to charge and credit Deposit Account No. **02-1731** as described below. A duplicate copy of this sheet is enclosed.
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  - ☒ Credit any overpayment.
  - ☒ Charge any additional filing fees required under 37 C.F.R. 1.16 and 1.17.
  - ☐ Charge the issue fee set in 37 C.F.R. 1.18 at the mailing of the Notice of Allowance, pursuant to 37 C.F.R. 1.311(b).

Dated: **November 16, 2000**

Signature

cc:

P01SMALL/REV05

PATENT APPLICATION TRANSMITTAL LETTER (Small Entity)	Docket No. Q982-DB

TO THE ASSISTANT COMMISSIONER FOR PATENTS

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- ☐ Preliminary Amendment
- ☐ Small Entity Status declared by Attorney for Applicant
- ☐ Verified Statement(s) to Establish Small Entity Status Under 37 C.F.R. 1.9 and 1.27.
- ☐ Other: **Assignment of Rights, Title and Interest in Invention, and check in the sum of $40.00**

CLAIMS AS FILED

For	#Filed	#Allowed	#Extra	Rate	Fee
Total Claims	9	- 20 =	0	x $9.00	$0.00
Indep. Claims	6	- 3 =	3	x $40.00	$120.00
Multiple Dependent Claims (check if applicable) ☐					$0.00
				BASIC FEE	$355.00
				TOTAL FILING FEE	$475.00

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  - ☐ Charge the issue fee set in 37 C.F.R. 1.18 at the mailing of the Notice of Allowance, pursuant to 37 C.F.R. 1.311(b).

Dated: **November 16, 2000**

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CERTIFICATE OF MAILING BY "EXPRESS MAIL" (37 CFR 1.10) Applicant(s): Donald N. Cohen			Docket No. Q982-DB
Serial No. Not yet known	Filing Date Filed herewith	Examiner	Group Art Unit

Invention: PACKET FLOODING DEFENSE SYSTEM

jc825 U.S. PTO
09/715013
11/16/00

I hereby certify that this Patent Application, above referenced.
(Identify type of correspondence)

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Packet Flooding Defense System

Field of Invention

The invention pertains to network data transmission controls. More particularly, the invention relates to systems for minimizing the effects of packet flooding attacks directed against computers or routers connected to a network.

Background of the Invention

Various types of systems have been developed for handling unwanted network data transmission incorporating a number of different technologies. U.S. Patent No. 5,581,559 issued to *Crayford et al.* discloses a method that verifies the integrity of data transmitted over a network by comparing the destination address for a data packet with end station addresses stored on network repeaters. Where the destination address fails to match the stored end station addresses, the data packet will be disrupted.

U.S. Patent No. 6,044,402 issued to *Jacobson et al.*, describes a system in which the only data packets that are transmitted between source and destination network addresses are those that satisfy the blocking policies stored by the blocking data structure. Thus only, "pre-approved" data can flow through such a control mechanism. U.S. Patent No. 5,455,865, issued to *Perlman* discloses a system that relies upon a stored list of acceptable packet identifiers at each node in the network. U.S. Patent No. 5,353,353 issued to *Vijeh et al.* describes a system that determines the acceptability of data packets based upon a destination address/source address match and will disrupt any packet not satisfying these criteria. U.S. Patent No. 5,850,515 issued to *Lo et al.* discloses a system that uses source and destination address matching to determine if packets should be transmitted to an end station or the end

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station disabled from participating in the network. It also employs a system where an end station can be disabled by a program that determines that a certain number of unauthorized packets have been detected. While other variations exist, the above-described designs for handling unwanted network data transmissions are typical of those encountered in the prior art.

The primary objective of the present invention is to defend against "packet flooding attacks" in which an attacker tries to use up all the bandwidth to the victim by sending data of little or no value (at least to the victim), thereby making more valuable communication with the victim slow or unreliable. A secondary objective is to defend against a related class of attacks in which the attacker tries to use up some other resource by sending more requests of some particular type to the victim than the victim can handle.

One way to view all these attacks is that a resource is being allocated in an unfair way. Well-behaved users request reasonable amounts, while attackers request unreasonable amounts. The most straight-forward allocation mechanism, which might be called "first come first served", ends up allocating almost all of the resource to the attackers. A more "fair" allocation would reduce the impact of an attacker to that of a normal user.

There are two obvious impediments to the "fair service" goal above. One is lack of a reliable way to associate incoming packets with those users among whom bandwidth should be fairly allocated. The other is lack of control over what packets arrive. The solution described here to both of these problems requires help from the routers that forward packets to the victim.

The defense is distributed among cooperating sites and routers. A set of transitively connected cooperating machines is called a "cooperating neighborhood". The quality of the

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defense is related to the size of the cooperating neighborhood, a larger neighborhood providing better defense. Within the neighborhood it is possible to trace the forwarding path of packets. The association of packets with the "users" is approximated by associating packets with "places" in the cooperating neighborhood from which those packets are forwarded. That is, service will be allocated in a fair (or otherwise reasonable) manner among these places. A "place" in this sense is typically a particular interface from which a packet arrived at a cooperating router.

One such place is likely to be shared by many actual users. An attack will deny service to those users sharing the same place. The advantage of a large number of such places is that each place is shared by fewer users, so an attack will deny service to fewer users. It is advantageous to a user who wants to communicate with a particular machine, to be in the cooperating neighborhood of that machine, since no attacker from another machine can deny him service. Conversely, an attacker wishing to deny service to as many users as possible prefers to share an entry point into the cooperating neighborhood with as many users as possible.

Routers will supply data about the forwarding path of the packets that arrive at a site. The site can use this data to allocate service as described above among the packets that arrive. This would solve the problem of unfair service if the packets that arrived were a fair sample of those that were sent to the site. This may not be the case, however, if routers are unable to forward all the packets they receive. To some extent fair service is limited by network topology, i.e., too many legitimate users trying to share parts of the same path will inevitably suffer relative to users of uncrowded paths. However another potential cause for this problem is a flooding attack against a router. That problem is solved by letting routers allocate their

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services in a similar way to that described above for sites. That is, they allocate the limited resource of forwarding bandwidth along any given output in a reasonable way among some set of places in the cooperating neighborhood.

The final step in the defense is that cooperating routers will limit the rate at which they forward packets to places that so request. This may not be essential in the allocation of service, but it is useful for limiting the bandwidth used by "unwanted" packets. The rate-limiting request is to be made when a site detects a high rate of unwanted packets coming from one place. This helps the site because it no longer has to process as many unwanted packets. It helps the network by freeing some of the bandwidth for other use.

Even if the traffic is not reduced, the distinction between "wanted" and "unwanted" packets plays an important role in "reasonable" allocation. For a site there are normally some packets (in fact, the great majority) that are expected in a very strong sense. It is reasonable to process these at the highest possible rate. All other packets are not exactly unwanted, but the site is willing to process them at only a limited rate. A reasonable approach is to schedule these as described above (using the places from which they were forwarded) at a limited rate, and regard as "unwanted" those that end up being significantly delayed (or discarded).

Summary of the Invention

The present invention addresses many of the deficiencies of prior network defense systems and satisfies all of the objectives described above.

A packet flooding defense system for a network providing the desired features may be constructed from the following components. The network includes a plurality of host

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computers, routers, communication lines and transmitted data packets. Means are provided for classifying data packets received at a host computer as are means for associating a maximum acceptable processing rate with each class of data packet received at the computer. Means are also provided for the computer to find information for packets it receives regarding the path by which the packets came to the computer. Thus, the computer can use the information to allocate the processing rate available for packets of each class in a desired way.

In another variant, a packet flooding defense system for a network including a plurality of host computers, routers, communication lines and transmitted data packets includes means for classifying data packets received at a host computer and means for associating a maximum acceptable processing rate with each class of data packet received at the computer. Means are provided for the computer to determine the rate at which data packets of each class are transmitted from a router to the computer as are means for the router to receive information regarding maximum acceptable transmission rate for data packets being transmitted to the computer. Means are provided for the router to control the rate of transmission of data packets from the router to the computer. Thus, the rate of data packet transmissions received at the computer is kept below the maximum acceptable processing rate for each data packet class by the control of the rate of transmission of data packets from the router, thereby freeing a portion of the network providing data packet transmission to the computer.

In yet another variant, the router is capable of receiving information regarding maximum acceptable transmission rate for each class of data packet being transmitted to the computer and the router is capable of controlling the rate of transmission of each class of data packets to the computer.

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In still another variant, a packet flooding defense system for a network including a plurality of host computers, routers, communication lines and transmitted data packets includes means for classifying data packets received at a router and means for associating a maximum acceptable transmission rate with each class of data packet received at the router. Means are provided for the router to find information for packets it receives regarding the path by which the packets came to the router. Thus, the router can use the information to allocate the transmission rate for each class in a desired way.

In a further variant of the invention, a packet flooding defense system for a network including a plurality of host computers, routers, communication lines and transmitted data packets includes means for classifying data packets received at a first router and means for associating a maximum acceptable transmission rate with each class of data packet received at the first router. Means are provided for the first router to determine the rate at which data packets of each class are transmitted from a second router to the first router as are means for the second router to receive information regarding maximum acceptable transmission rate for data packets being transmitted to the first router. Means are provided for the second router to control the rate of transmission of data packets from the second router to the first router. Thus, the rate of data packet transmissions received at the first router is kept below the maximum acceptable transmission rate for each data packet class by the control of the rate of transmission of data packets from the second router, thereby freeing a portion of the network providing data packet transmission to the first router.

In yet a further variant, the second router is capable of receiving information regarding maximum acceptable transmission rate for each class of data packet being transmitted to the

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first router and the second router is capable of controlling the rate of transmission of each class of data packets to the first router.

In another variant, a packet flooding defense system for a network including a plurality of host computers, routers, communication lines and transmitted data packets includes at least one firewall. The firewall includes hardware and software serving to control packet transmission between the network and a host computer connected to an internal network. Means are provided for classifying data packets received at the firewall as are means for associating a maximum acceptable transmission rate with each class of data packet received at the firewall. Means are provided for the firewall to find information for packets it receives regarding the path by which the packets came to the firewall. Thus, the firewall can use the information to allocate the transmission rate for each class in a desired way.

In still another variant of the invention, a packet flooding defense system for a network including a plurality of host computers, routers, communication lines and transmitted data packets includes at least one firewall. The firewall includes hardware and software serving to control packet transmission between the network and a host computer connected to an internal network and means for classifying data packets received at the firewall. Means are provided for associating a maximum acceptable transmission rate with each class of data packet received at the firewall as are means for the firewall to determine the rate at which data packets of each class are transmitted from a router to the firewall. Means are provided for the router to receive information regarding maximum acceptable transmission rate for data packets being transmitted to the firewall as are means for the router to control the rate of transmission of data packets from the router to the firewall. Thus, the rate of data packet transmissions received at the firewall is kept below the maximum acceptable transmission rate

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for each data packet class by the control of the rate of transmission of data packets from the router, thereby freeing a portion of the network providing data packet transmission to the firewall.

In a final variant of the invention, the router is capable of receiving information regarding maximum acceptable transmission rate for each class of data packet being transmitted to the firewall and the router is capable of controlling the rate of transmission of each class of data packets to the firewall.

An appreciation of the other aims and objectives of the present invention and an understanding of it may be achieved by referring to the accompanying drawings and the detailed description of a preferred embodiment.

Description of the Drawings

Figure 1 is a schematic view of a first embodiment of the invention illustrating the association of maximum acceptable processing rates for each class of packet received at a computer and a path by which the packets came to the computer;

Figure 2 is a schematic view of a second embodiment illustrating the association of maximum acceptable processing rates for each class of packet received at a computer, a path by which the packets came to the computer and illustrating information received at a router regarding maximum acceptable transmission rate for data packets being transmitted to the computer;

Figure 3 is a schematic view of a third embodiment illustrating information received at a router regarding maximum acceptable transmission rate for each class of data packets being transmitted to the computer;

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Figure 4 is a schematic view of a fourth embodiment illustrating association of maximum acceptable transmission rates for each class of packet received at a router and a path by which the packets came to the router;

Figure 5 is a schematic view of a fifth embodiment illustrating the association of maximum acceptable transmission rates for each class of packet received at a first router, a path by which the packets came to the first router and illustrating information received at a second router regarding maximum acceptable transmission rate for data packets being transmitted to the first router;

Figure 6 is a schematic view of a sixth embodiment illustrating information received at the second router regarding maximum acceptable transmission rate for each class of data packets being transmitted to the first router;

Figure 7 is a schematic view of a seventh embodiment of the invention illustrating the association of maximum acceptable transmission rates for each class of packet received at a firewall and a path by which the packets came to the firewall;

Figure 8 is a schematic view of an eighth embodiment illustrating the association of maximum acceptable transmission rates for each class of packet received at the firewall, a path by which the packets came to the firewall and illustrating information received at a router regarding maximum acceptable transmission rate for data packets being transmitted to the firewall; and

Figure 9 is a schematic view of a ninth embodiment illustrating information received at a router regarding maximum acceptable transmission rate for each class of data packets being transmitted to the firewall.

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Detailed Description of the Preferred Embodiment

Figure 1 illustrates a packet flooding defense system **10** for a network **14** providing the desired features that may be constructed from the following components. The network **14** includes a plurality of host computers **18**, routers **22**, communication lines **26** and transmitted data packets **30**. Means are provided for classifying data packets **30** received at a host computer **18** as are means for associating a maximum acceptable processing rate **34** with each class **38** of data packet **30** received at the computer **18**. Means are also provided for the computer **18** to find information for packets **30** it receives regarding the path **46** by which the packets **30** came to the computer **18**. Thus, the computer **18** can use the information to allocate the processing rate for each class **38** in a desired way among the places from which packets **30** are transmitted.

In another variant, as illustrated in **Figure 2**, a packet flooding defense system **10** for a network **14** including a plurality of host computers **18**, routers **22**, communication lines **26** and transmitted data packets **30** includes means for classifying data packets **30** received at a host computer **18** and means for associating a maximum acceptable processing rate **34** with each class **38** of data packet **30** received at the computer **18**. Means are provided for the computer **18** to determine the rate at which data packets **30** of each class **38** are transmitted from a router **22** to the computer **18** as are means for the router **22** to receive information regarding maximum acceptable transmission rate **70** for data packets **30** being transmitted to the computer **18**. Means are provided for the router **22** to control the rate of transmission of data

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packets **30** from the router **22** to the computer **18**. Thus, the rate of data packet transmissions received at the computer **18** is kept below the maximum acceptable processing rate **34** for each data packet class **38** by the control of the rate of transmission of data packets **30** from the router **22**, thereby freeing a portion of the network **14** providing data packet transmission to the computer **18**.

In yet another variant, as illustrated in **Figure 3**, the router **22** is capable of receiving information regarding maximum acceptable transmission rate **70** for each class **38** of data packet **30** being transmitted to the computer **18** and the router **22** is capable of controlling the rate of transmission of each class **38** of data packets **30** to the computer **18**.

In still another variant, as illustrated in **Figure 4**, a packet flooding defense system **10** for a network **14** including a plurality of host computers **18**, routers **22**, communication lines **26** and transmitted data packets **30**, includes means for classifying data packets **30** received at a router **22** and means for associating a maximum acceptable transmission rate **74** with each class **38** of data packet **30** received at the router **22**. Means are provided for the router **22** to find information for packets **30** it receives regarding the path **50** by which the packets **30** came to the router **22**. Thus, the router **22** can use the information to allocate the transmission rate for each class **38** in a desired way.

In a further variant of the invention, as illustrated in **Figure 5**, a packet flooding defense system **10** for a network **14** including a plurality of host computers **18**, routers **22**, communication lines **26** and transmitted data packets **30** includes means for classifying data packets **30** received at a first router **54** and means for associating a maximum acceptable transmission rate **78** with each class **38** of data packet **30** received at the first router **54**. Means are provided for the first router **54** to determine the rate at which data packets **30** of each class

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38 are transmitted from a second router 58 to the first router 54 as are means for the second router 58 to receive information regarding maximum acceptable transmission rate 82 for data packets 30 being transmitted to the first router 54. Means are provided for the second router 58 to control the rate of transmission of data packets 30 from the second router 58 to the first router 54. Thus, the rate of data packet transmissions received at the first router 54 is kept below the maximum acceptable transmission rate 78 for each data packet class 38 by the control of the rate of transmission of data packets 30 from the second router 58 , thereby freeing a portion of the network 14 providing data packet transmission to the first router 54.

In yet a further variant, as illustrated in **Figure 6**, the second router 58 is capable of receiving information regarding maximum acceptable transmission rate 84 for each class 38 of data packet 30 being transmitted to the first router 54 and the second router 58 is capable of controlling the rate of transmission of each class 38 of data packets 30 to the first router 54.

In another variant, as illustrated in **Figure 7**, a packet flooding defense system 10 for a network 14 including a plurality of host computers 18, routers 22, communication lines 26 and transmitted data packets 30 includes at least one firewall 86. The firewall 86 includes hardware and software serving to control packet transmission between the network 14 and a host computer 18 connected to an internal network 90. Means are provided for classifying data packets 30 received at the firewall 86 as are means for associating a maximum acceptable transmission rate 94 with each class 38 of data packet 30 received at the firewall 86. Means are provided for the firewall 86 to find information for packets 30 it receives regarding the path 98 by which the packets 30 came to the firewall 86. Thus, the firewall 86 can use the information to allocate the transmission rate for each class 38 in a desired way.

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In still another variant of the invention, as illustrated in **Figure 8**, a packet flooding defense system **10** for a network **14** including a plurality of host computers **18**, routers **22**, communication lines **26** and transmitted data packets **30** includes at least one firewall **86**. The firewall **86** includes hardware and software serving to control packet transmission between the network **14** and a host computer **18** connected to an internal network **90** and means for classifying data packets **30** received at the firewall **86**. Means are provided for associating a maximum acceptable transmission rate **94** with each class **38** of data packet **30** received at the firewall **86** as are means for the firewall **86** to determine the rate at which data packets **30** of each class **38** are transmitted from a router **22** to the firewall **86**. Means are provided for the router **22** to receive information regarding maximum acceptable transmission rate **92** for data packets **30** being transmitted to the firewall **86** as are means for the router **22** to control the rate of transmission of data packets **30** from the router **22** to the firewall **86**. Thus, the rate of data packet transmissions received at the firewall **86** is kept below the maximum acceptable transmission rate **94** for each data packet class **38** by the control of the rate of transmission of data packets **30** from the router **22**, thereby freeing a portion of the network **14** providing data packet transmission to the firewall **86**.

In a final variant of the invention, as illustrated in **Figure 9**, the router **22** is capable of receiving information regarding maximum acceptable transmission rate **98** for each class **38** of data packet **30** being transmitted to the firewall **86** and the router **22** is capable of controlling the rate of transmission of each class **38** of data packets **30** to the firewall **86**.

The packet flooding defense system **10** has been described with reference to particular embodiments. Other modifications and enhancements can be made without departing from the spirit and scope of the claims that follow.

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CLAIMS

1. A packet flooding defense system for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets, said system comprising:

means for classifying data packets received at a host computer;

means for associating a maximum acceptable processing rate with each class of data packet received at said computer;

means for said computer to find information for packets it receives regarding the path by which said packets came to said computer; and

whereby, said computer can use said information to allocate the processing rate available for packets of each class in a desired way.

2. A packet flooding defense system for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets, said system comprising:

means for classifying data packets received at a host computer;

means for associating a maximum acceptable processing rate with each class of data packet received at said computer;

means for said computer to determine the rate at which data packets of each class are transmitted from a router to said computer;

means for said router to receive information regarding maximum acceptable transmission rate for data packets being transmitted to said computer;

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means for said router to control the rate of transmission of data packets from said router to said computer; and

whereby, the rate of data packet transmissions received at said computer is kept below the maximum acceptable processing rate for each data packet class by said control of the rate of transmission of data packets from said router, thereby freeing a portion of the network providing data packet transmission to said computer.

3. A packet flooding defense system as described in Claim 2, wherein:

said router is capable of receiving information regarding maximum acceptable transmission rate for each class of data packet being transmitted to said computer; and

said router is capable of control

ling the rate of transmission of each class of data packets to said computer.

4. A packet flooding defense system for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets, said system comprising:

means for classifying data packets received at a router;

means for associating a maximum acceptable transmission rate with each class of data packet received at said router;

means for said router to find information for packets it receives regarding the path by which said packets came to said router; and

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whereby, said router can use said information to allocate the transmission rate for each class in a desired way.

5. A packet flooding defense system for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets, said system comprising:

means for classifying data packets received at a first router;

means for associating a maximum acceptable transmission rate with each class of data packet received at said first router;

means for said first router to determine the rate at which data packets of each class are transmitted from a second router to said first router;

means for said second router to receive information regarding maximum acceptable transmission rate for data packets being transmitted to said first router;

means for said second router to control the rate of transmission of data packets from said second router to said first router; and

whereby, the rate of data packet transmissions received at said first router is kept below the maximum acceptable transmission rate for each data packet class by said control of the rate of transmission of data packets from said second router, thereby freeing a portion of the network providing data packet transmission to said first router.

6. A packet flooding defense system as described in Claim 5, wherein:

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said second router is capable of receiving information regarding maximum acceptable transmission rate for each class of data packet being transmitted to said first router; and

said second router is capable of controlling the rate of transmission of each class of data packets to said first router.

7. A packet flooding defense system for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets, said system comprising:

at least one firewall, said firewall comprising:

hardware and software serving to control packet transmission between said network and a host computer connected to an internal network;

means for classifying data packets received at said firewall;

means for associating a maximum acceptable transmission rate with each class of data packet received at said firewall;

means for said firewall to find information for packets it receives regarding the path by which said packets came to said firewall; and

whereby, said firewall can use said information to allocate the transmission rate for each class in a desired way.

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8. A packet flooding defense system for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets, said system comprising:

at least one firewall, said firewall comprising:

hardware and software serving to control packet transmission between said network and a host computer connected to an internal network;

means for classifying data packets received at said firewall;

means for associating a maximum acceptable transmission rate with each class of data packet received at said firewall;

means for said firewall to determine the rate at which data packets of each class are transmitted from a router to said firewall;

means for said router to receive information regarding maximum acceptable transmission rate for data packets being transmitted to said firewall;

means for said router to control the rate of transmission of data packets from said router to said firewall; and

whereby, the rate of data packet transmissions received at said firewall is kept below the maximum acceptable transmission rate for each data packet class by said control of the rate of transmission of data packets from said router, thereby freeing a portion of the network providing data packet transmission to said firewall.

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9. A packet flooding defense system as described in Claim 8, wherein:

said router is capable of receiving information regarding maximum acceptable transmission rate for each class of data packet being transmitted to said firewall; and

said router is capable of controlling the rate of transmission of each class of data packets to said firewall.

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ABSTRACT

The invention prevents "packet flooding", where an attacker uses up all available bandwidth to a victim with useless data. It can also be used to prevent some other related denial of service attacks. The defense is distributed among cooperating sites and routers. The sites identify data they don't want. The routers help sites to determine which routers forward that data. The sites then ask these routers to reduce the rate at which such data is forwarded. Variations of the defense protect against packet flooding attacks on routers and attacks in which an attacker tries to use up some service offered by a site.

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Docket No.
Q982-P

Declaration and Power of Attorney For Patent Application

English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

PACKET FLOODING DEFENSE SYSTEM

the specification of which

(check one)

☒ is attached hereto.

☐ was filed on _____ as United States Application No. or PCT International Application Number _____

and was amended on _____
(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)			Priority Not Claimed
_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	☐
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_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	☐

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I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional

(Application Serial No.)	(Filing Date)
(Application Serial No.)	(Filing Date)
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I hereby claim the benefit under 35 U. S. C. Section 120 of any United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, C. F. R., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

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Second inventor's signature — Date

Residence

Citizenship

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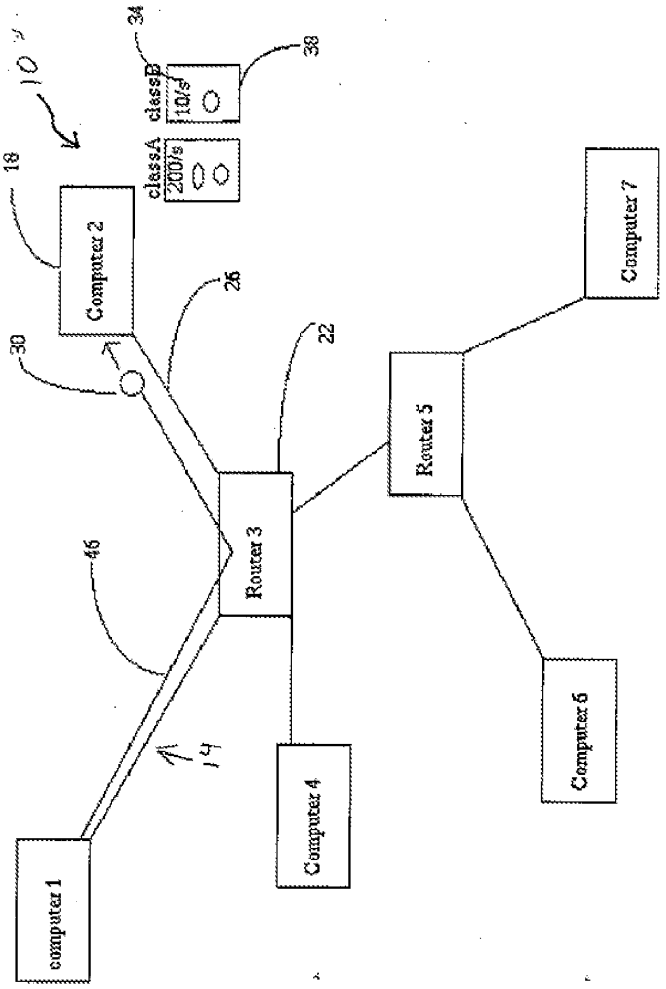


Figure 1

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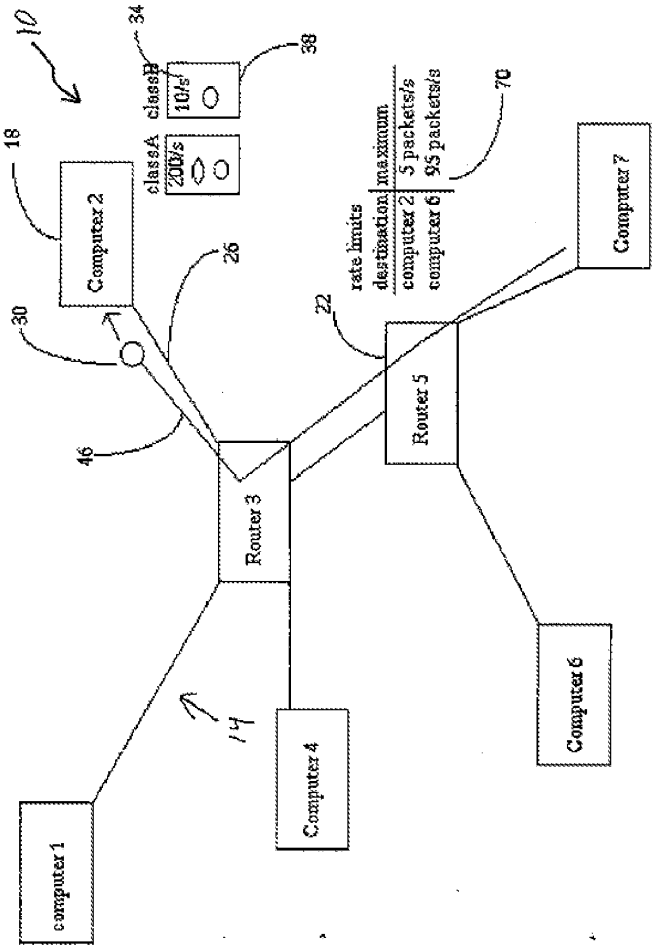


Figure 2

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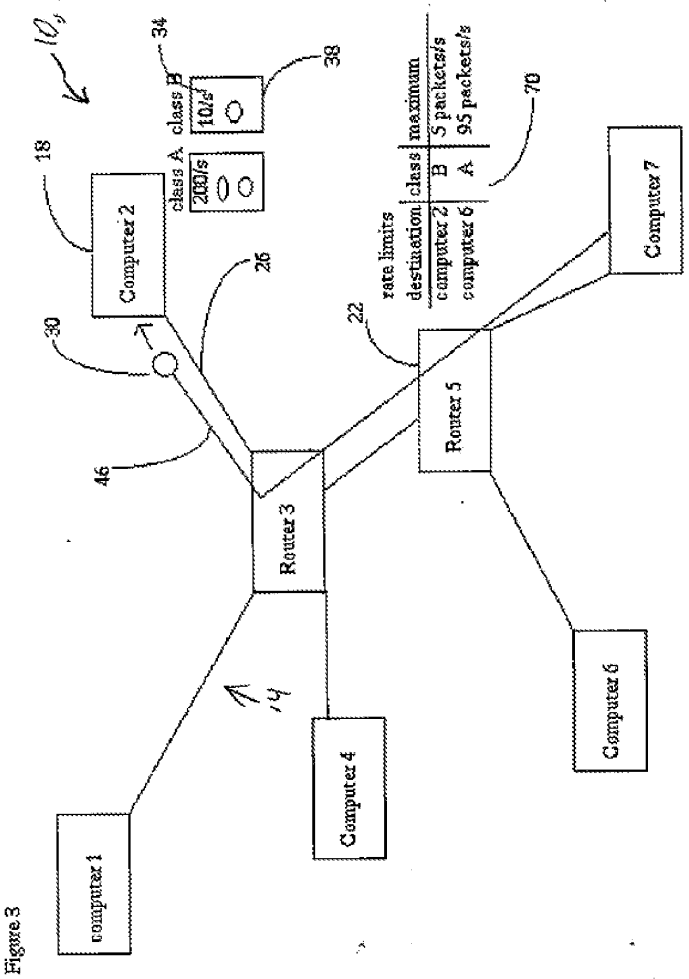


Figure 3

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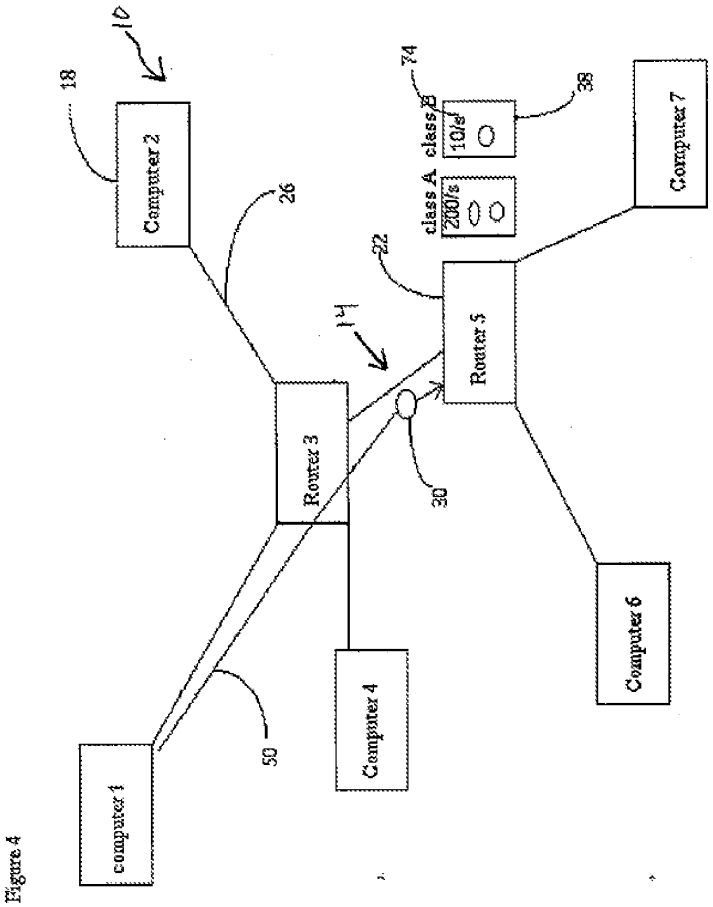


Figure 4

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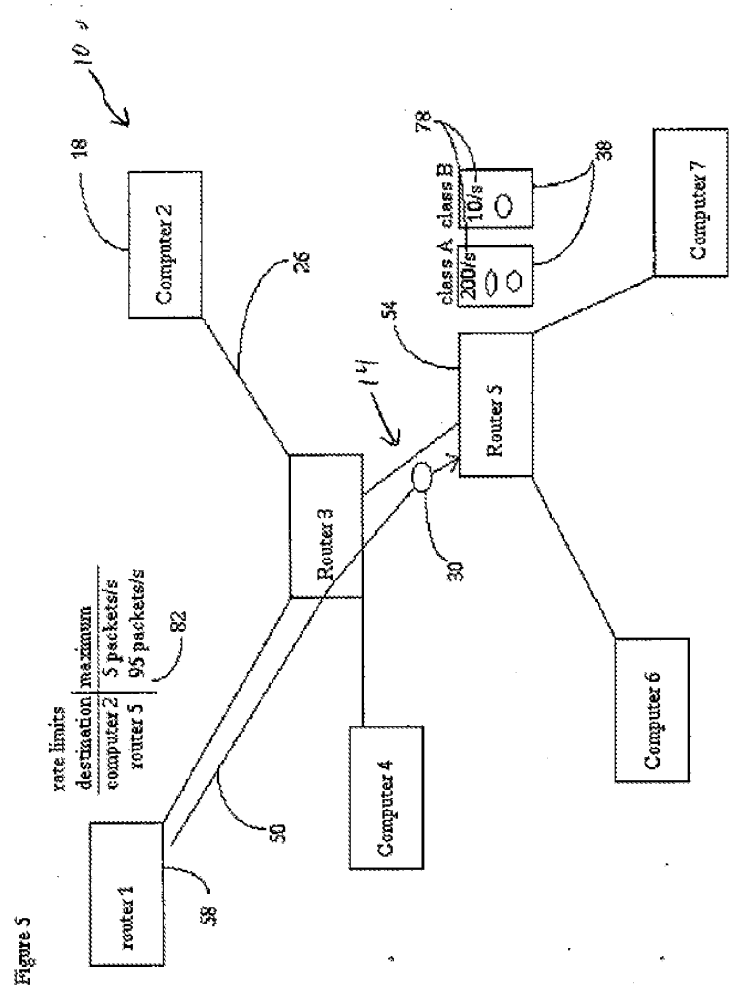


Figure 5

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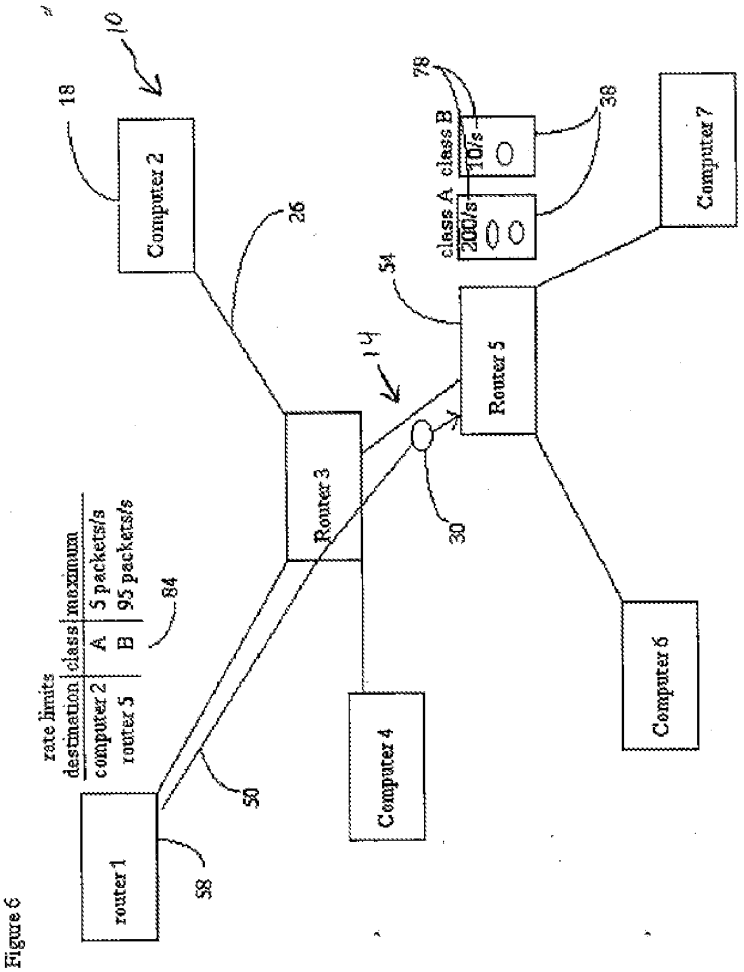


Figure 6

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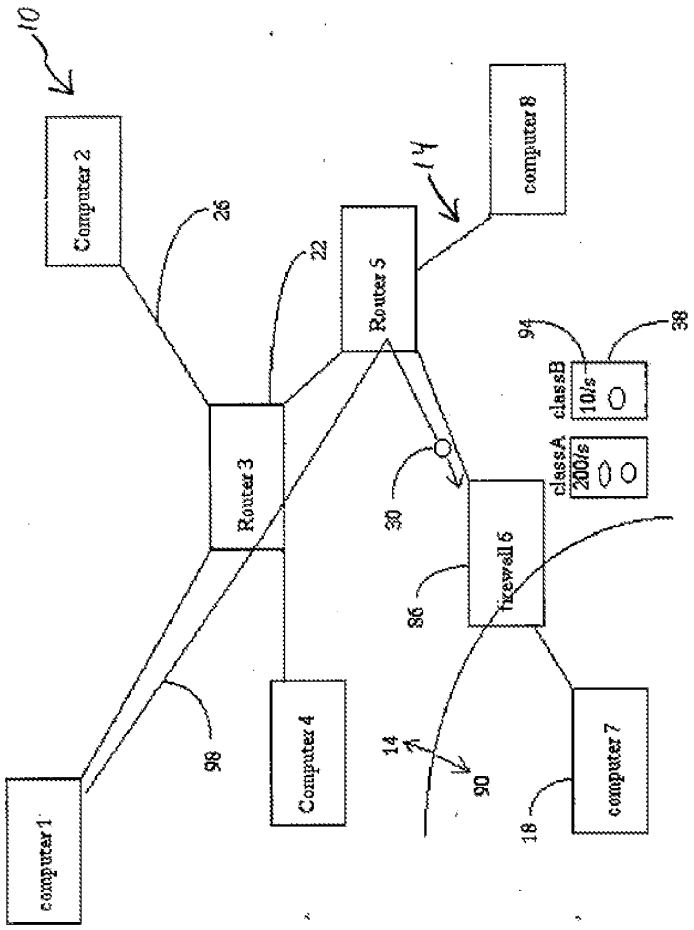


Figure 7

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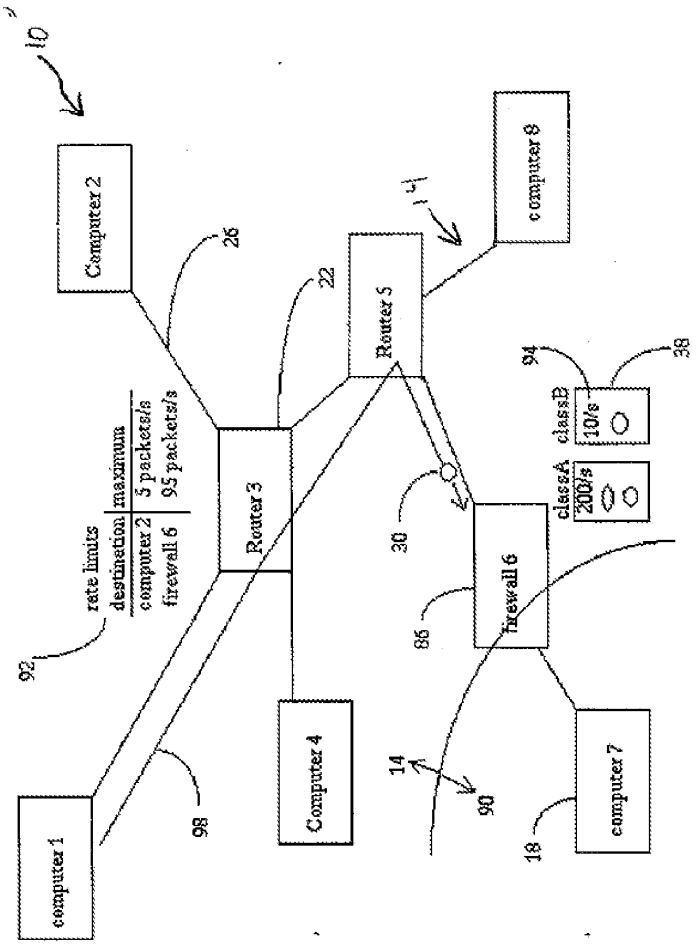


Figure 8

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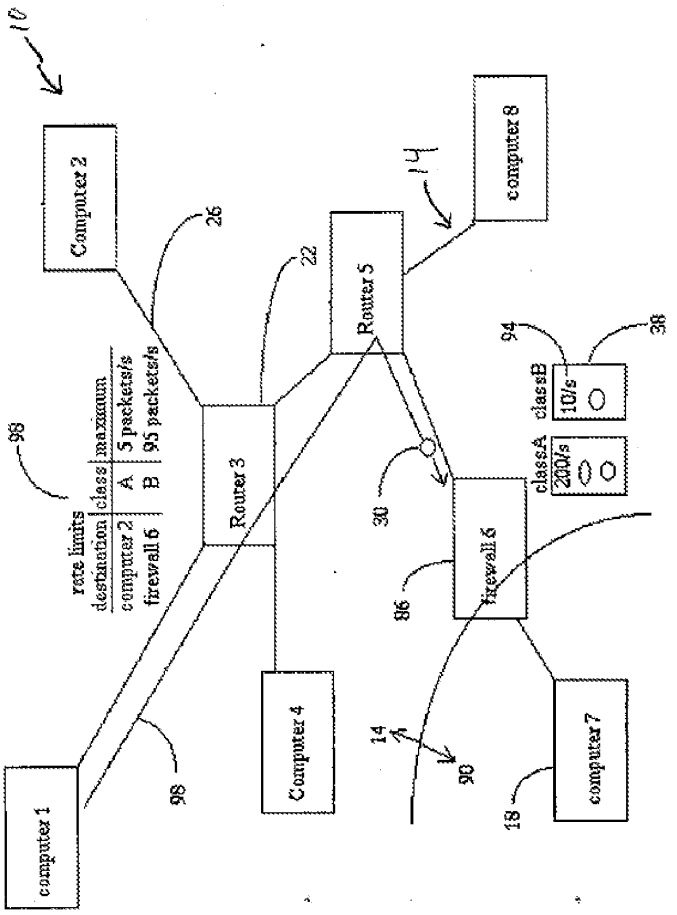


Figure 9

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12-19-02

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- [ ] Information Disclosure Statement
- [ ] Certified Copy of Priority Document(s)
- [ ] Response to Missing Parts/ Incomplete Application
  - [ ] Response to Missing Parts under 37 CFR 1.52 or 1.53
- [ ] Assignment Papers *(for an Application)*
- [ ] Drawing(s)
- [ ] Licensing-related Papers
- [ ] Petition Routing Slip (PTO/SB/69) and Accompanying Petition
- [ ] Petition to Convert to a Provisional Application
- [X] Power of Attorney, Revocation Change of Correspondence Address
- [ ] Terminal Disclaimer
- [ ] Small Entity Statement
- [ ] Request for Refund
- [ ] After Allowance Communication to Group
- [ ] Appeal Communication to Board of Appeals and Interferences
- [ ] Appeal Communication to Group *(Appeal Notice, Brief, Reply Brief)*
- [ ] Proprietary Information
- [ ] Status Letter
- [ ] Additional Enclosure(s) *(please identify below):*

Statement Under 37 CFR 3.73(b), Return Postcard

Remarks

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm or Individual name	David A. Belasco, Registration No. 41,609 BELASCO JACOBS & TOWNSLEY, LLP
Signature	
Date	12/10/2002

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Assistant Commissioner for Patents, Washington, D.C. 20231 on this date: 12-10-02

Typed or printed name	Brandy George		
Signature	Brandy George	Date	12-10-02

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a

Docket No. 02-322-B
Old Docket No. Q982-DB



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:

Donald N. Cohen

Serial No. 09/715,813

Filed: November 16, 2000

For: PACKET FLOODING DEFENSE SYSTEM

PATENTS

Primary Examiner:
Not Assigned

Art Unit 2131

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PRELIMINARY AMENDMENT

Box Non-Fee Amendment
Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sirs:

Please amend the specification of the above-described patent application to include the following:

A1

This invention was made with Government support under Contract # DAAH01-00-C-R211 awarded by U.S. Army Aviation and Missile Command. The Government has certain rights in the invention.

///

///

///

J:\BJ&T\Client\CS\02-322-B\Amendments and Office Actions\Preliminary Amendment.doc

16

A

Please note that the undersigned attorney is now with a different law firm as will be evidenced by a new Power of Attorney provided herewith.

Respectfully submitted,

BELASCO JACOBS & TOWNSLEY, LLP

Dated: December 9, 2002

By: _____
David A. Belasco
Registration No. 41,609
Attorney for Applicant

Cloudflare, Inc. Exhibit 1003 Page 1644



FTO/SB/96 (08-00)
Approved for use through 10/31/2002. OMB 0651-0031
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STATEMENT UNDER 37 CFR 3.73(b)

Applicant/Patent Owner: Cohen, Donald

Application No./Patent No.: 09/715,813 Filed/Issue Date: 11/19/2000

Entitled: Packet Flooding Defense System

Computing Services Support Solutions, Inc., a California corporation

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

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states that it is:

1. ☒ the assignee of the entire right, title, and interest; or

2. ☐ an assignee of less than the entire right, title and interest.
The extent (by, percentage) of its ownership interest is ____ %

in the patent application/patent identified above by virtue of either:

A. ☒ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel 011326, Frame 0127, or for which a copy thereof is attached.

OR

B. [ ] A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as shown below:

1. From: _____ To: _____
The document was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy thereof is attached.

2. From: _____ To: _____
The document was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy thereof is attached.

3. From: _____ To: _____
The document was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy thereof is attached.

[ ] Additional documents in the chain of title are listed on a supplemental sheet.

[ ] Copies of assignments or other documents in the chain of title are attached.
NOTE: A separate copy (i.e., the original assignment document or a true copy of the original document) must be submitted to Assignment Division in accordance with 37 CFR Part 3, if the assignment is to be recorded in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

09 December 2002
Date

Deborah A. Taylor
Typed or printed name

Signature

President
Title

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Washington, DC 20231.

O.I.P.E. JC16 DEC 16 2002 PATENT & TRADEMARK OFFICE

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POWER OF ATTORNEY OR AUTHORIZATION OF AGENT

Application Number	09/715,813
Filing Date	11/16/2000
First Named Inventor	Cohen
Title	Packet Flooding Defense
Group Art Unit	2131
Examiner Name	Not Assigned
Attorney Docket Number	02-322-B (old Q982-09)

I hereby appoint:

☒ Practitioners at Customer Number 31718 →

OR

☐ Practitioner(s) named below:

Name	Registration Number

as my/our attorney(s) or agent(s) to prosecute the application identified above, and to transact all business in the United States Patent and Trademark Office connected therewith.

Please change the correspondence address for the above-identified application to:

☒ The above-identified Customer Number.

OR

☐ Practitioners at Customer Number [ ] → Place Customer Number Bar Code Label here

OR

☐ Firm or Individual Name	
Address	
Address	
City	State Zip
Country	
Telephone	Fax

I am the:

☐ Applicant/inventor.

☒ Assignee of record of the entire interest. See 37 CFR 3.71.
Statement under 37 CFR 3.73(b) is enclosed. (Form PTO/SB/96).

SIGNATURE of Applicant or Assignee of Record	
Name	Deborah A. Taylor, President, Computing Services Support Solutions, Inc.
Signature	Deborah A. Taylor
Date	09 December 2002

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below*.

☒ *Total of 1 forms are submitted.

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REVOCATION OF POWER OF ATTORNEY OR AUTHORIZATION OF AGENT

Application Number	09/715,813
Filing Date	11/16/2000
First Named Inventor	Cohen
Group Art Unit	2131
Examiner Name	Not Assigned
Attorney Docket Number	02-322-B (old 0982-DS)

I hereby revoke all previous powers of attorney or authorizations of agent given in the above-identified application:

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☒ A Power of Attorney or Authorization of Agent is submitted herewith.

OR

☐ Please change the correspondence address for the above-identified application to:

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OR

☐ Firm or Individual Name					
Address					
Address					
City					
Country		State		ZIP	
Telephone		Fax			

I am the:

☐ Applicant/Inventor.

☒ Assignee of record of the entire interest. See 37 CFR 3.71.
Statement under 37 CFR 3.73(b) is enclosed. (Form PTO/SB/96)

SIGNATURE of Applicant or Assignee of Record

Name	Deborah A. Taylor, President, Computing Services Support Solutions, Inc.
Signature	Deborah A. Taylor
Date	09 December 2002

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below*.

☒ *Total of 1 forms are submitted.

Burden Hour Statement: This form is estimated to take 3 minutes to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Washington, DC 20231.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/715,813	11/16/2000	Donald N. Cohen	Q982-DB	8097

2590 10/30/2003

David A Belasco Esq
Beehler & Pavitt
100 Corporate Pointe Suite 330
Culver City, CA 90230

EXAMINER	
BAUM, RONALD	

ART UNIT	PAPER NUMBER
2131	

DATE MAILED: 10/30/2003

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)	
	09/715,813	COHEN, DONALD N.	
	Examiner	Art Unit	
	Ronald Baum	2131	

-- *The MAILING DATE of this communication appears on the cover sheet with the correspondence 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 _____ .

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) 1-9 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) 1-9 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).

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:

Cloudflare, Inc. Exhibit 1003 Page 1649

DETAILED ACTION

1. Claims 1-9 are pending for examination.

2. Claims 1-9 are rejected.

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 –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

3. Claims 1-9 are rejected under 35 U.S.C. 102(b) as being anticipated by Chang et al, U.S. Patent 5,367,523.

4. As per claim 1; "A packet flooding defense system [col. 1, lines 7-11,col. 2, lines 53-col. 3, line 11, whereas flow and congestion control in packet networks corresponds to a packet flooding defense, and whereas senders, receivers, and intermediate nodes in a packet communications network correspond to network computers per se as well as typically computers configured as gateways, routers, and firewalls (i.e., col. 1, lines 27-col. 2, line 8)] for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets [figure 1 as applied to appropriate figures 2-9 and accompanying descriptions], said system comprising: means for classifying data packets received at a host computer; means for associating a maximum acceptable processing rate with each class of data packet received at said computer [col. 3, lines 12-46, col. 10, lines 8-col. 11, line 10, whereas the color coded green, yellow, etc., packet characterizations constitute classification, upon which rate criteria is

established, which in itself is control of processing rate resources.]; means for said computer to find information for packets it receives regarding the path by which said packets came to said computer [col. 5, lines 50-col. 6, line 9, col. 6, lines 21-48]; and whereby, said computer can use said information to allocate the processing rate available for packets of each class in a desired way [figures 5-9 and accompanying descriptions].";

5. As per claim 2; "A packet flooding defense system [col. 1, lines 7-11,col. 2, lines 53-col. 3, line 11, whereas flow and congestion control in packet networks corresponds to a packet flooding defense, and whereas senders, receivers, and intermediate nodes in a packet communications network correspond to network computers per se as well as typically computers configured as gateways, routers, and firewalls (i.e., col. 1, lines 27-col. 2, line 8)] for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets [figure 1 as applied to appropriate figures 2-9 and accompanying descriptions], said system comprising: means for classifying data packets received at a host computer; means for associating a maximum acceptable processing rate with each class of data packet received at said computer [col. 3, lines 12-46, col. 10, lines 8-col. 11, line 10, whereas the color coded green, yellow, etc., packet characterizations constitute classification, upon which rate criteria is established, which in itself is control of processing rate resources.]; means for said computer to determine the rate at which data packets of each class are transmitted from a router to said computer; means for said router to receive information regarding maximum acceptable transmission rate for data packets being transmitted to said computer; means for said router to control the rate of transmission of data packets from said router to said computer; and whereby, the rate of data packet transmissions received at said computer is kept below the maximum

acceptable processing rate for each data packet class by said control of the rate of transmission of data packets from said router, thereby freeing a portion of the network providing data packet transmission to said computer [figures 5-9 and accompanying descriptions].".

6. Claim 3 ***additionally recites*** the limitations that "A packet flooding defense system as described in Claim 2, wherein: said router is capable of receiving information regarding maximum acceptable transmission rate for each class of data packet being transmitted to said computer; and said router is capable of controlling the rate of transmission of each class of data packets to said computer.". The teachings of Chang et al (figures 5-9 and accompanying descriptions), suggest such limitations.

7. As per claim 4; "A packet flooding defense system [col. 1, lines 7-11,col. 2, lines 53-col. 3, line 11, whereas flow and congestion control in packet networks corresponds to a packet flooding defense, and whereas senders, receivers, and intermediate nodes in a packet communications network correspond to network computers per se as well as typically computers configured as gateways, routers, and firewalls (i.e., col. 1, lines 27-col. 2, line 8)] for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets [figure 1 as applied to appropriate figures 2-9 and accompanying descriptions], said system comprising: means for classifying data packets received at a router; means for associating a maximum acceptable transmission rate with each class of data packet received at said router [col. 3, lines 12-46, col. 10, lines 8-col. 11, line 10, whereas the color coded green, yellow, etc., packet characterizations constitute classification, upon which rate criteria is established, which in itself is control of processing rate resources.]; means for said router to find information for packets it receives regarding the path by which said packets came to said router [col. 5, lines 50-

col. 6, line 9, col. 6, lines 21-48]; and whereby, said router can use said information to allocate the transmission rate for each class in a desired way [figures 5-9 and accompanying descriptions].".

8. As per claim 5; "A packet flooding defense system [col. 1, lines 7-11,col. 2, lines 53-col. 3, line 11, whereas flow and congestion control in packet networks corresponds to a packet flooding defense, and whereas senders, receivers, and intermediate nodes in a packet communications network correspond to network computers per se as well as typically computers configured as gateways, routers, and firewalls (i.e., col. 1, lines 27-col. 2, line 8)]for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets [figure 1 as applied to appropriate figures 2-9 and accompanying descriptions], said system comprising: means for classifying data packets received at a first router; means for associating a maximum acceptable transmission rate with each class of data packet received at said first router [col. 3, lines 12-46, col. 10, lines 8-col. 11, line 10, whereas the color coded green, yellow, etc., packet characterizations constitute classification, upon which rate criteria is established, which in itself is control of processing rate resources.]; means for said first router to determine the rate at which data packets of each class are transmitted from a second router to said first router; means for said second router to receive information regarding maximum acceptable transmission rate for data packets being transmitted to said first router; means for said second router to control the rate of transmission of data packets from said second router to said first router; and whereby, the rate of data packet transmissions received at said first router is kept below the maximum acceptable transmission rate for each data packet class by said control of the

rate of transmission of data packets from said second router, thereby freeing a portion of the network providing data packet transmission to said first router.".

9. Claim 6 ***additionally recites*** the limitations that "A packet flooding defense system as described in Claim 5, wherein: said second router is capable of receiving information regarding maximum acceptable transmission rate for each class of data packet being transmitted to said first router; and said second router is capable of controlling the rate of transmission of each class of data packets to said first router.". The teachings of Chang et al (figures 5-9 and accompanying descriptions), suggest such limitations.

10. As per claim 7; "A packet flooding defense system [col. 1, lines 7-11,col. 2, lines 53-col. 3, line 11, whereas flow and congestion control in packet networks corresponds to a packet flooding defense, and whereas senders, receivers, and intermediate nodes in a packet communications network correspond to network computers per se as well as typically computers configured as gateways, routers, and firewalls (i.e., col. 1, lines 27-col. 2, line 8)] for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets [figure 1 as applied to appropriate figures 2-9 and accompanying descriptions], said system comprising: at least one firewall, said firewall comprising: hardware and software serving to control packet transmission between said network and a host computer connected to an internal network; means for classifying data packets received at said firewall; means for associating a maximum acceptable transmission rate with each class of data packet received at said firewall [col. 3, lines 12-46, col. 10, lines 8-col. 11, line 10, whereas the color coded green, yellow, etc., packet characterizations constitute classification, upon which rate criteria is established, which in itself is control of processing rate resources.]; means for said firewall to

find information for packets it receives regarding the path by which said packets came to said firewall [col. 5, lines 50-col. 6, line 9, col. 6, lines 21-48]; and whereby, said firewall can use said information to allocate the transmission rate for each class in a desired way [figures 5-9 and accompanying descriptions].".

11. As per claim 8; "A packet flooding defense system [col. 1, lines 7-11,col. 2, lines 53-col. 3, line 11, whereas flow and congestion control in packet networks corresponds to a packet flooding defense, and whereas senders, receivers, and intermediate nodes in a packet communications network correspond to network computers per se as well as typically computers configured as gateways, routers, and firewalls (i.e., col. 1, lines 27-col. 2, line 8)] for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets [figure 1 as applied to appropriate figures 2-9 and accompanying descriptions], said system comprising: at least one firewall, said firewall comprising: hardware and software serving to control packet transmission between said network and a host computer connected to an internal network; means for classifying data packets received at said firewall; means for associating a maximum acceptable transmission rate with each class of data packet received at said firewall [col. 3, lines 12-46, col. 10, lines 8-col. 11, line 10, whereas the color coded green, yellow, etc., packet characterizations constitute classification, upon which rate criteria is established, which in itself is control of processing rate resources.]; means for said firewall to determine the rate at which data packets of each class are transmitted from a router to said firewall; means for said router to receive information regarding maximum acceptable transmission rate for data packets being transmitted to said firewall; means for said router to control the rate of transmission of data packets from said router to said firewall; and whereby,

the rate of data packet transmissions received at said firewall is kept below the maximum acceptable transmission rate for each data packet class by said control of the rate of transmission of data packets from said router, thereby freeing a portion of the network providing data packet transmission to said firewall.".

12. Claim 9 ***additionally recites*** the limitations that "A packet flooding defense system as described in Claim 8, wherein: said router is capable of receiving information regarding maximum acceptable transmission rate for each class of data packet being transmitted to said firewall; and said router is capable of controlling the rate of transmission of each class of data packets to said firewall.". The teachings of Chang et al (figures 5-9 and accompanying descriptions), suggest such limitations.

Conclusion

13. Any inquiry concerning this communication or earlier communications from examiner should be directed to Ronald Baum, whose telephone number is (703) 305-4276. The examiner can normally be reached Monday through Friday from 8:00 AM to 5:30 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Ayaz Sheikh, can be reached at (703) 305-9648. The Fax numbers for the organization where this application is assigned are:

After-final	(703) 746-7238
Official	(703) 746-7239
Non-Official/Draft	(703) 746-7246

Ronald Baum

AYAZ SHEIKH
SUPERVISORY PATENT EXAMINER
TECHNOLOGY CENTER 2100

Notice of References Cited	Application/Control No. 09/715,813	Applicant(s)/Patent Under Reexamination COHEN, DONALD N.	
	Examiner Ronald Baum	Art Unit 2131	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
	A	US-5,367,523	11-1994	Chang et al.	370/235
	B	US-5,007,052	04-1991	Flammer, George	370/389
	C	US-6,412,000	06-2002	Riddle et al.	709/224
	D	US-5,434,860	07-1995	Riddle, Guy G.	370/232
	E	US-2002/0032871	03-2002	Malan et al.	713/201
	F	US-6,088,804	07-2000	Hill et al.	713/201
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	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.

L Number	Hits	Search Text	DB	Time stamp
-	2070	713/201.ccls.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 11:55
-	3	713/201.ccls. and packet with flooding and router	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 11:56
-	3	713/201.ccls. and packet with flooding and router	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 11:56
-	94	packet with flooding and router	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 11:56
-	5	packet with flooding and router and denial and bandwidth	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 11:57
-	485	router and denial and bandwidth	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 11:59
-	471	router and denial adj1 service	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 11:59
-	329	router and denial adj1 service and bandwidth	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:00
-	64	router and denial and bandwidth and transmi$ adj1 rate	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:00
-	8	router and denial and bandwidth and send$ adj1 rate	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:00
-	982	network same router and flood$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:01
-	118	network same router and flood$ and defen$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:01
-	130	router and flood$ and defen$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:01

-	91	ddos	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:02
-	30	packet adj1 class$ and denial adj1 service	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:02
-	6	throttl$ with bandwidth and denial	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:03
-	8	709/238-244.ccls. and denial and allocate	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:06
-	4	709/238-244.ccls. and flood$ with rate	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:07
-	241	709/238-244.ccls. and transmi$ with rate	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:07
-	128	router with flow adj1 control	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:08
-	7	packet adj1 flood$ and defense	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:08
-	446	packet with overload$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:16
-	50	packet adj2 overload$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:17
-	98	packet adj1 flood$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:33
-	569	packet with flow adj2 (control or allocat$) and router$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:34
-	67	packet with flow adj2 (control or allocat$) and router$ and (defense or denial)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:59

-	25	router with flow adj2 (control or allocat$) and (defense or denial)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:54
-	2	5367523.pn.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 13:06
-	2	5007052.pn.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 13:09
-	2	5699513.pn.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 13:12
-	2	6412000.pn.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 13:15
-	2	5434860.pn.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 13:17
-	2	20020032871.pn.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 13:19
-	2	4817080.pn.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 13:21
-	2	6088804.pn.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 13:21

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Typed or Printed Name: David A. Belasco

Signature:

Date: December 18, 2003 Telephone: 1-310-743-1188

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below*.

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2131

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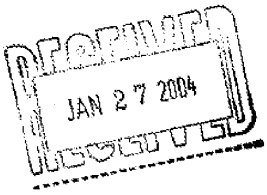
PATENT
02-322-B
Formerly Q982-DB

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Cohen	Examiner:	Baum
Serial No.:	09/715,813	Group Art Unit:	2131
Title:	**PACKET FLOODING DEFENSE SYSTEM**		
Filed:	11/16/2000		

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Donna Miller Date: 1-19-04
Donna Miller

REQUEST FOR RECONSIDERATION

This document is being submitted in response to the Office Action mailed 10/20/2003. Claims 1-9 remain in this application.

Applicable Standard

> Under 35 U.S.C. §102, anticipation requires that each and every element of the claimed invention be disclosed in the prior art. . . . In addition, the prior art reference must be enabling, thus placing the allegedly disclosed matter in the possession of the public. ***Akzo N.V. v. United States Int'l Trade Comm'n***, 1 USPQ 2d 1241, 1245 (Fed. Cir. 1986), ***cert. denied***, 482 U.S. 909 (1987)
>
> Anticipation requires the presence in a single prior art reference disclosure of each

> and every element of the claimed invention, *arranged as in the claim.* ***Lindemann Maschinenfabrik GmbH v. American Hoist & Derrick Co.***, 221 USPQ 481, 485 (Fed. Cir. 1984) (emphasis added)
>
> Under section 102(b), anticipation requires that the prior art reference disclose, either expressly or under the principles of inherency, every limitation of the claim. . . .
>
> But to be prior art under section 102(b), a reference must be enabling. . . . That is, it must put the claimed invention in the hand of one skilled in the art. . . . The examiner bears the burden of presenting at least a prima facie case of anticipation. ***In re Sun***, 31 USPQ 2d 1451, 1453 (Fed. Cir. 1993) (unpublished)

The Examiner Stated

> 3. Claims 1-9 are rejected under 35 U.S.C. 102(b) as being anticipated by Chang et al., U.S. Patent 5,367,523.
>
> 4. As per claim 1; "A packet flooding defense system (col. 1, lines 7-11, col. 2, lines 53-col. 3, line 11) whereas flow and congestion control in packet networks corresponds to a packet flooding defense, and whereas senders, receivers, and intermediate nodes in a packet communications network correspond to network computers per se as well as typically computers configured as gateways, routers, and firewalls (i.e., col. 1, lines 27-col. 2, line 8) for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets (figure 1 as applied to appropriate figures 2-9 and accompanying descriptions), said system comprising: means for classifying data packets received at a host computer; means for associating a maximum acceptable processing rate with each class of data packet received at said computer (col. 3, lines 12-46, col. 10, lines 8-col. 11, line 10, whereas the color coded green, yellow, etc., packet characterizations constitute classification, upon which rate criteria is established, which in itself is control of processing rate resources); means for said computer to find information for packets it receives regarding the path by which said packets came to said computer (col. 5, line 50-col. 6, line 9, col. 6, lines 21-48); and whereby, said computer can use said information to allocate the processing rate available for packets of each class in a desired way (figures 5-9 and accompanying descriptions)."

Applicant Responds

Applicant respectfully traverses this rejection for the following reasons:

a. A packet flooding defense system is definitely not equivalent to a flow and congestion

control system. The aim of Chang et al. is to adjust the data rate in a network based on the congestion in the network. See Abstract. The aim of the instant invention is to prevent packet flooding of a particular user. Packet flooding is a form of electronic attack in which the perpetrator floods the victim with massive amounts of useless data thus using up all available bandwidth. See Abstract.

b. Chang et al. does not include any means for classifying individual packets of data. Chang et al. does classify the congestion in the network as green, yellow, etc. See col. 3, lines 12-68. This is accomplished essentially by timing, on a sampling basis, how long it takes for data to traverse the network from a sender to a receiver. See col. 2, line 53 – col. 3, line 5; claims 1 and 12; and Figures 5-9 and their accompanying descriptions. The only way that Chang et al. uses individual packets of data is to transmit rate information from the receiver to the sender. See col. 3, line 5-11. In sharp contrast, the instant invention classifies individual packets of data that are received by a host computer and assigns a receive rate to each class. See page 5, lines 1-6.

c. Chang et al. does not include any means for determining the path by which the data arrives at the receiver. The citations provided by the Examiner (col. 5, line 50-col. 6, line 9, col. 6, lines 21-48) simply explain how data is routed through a prior art network from the sender to the designated receiver. Chang et al. has no need to determine where the data comes from and make no mention of the necessity of determining where the data originates. From Chang et al.'s description of the process it does not even sound possible to determine the source of data from the header information included with each packet of data. In sharp contrast the instant invention needs to determine the source of the data. This is so that data can be classified as to source so that packet flooding from a particular source can be detected and stopped.

The Examiner Stated

> 5. As per claim 2; "A packet flooding defense system (col. 1, lines 7-11,col. 2, lines 53-col. 3, line 11) whereas flow and congestion control in packet networks corresponds to a packet flooding defense, and whereas senders, receivers, and intermediate nodes in a packet communications network correspond to network computers per se as well as typically computers configured as gateways, routers, and firewalls (i.e., col. 1, lines 27-col. 2, line 8) for a network comprising a

> plurality of host computers, routers, communication lines and transmitted data packets (figure 1 as applied to appropriate figures 2-9 and accompanying descriptions), said system comprising: means for classifying data packets received at a host computer; means for associating a maximum acceptable processing rate with each class of data packet received at said computer (col. 3, lines 12-46, col. 10, line 8-col. 11, line 10, whereas the color coded green, yellow, etc., packet characterizations constitute classification, upon which rate criteria is established, which in itself is control of processing rate resources); means for said computer to determine the rate at which data packets of each class are transmitted from a router to said computer; means for said router to receive information regarding maximum acceptable transmission rate for data packets being transmitted to said computer; means for said router to control the rate of transmission of data packets from said router to said computer; and whereby, the rate of data packet transmissions received at said computer is kept below the maximum acceptable processing rate for each data packet class by said control of the rate of transmission of data packets from said router, thereby freeing a portion of the network providing data packet transmission to said computer (5-9 and accompanying descriptions)."

Applicant Responds

Applicant respectfully traverses this rejection for the following reasons:

a. A packet flooding defense system is definitely not equivalent to a flow and congestion control system. The aim of Chang et al. is to adjust the data rate in a network based on the congestion in the network. See Abstract. The aim of the instant invention is to prevent packet flooding of a particular user. Packet flooding is a form of electronic attack in which the perpetrator floods the victim with massive amounts of useless data thus using up all available bandwidth. See Abstract.

b. The essence of Claim 2 is that the invention is incorporated into a router whereas Chang et al. does not incorporate their invention into a router. Chang et al. nowhere mentions the word router. The Chang et al. invention is incorporated into the endnodes of the network that are the sending and receiving computers. See col. 4, lines 39-41; and Figures 1 and 2 and their accompanying descriptions.

c. Chang et al. does not include any means for classifying individual packets of data. Chang

et al. does classify the congestion in the network as green, yellow, etc. See col. 3, lines 12-68. This is accomplished essentially by timing, on a sampling basis, how long it takes for data to traverse the network from a sender to a receiver. See col. 2, line 53 – col. 3, line 5; claims 1 and 12; and Figures 5-9 and their accompanying descriptions. The only way that Chang et al. uses individual packets of data is to transmit rate information from the receiver to the sender. See col. 3, line 5-11. In sharp contrast, the instant invention classifies individual packets of data that are received by a host computer and assigns a receive rate to each class. See page 5, lines 1-6.

d. The Examiner has not provided any citations from Chang et al. or any reasons why the following elements of claim 2 are disclosed:

> means for said router to receive information regarding maximum acceptable transmission rate for data packets being transmitted to said computer; and
>
> means for said router to control the rate of transmission of data packets from said router to said computer.

As all of the elements of claim 2 are not disclosed, claim 2 cannot be anticipated.

The Examiner Stated

> 6. Claim 3 additionally recites the limitations that "A packet flooding defense system as described in Claim 2, wherein: said router is capable of receiving information regarding maximum acceptable transmission rate for each class of data packet being transmitted to said computer; and said router is capable of controlling the rate of transmission of each class of data packets to said computer.". The teachings of Chang et al. (figures 5-9 and accompanying descriptions), suggest such limitations.

Applicant Responds

Applicant respectfully traverses this rejection. Applicant has examined Figures 5-9 and accompanying descriptions and can find no mention on the Figures or in the text of routers. In fact, as pointed out above, the Chang et al. invention works only at the endnodes. See col. 5, lines 16-44.

The Examiner Stated

> 7. As per claim 4; "A packet flooding defense system (col. 1, lines 7- 11, col. 2, line 53-col. 3, line 11) whereas flow and congestion control in packet networks corresponds to a packet flooding defense, and whereas senders, receivers, and intermediate nodes in a packet communications network correspond to network computers per se as well as typically computers configured as gateways, routers, and firewalls (i.e., col. 1, line 27-col. 2, line 8) for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets (figure 1 as applied to appropriate figures 2-9 and accompanying descriptions), said system comprising: means for classifying data packets received at a router; means for associating a maximum acceptable transmission rate with each class of data packet received at said router (col. 3, lines 12-46, col. 10, line 8-col. 11, line 10, whereas the color coded green, yellow, etc., packet characterizations constitute classification, upon which rate criteria is established, which in itself is control of processing rate resources.); means for said router to find information for packets it receives regarding the path by which said packets came to said router (col. 5, lines 50-col. 6, line 9, col. 6, lines 21-48); and whereby, said router can use said information to allocate the transmission rate for each class in a desired way (figure 5-9 and accompanying descriptions)."

Applicant Responds

Applicant respectfully traverses this rejection for the following reasons:

a. A packet flooding defense system is definitely not equivalent to a flow and congestion control system. The aim of Chang et al. is to adjust the data rate in a network based on the congestion in the network. See Abstract. The aim of the instant invention is to prevent packet flooding of a particular user. Packet flooding is a form of electronic attack in which the perpetrator floods the victim with massive amounts of useless data thus using up all available bandwidth. See Abstract.

b. The essence of Claim 4 is that the invention is incorporated into a router whereas Chang et al. does not incorporate their invention into a router. Chang et al. nowhere mentions the word router. The Chang et al. invention is incorporated into the endnodes of the network which are the sending and receiving computers. See col. 4, lines 39-41; and Figures 1 and 2 and their accompanying descriptions.

c. Chang et al. does not include any means for classifying individual packets of data. Chang et al. does classify the congestion in the network as green, yellow, etc. See col. 3, lines 12-68. This is accomplished essentially by timing, on a sampling basis, how long it takes for data to traverse the network from a sender to a receiver. See col. 2, line 53 – col. 3, line 5; claims 1 and 12; and Figures 5-9 and their accompanying descriptions. The only way that Chang et al. uses individual packets of data is to transmit rate information from the receiver to the sender. See col. 3, line 5-11. In sharp contrast, the instant invention classifies individual packets of data that are received by a host computer and assigns a receive rate to each class. See page 5, lines 1-6.

d. Chang et al. does not include any means for determining the path by which the data arrives at the router. The citations provided by the Examiner (col. 5, line 50-col. 6, line 9, col. 6, lines 21-48) simply explain how data is routed through a prior art network from the sender to the designated receiver. Chang et al. has no need to determine where the data comes from and make no mention of the necessity of determining where the data originates. From Chang et al.'s description of the process it does not even sound possible to determine the source of data from the header information included with each packet of data. In sharp contrast the instant invention needs to determine the source of the data. This is so that data can be classified as to source so that packet flooding from a particular source can be detected and stopped.

The Examiner Stated

> 8. As per claim 5; "A packet flooding defense system (1, lines 7-11,col. 2, lines 53-col. 3, line 11, whereas flow and congestion control in packet networks corresponds to a packet flooding defense, and whereas senders, receivers, and intermediate nodes in a packet communications network correspond to network computers per se as well as typically computers configured as gateways, routers, and firewalls (i.e., col. 1, lines 27-col. 2, line 8) for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets (figure 1 as applied to appropriate figures 2-9 and accompanying descriptions), said system comprising: means for classifying data packets received at a first router; means for associating a maximum acceptable transmission rate with each class of data packet received at said first router (col. 3, lines 12-46, col. 10, lines 8-col. 11, line 10, whereas the color coded green, yellow, etc., packet characterizations constitute classification, upon which rate criteria is established, which in itself is control of processing rate resources.); means for said first router

to determine the rate at which data packets of each class are transmitted from a second router to said first router; means for said second router to receive information regarding maximum acceptable transmission rate for data packets being transmitted to said first router; means for said second router to control the rate of transmission of data packets from said second router to said first router; and whereby, the rate of data packet transmissions received at said first router is kept below the maximum acceptable transmission rate for each data packet class by said control of the rate of transmission of data packets from said second router, thereby freeing a portion of the network providing data packet transmission to said first router."

Applicant Responds

Applicant respectfully traverses this rejection for the following reasons:

a. A packet flooding defense system is definitely not equivalent to a flow and congestion control system. The aim of Chang et al. is to adjust the data rate in a network based on the congestion in the network. See Abstract. The aim of the instant invention is to prevent packet flooding of a particular user. Packet flooding is a form of electronic attack in which the perpetrator floods the victim with massive amounts of useless data thus using up all available bandwidth. See Abstract.

b. The essence of Claim 5 is that the invention is incorporated into two routers whereas Chang et al. do not incorporate their invention into a router. Chang et al. nowhere mentions the word router. The Chang et al. invention is incorporated into the endnodes of the network which are the sending and receiving computers. See col. 4, lines 39-41; and Figures 1 and 2 and their accompanying descriptions.

c. Chang et al. does not include any means for classifying individual packets of data. Chang et al. does classify the congestion in the network as green, yellow, etc. See col. 3, lines 12-68. This is accomplished essentially by timing, on a sampling basis, how long it takes for data to traverse the network from a sender to a receiver. See col. 2, line 53 – col. 3, line 5; claims 1 and 12; and Figures 5-9 and their accompanying descriptions. The only way that Chang et al. uses individual packets of data is to transmit rate information from the receiver to the sender. See col. 3, line 5-11. In sharp contrast, the instant invention classifies individual packets of data that are

received by a host computer and assigns a receive rate to each class. See page 5, lines 1-6.

d. The Examiner has not provided any citations from Chang et al. or any reasons why the following elements of claim 5 are disclosed:

> means for said first router to determine the rate at which data packets of each class are transmitted from a second router to said first router;
>
> means for said second router to receive information regarding maximum acceptable transmission rate for data packets being transmitted to said first router;
> means for said second router to control the rate of transmission of data packets from said second router to said first router;
>
> and whereby, the rate of data packet transmissions received at said first router is kept below the maximum acceptable transmission rate for each data packet class by said control of the rate of transmission of data packets from said second router, thereby freeing a portion of the network providing data packet transmission to said first router.

As all of the elements of claim 5 are not disclosed, claim 5 cannot be anticipated.

The Examiner Stated

> 9. Claim 6 additionally recites the limitations that "A packet flooding defense system as described in Claim 5, wherein: said second router is capable of receiving information regarding maximum acceptable transmission rate for each class of data packet being transmitted to said first router; and said second router is capable of controlling the rate of transmission of each class of data packets to said first router." The teachings of Chang et al. (figures 5-9 and accompanying descriptions), suggest such limitations.

Applicant Responds

Applicant respectfully traverses this rejection. Applicant has examined Figures 5-9 and accompanying descriptions and can find no mention on the Figures or in the text of routers. In

fact, as pointed out above, the Chang et al. invention works only at the endnodes. See col. 5, lines 16-44.

The Examiner Stated

> 10. As per claim 7; "A packet flooding defense system (1, lines 7-11,col. 2, lines 53-col. 3, line 11, whereas flow and congestion control in packet networks corresponds to a packet flooding defense, and whereas senders, receivers, and intermediate nodes in a packet communications network correspond to network computers per se as well as typically computers configured as gateways, routers, and firewalls (i.e., col. 1, lines 27-col. 2, line 8) for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets (figure 1 as applied to appropriate figures 2-9 and accompanying descriptions), said system comprising: at least one firewall, said firewall comprising: hardware and software serving to control packet transmission between said network and a host computer connected to an internal network; means for classifying data packets received at said firewall; means for associating a maximum acceptable transmission rate with each class of data packet received at said firewall (col. 3, lines 12-46, col. 10, lines 8-col. 11, line 10, whereas the color coded green, yellow, etc., packet characterizations constitute classification, upon which rate criteria is established, which in itself is control of processing rate resources); means for said firewall to find information for packets it receives regarding the path by which said packets came to said firewall (col. 5, lines 50-col. 6, line 9, col. 6, lines 21-48); and whereby, said firewall can use said information to allocate the transmission rate for each class in a desired way (figures 5-9 and accompanying descriptions)."

Applicant Responds

Applicant respectfully traverses this rejection for the following reasons:

a. A packet flooding defense system is definitely not equivalent to a flow and congestion control system. The aim of Chang et al. is to adjust the data rate in a network based on the congestion in the network. See Abstract. The aim of the instant invention is to prevent packet flooding of a particular user. Packet flooding is a form of electronic attack in which the perpetrator floods the victim with massive amounts of useless data thus using up all available bandwidth. See Abstract.

b. The essence of Claim 7 is that the invention is incorporated into a firewall whereas Chang

et al. does not incorporate their invention into a firewall. Chang et al. nowhere mentions the word firewall. The Chang et al. invention is incorporated into the endnodes of the network which are the sending and receiving computers. See col. 4, lines 39-41; and Figures 1 and 2 and their accompanying descriptions.

c. Chang et al. does not include any means for classifying individual packets of data. Chang et al. does classify the congestion in the network as green, yellow, etc. See col. 3, lines 12-68. This is accomplished essentially by timing, on a sampling basis, how long it takes for data to traverse the network from a sender to a receiver. See col. 2, line 53 – col. 3, line 5; claims 1 and 12; and Figures 5-9 and their accompanying descriptions. The only way that Chang et al. uses individual packets of data is to transmit rate information from the receiver to the sender. See col. 3, line 5-11. In sharp contrast, the instant invention classifies individual packets of data that are received by a host computer and assigns a receive rate to each class. See page 5, lines 1-6.

d. Chang et al. does not include any means for determining the path by which the data arrives at the firewall. The citations provided by the Examiner (col. 5, line 50-col. 6, line 9, col. 6, lines 21-48) simply explain how data is routed through a prior art network from the sender to the designated receiver. Chang et al. has no need to determine where the data comes from and make no mention of the necessity of determining where the data originates. From Chang et al.'s description of the process it does not even sound possible to determine the source of data from the header information included with each packet of data. In sharp contrast the instant invention needs to determine the source of the data. This is so that data can be classified as to source so that packet flooding from a particular source can be detected and stopped.

The Examiner Stated

> 11. As per claim 8; "A packet flooding defense system (col. 1, lines 7-1 1,col. 2, lines 53-col. 3, line 11, whereas flow and congestion control in packet networks corresponds to a packet flooding defense, and whereas senders, receivers, and intermediate nodes in a packet communications network correspond to network computers per se as well as typically computers configured as gateways, routers, and firewalls (i.e., col. 1, lines 27-col. 2, line 8) for a network comprising a plurality of host computers, routers, communication lines and transmitted data

packets (figure 1 as applied to appropriate figures 2-9 and accompanying descriptions), said system comprising: at least one firewall, said firewall comprising: hardware and software serving to control packet transmission between said network and a host computer connected to an internal network; means for classifying data packets received at said firewall; means for associating a maximum acceptable transmission rate with each class of data packet received at said firewall (col. 3, lines 12-46, col. 10, lines 8-col. 11, line 10, whereas the color coded green, yellow, etc., packet characterizations constitute classification, upon which rate criteria is established, which in itself is control of processing rate resources.); means for said firewall to determine the rate at which data packets of each class are transmitted from a router to said firewall; means for said router to receive information regarding maximum acceptable transmission rate for data packets being transmitted to said firewall; means for said router to control the rate of transmission of data packets from said router to said firewall; and whereby, the rate of data packet transmissions received at said firewall is kept below the maximum acceptable transmission rate for each data packet class by said control of the rate of transmission of data packets from said router, thereby freeing a portion of the network providing data packet transmission to said firewall.".

Applicant Responds

Applicant respectfully traverses this rejection for the following reasons:

a. A packet flooding defense system is definitely not equivalent to a flow and congestion control system. The aim of Chang et al. is to adjust the data rate in a network based on the congestion in the network. See Abstract. The aim of the instant invention is to prevent packet flooding of a particular user. Packet flooding is a form of electronic attack in which the perpetrator floods the victim with massive amounts of useless data thus using up all available bandwidth. See Abstract.

b. The essence of Claim 8 is that the invention is incorporated into a firewall whereas Chang et al. does not incorporate their invention into a firewall. Chang et al. nowhere mentions the word firewall. The Chang et al. invention is incorporated into the endnodes of the network which are the sending and receiving computers. See col. 4, lines 39-41; and Figures 1 and 2 and their accompanying descriptions.

c. Chang et al. does not include any means for classifying individual packets of data. Chang

et al. does classify the congestion in the network as green, yellow, etc. See col. 3, lines 12-68. This is accomplished essentially by timing, on a sampling basis, how long it takes for data to traverse the network from a sender to a receiver. See col. 2, line 53 – col. 3, line 5; claims 1 and 12; and Figures 5-9 and their accompanying descriptions. The only way that Chang et al. uses individual packets of data is to transmit rate information from the receiver to the sender. See col. 3, line 5-11. In sharp contrast, the instant invention classifies individual packets of data that are received by a host computer and assigns a receive rate to each class. See page 5, lines 1-6.

d. The Examiner has not provided any citations from Chang et al. or any reasons why the following elements of claim 8 are disclosed:

> means for said firewall to determine the rate at which data packets of each class are transmitted from a router to said firewall;
>
> means for said router to receive information regarding maximum acceptable transmission rate for data packets being transmitted to said firewall; means for said router to control the rate of transmission of data packets from said router to said firewall;
>
> and whereby, the rate of data packet transmissions received at said firewall is kept below the maximum acceptable transmission rate for each data packet class by said control of the rate of transmission of data packets from said router, thereby freeing a portion of the network providing data packet transmission to said firewall.

As all of the elements of claim 8 are not disclosed, claim 8 cannot be anticipated.

The Examiner Stated

> 12. Claim 9 additionally recites the limitations that "A packet flooding defense system as described in Claim 8, wherein: said router is capable of receiving information regarding maximum acceptable transmission rate for each class of data packet being transmitted to said firewall; and said router is capable of

controlling the rate of transmission of each class of data packets to said firewall." The teachings of Chang et al. (figures 5-9 and accompanying descriptions), suggest such limitations.

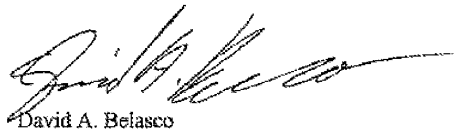
Applicant Responds

Applicant respectfully traverses this rejection. Applicant has examined Figures 5-9 and accompanying descriptions and can find no mention on the Figures or in the text of routers. In fact, as pointed out above, the Chang et al. invention works only at the endnodes. See col. 5, lines 16-44.

Conclusion

It is respectfully submitted that the instant invention is not anticipated by Chang et al. and the Examiner has not met his burden of showing anticipation. Reconsideration of this application and its early allowance are respectfully requested in view of the above presented remarks.

Respectfully submitted,



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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/715,813	11/16/2000	Donald N. Cohen	Q982-DB	8097

31718 7590 03/01/2004

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EXAMINER	
BAUM, RONALD	

ART UNIT	PAPER NUMBER
2135	6

DATE MAILED: 03/01/2004

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)
	09/715,813	COHEN, DONALD N.
	Examiner	Art Unit
	Ronald Baum	2135

-- *The MAILING DATE of this communication appears on the cover sheet with the correspondence 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 this 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 _____.

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) 1-9 is/are pending in the application.

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

5)☒ Claim(s) 7-9 is/are allowed.

6)☒ Claim(s) 1-6 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

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.

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 or PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

Cloudflare, Inc. Exhibit 1003 Page 1677

DETAILED ACTION

1. This action is in reply to applicant's correspondence of 23 January 2004.

2. Claims 1-9 are pending for examination.

Claims 1-6 remain rejected.

Claims 7-9 are allowed.

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 –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

3. Claims 1-6 remain rejected under 35 U.S.C. 102(b) as being anticipated by Chang et al, U.S. Patent 5,367,523.

4. As per claim 1; "A packet flooding defense system [col. 1, lines 7-11,col. 2, lines 53-col. 3, line 11, whereas flow and congestion control in packet networks corresponds to a packet flooding defense, and whereas senders, receivers, and intermediate nodes in a packet communications network correspond to network computers per se as well as typically computers configured as gateways, routers, and firewalls (i.e., col. 1, lines 27-col. 2, line 8)] for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets [figure 1 as applied to appropriate figures 2-9 and accompanying descriptions], said system comprising: means for classifying data packets received at a host computer; means for

associating a maximum acceptable processing rate with each class of data packet received at said computer [col. 3, lines 12-46, col. 10, lines 8-col. 11, line 10, whereas the color coded green, yellow, etc., packet characterizations constitute classification, upon which rate criteria is established, which in itself is control of processing rate resources.]; means for said computer to find information for packets it receives regarding the path by which said packets came to said computer [col. 5, lines 50-col. 6, line 9, col. 6, lines 21-48]; and whereby, said computer can use said information to allocate the processing rate available for packets of each class in a desired way [figures 5-9 and accompanying descriptions].";

5. As per claim 2; "A packet flooding defense system [col. 1, lines 7-11,col. 2, lines 53-col. 3, line 11, whereas flow and congestion control in packet networks corresponds to a packet flooding defense, and whereas senders, receivers, and intermediate nodes in a packet communications network correspond to network computers per se as well as typically computers configured as gateways, routers, and firewalls (i.e., col. 1, lines 27-col. 2, line 8)] for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets [figure 1 as applied to appropriate figures 2-9 and accompanying descriptions], said system comprising: means for classifying data packets received at a host computer; means for associating a maximum acceptable processing rate with each class of data packet received at said computer [col. 3, lines 12-46, col. 10, lines 8-col. 11, line 10, whereas the color coded green, yellow, etc., packet characterizations constitute classification, upon which rate criteria is established, which in itself is control of processing rate resources.]; means for said computer to determine the rate at which data packets of each class are transmitted from a router to said computer; means for said router to receive information regarding maximum acceptable

transmission rate for data packets being transmitted to said computer; means for said router to control the rate of transmission of data packets from said router to said computer; and whereby, the rate of data packet transmissions received at said computer is kept below the maximum acceptable processing rate for each data packet class by said control of the rate of transmission of data packets from said router, thereby freeing a portion of the network providing data packet transmission to said computer [figures 5-9 and accompanying descriptions].".

6. Claim 3 ***additionally recites*** the limitations that "A packet flooding defense system as described in Claim 2, wherein: said router is capable of receiving information regarding maximum acceptable transmission rate for each class of data packet being transmitted to said computer; and said router is capable of controlling the rate of transmission of each class of data packets to said computer.". The teachings of Chang et al (figures 5-9 and accompanying descriptions), suggest such limitations.

7. As per claim 4; "A packet flooding defense system [col. 1, lines 7-11,col. 2, lines 53-col. 3, line 11, whereas flow and congestion control in packet networks corresponds to a packet flooding defense, and whereas senders, receivers, and intermediate nodes in a packet communications network correspond to network computers per se as well as typically computers configured as gateways, routers, and firewalls (i.e., col. 1, lines 27-col. 2, line 8)] for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets [figure 1 as applied to appropriate figures 2-9 and accompanying descriptions], said system comprising: means for classifying data packets received at a router; means for associating a maximum acceptable transmission rate with each class of data packet received at said router [col. 3, lines 12-46, col. 10, lines 8-col. 11, line 10, whereas the color coded green, yellow, etc.,

packet characterizations constitute classification, upon which rate criteria is established, which in itself is control of processing rate resources.]; means for said router to find information for packets it receives regarding the path by which said packets came to said router [col. 5, lines 50-col. 6, line 9, col. 6, lines 21-48]; and whereby, said router can use said information to allocate the transmission rate for each class in a desired way [figures 5-9 and accompanying descriptions].".

8. As per claim 5; "A packet flooding defense system [col. 1, lines 7-11,col. 2, lines 53-col. 3, line 11, whereas flow and congestion control in packet networks corresponds to a packet flooding defense, and whereas senders, receivers, and intermediate nodes in a packet communications network correspond to network computers per se as well as typically computers configured as gateways, routers, and firewalls (i.e., col. 1, lines 27-col. 2, line 8)]for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets [figure 1 as applied to appropriate figures 2-9 and accompanying descriptions], said system comprising: means for classifying data packets received at a first router; means for associating a maximum acceptable transmission rate with each class of data packet received at said first router [col. 3, lines 12-46, col. 10, lines 8-col. 11, line 10, whereas the color coded green, yellow, etc., packet characterizations constitute classification, upon which rate criteria is established, which in itself is control of processing rate resources.]; means for said first router to determine the rate at which data packets of each class are transmitted from a second router to said first router; means for said second router to receive information regarding maximum acceptable transmission rate for data packets being transmitted to said first router; means for said second router to control the rate of transmission of data packets from said second router to said

first router; and whereby, the rate of data packet transmissions received at said first router is kept below the maximum acceptable transmission rate for each data packet class by said control of the rate of transmission of data packets from said second router, thereby freeing a portion of the network providing data packet transmission to said first router.".

9. Claim 6 ***additionally recites*** the limitations that "A packet flooding defense system as described in Claim 5, wherein: said second router is capable of receiving information regarding maximum acceptable transmission rate for each class of data packet being transmitted to said first router; and said second router is capable of controlling the rate of transmission of each class of data packets to said first router.". The teachings of Chang et al (figures 5-9 and accompanying descriptions), suggest such limitations.

Allowable Subject Matter

10. Claims 7-9 are allowable as these claims embody the claim 1-6 elements as applied to a firewall oriented configuration. Chang et al and the art of record does not deal with or suggest alone, or in combination with appropriate motivation to combine, the use of firewalls, as applied to the claims 1-6, as configured with said firewall(s).

Response to Arguments

11. As per applicant's argument concerning the Chang et al reference teachings not suggesting a packet flooding defense system is a flow and congestion control system, the examiner disagrees in that "defense' in the context of packet flooding is broadly interpreted as control of an "amount" of packets, which clearly is a matter of traffic congestion, as per col. 1,

lines 7-11,col. 2, lines 53-col. 3, line. Therefore, while the applicant's arguments have been fully considered by the examiner, they are not persuasive.

12. As per applicant's argument concerning the Chang et al reference teachings not suggesting a means for classifying individual packets of data, the examiner disagrees in that the criteria for classifying data packets is not defined in the specification; only means provided for is recited. Further, (col. 3, lines 15-16, "...the sender uses the traffic feedback information from the receiver to set the sender ...") means for classifying individual packets of data is suggested by the fact that the feedback is itself a classification of packet information that is sent back to the sender. Therefore, while the applicant's arguments have been fully considered by the examiner, they are not persuasive.

13. As per applicant's argument concerning the Chang et al reference teachings not suggesting a means for determining the path by which the data arrives at the receiver, the examiner disagrees in that the criteria for determining the path by which the data arrives at the receiver is not defined in the specification; only means provided for is recited. Further, (col. 6, lines 2-4, "Such routing decisions...response to information in the header of the data packet.") means for determining the path by which the data arrives at the receiver is suggested by the fact that the header contains source / destination (IP) network addressing information which clearly constitutes routing (path) information. Therefore, while the applicant's arguments have been fully considered by the examiner, they are not persuasive.

14. As per applicant's argument concerning the Chang et al reference teachings not suggesting a router versus the recited host computer, the examiner disagrees in that the packet communications network includes intermediate congestion control on a "hop by hop" (col. 1,

lines 27-40) basis which broadly defined clearly encompasses network routers. Further, (col. 6, lines 2-4, "Such routing decisions…response to information in the header of the data packet.") determining the path by which the data arrives at the receiver is suggested by the fact that the header contains source / destination (IP) network addressing information which clearly constitutes routing (path) information, and that would be suggestive of a router implemented function. Therefore, while the applicant's arguments have been fully considered by the examiner, they are not persuasive.

15. As per applicant's argument concerning the Chang et al reference teachings not suggesting a router receiving and controlling transmission rates, the examiner disagrees in that the packet communications network rate determination and classification of said rate requirements and forwarding of such (figures 5-7, and accompanying descriptions) clearly show rate request computation and rate information transfer (i.e., "piggy-back rate request", element 64, figure 5 et seq.) Therefore, while the applicant's arguments have been fully considered by the examiner, they are not persuasive.

16. As per applicant's argument concerning the Chang et al reference teachings not suggesting a router to router scenario analogous to the host to host recited in earlier claims, the argument above (for Chang et al even implementing with routing apparatus) would clearly apply to a router to router configuration receiving and controlling transmission rates, etc. Therefore, while the applicant's arguments have been fully considered by the examiner, they are not persuasive.

17. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

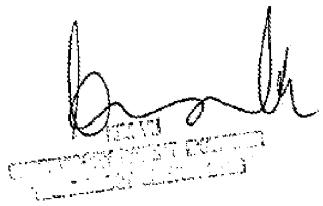
Conclusion

18. Any inquiry concerning this communication or earlier communications from examiner should be directed to Ronald Baum, whose telephone number is (703) 305-4276. The examiner can normally be reached Monday through Friday from 8:00 AM to 5:30 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Kim Vu, can be reached at (703) 305-4393. The Fax number for the organization where this application is assigned is 703-872-9306.

Ronald Baum

Patent Examiner



Interview Summary	Application No.	Applicant(s)	
	09/715,813	COHEN, DONALD N.	
	Examiner	Art Unit	
	Ronald Baum	2136	

All participants (applicant, applicant's representative, PTO personnel):

(1) *David A. Belasco*. (3)____.

(2) *Ronald Baum (examiner)*. (4)____.

Date of Interview: *01 June 2004*.

Type: a)☒ Telephonic b)☐ Video Conference

c)☐ Personal [copy given to: 1)☐ applicant 2)☐ applicant's representative]

Exhibit shown or demonstration conducted: d)☐ Yes e)☒ No.
If Yes, brief description: ____.

Claim(s) discussed: *7*.

Identification of prior art discussed: *N/A*.

Agreement with respect to the claims f)☒ was reached. g)☐ was not reached. h)☐ N/A.

Substance of Interview including description of the general nature of what was agreed to if an agreement was reached, or any other comments: *Pending amending claim 7 having a '112-2 issue with the phrase "can use". Mr. Belasco agreed that is the case, and an examiner amendment to correct the phrase to "uses" is proper to put the application in condition for allowance.*

(A fuller description, if necessary, and a copy of the amendments which the examiner agreed would render the claims allowable, if available, must be attached. Also, where no copy of the amendments that would render the claims allowable is available, a summary thereof must be attached.)

THE FORMAL WRITTEN REPLY TO THE LAST OFFICE ACTION MUST INCLUDE THE SUBSTANCE OF THE INTERVIEW. (See MPEP Section 713.04). If a reply to the last Office action has already been filed, APPLICANT IS GIVEN ONE MONTH FROM THIS INTERVIEW DATE, OR THE MAILING DATE OF THIS INTERVIEW SUMMARY FORM, WHICHEVER IS LATER, TO FILE A STATEMENT OF THE SUBSTANCE OF THE INTERVIEW. See Summary of Record of Interview requirements on reverse side or on attached sheet.

Examiner Note: You must sign this form unless it is an Attachment to a signed Office action.

Examiner's signature, if required

Summary of Record of Interview Require ts

Manual of Patent Examining Procedure (MPEP), Section 713.04, Substance of Interview Must be Made of Record
A complete written statement as to the substance of any face-to-face, video conference, or telephone interview with regard to an application must be made of record in the application whether or not an agreement with the examiner was reached at the interview.

Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews
Paragraph (b)
In every instance where reconsideration is requested in view of an interview with an examiner, a complete written statement of the reasons presented at the interview as warranting favorable action must be filed by the applicant. An interview does not remove the necessity for reply to Office action as specified in §§ 1.111, 1.135. (35 U.S.C. 132)

37 CFR §1.2 Business to be transacted in writing.
All business with the Patent or Trademark Office should be transacted in writing. The personal attendance of applicants or their attorneys or agents at the Patent and Trademark Office is unnecessary. The action of the Patent and Trademark Office will be based exclusively on the written record in the Office. No attention will be paid to any alleged oral promise, stipulation, or understanding in relation to which there is disagreement or doubt.

The action of the Patent and Trademark Office cannot be based exclusively on the written record in the Office if that record is itself incomplete through the failure to record the substance of interviews.

It is the responsibility of the applicant or the attorney or agent to make the substance of an interview of record in the application file, unless the examiner indicates he or she will do so. It is the examiner's responsibility to see that such a record is made and to correct material inaccuracies which bear directly on the question of patentability.

Examiners must complete an Interview Summary Form for each interview held where a matter of substance has been discussed during the interview by checking the appropriate boxes and filling in the blanks. Discussions regarding only procedural matters, directed solely to restriction requirements for which interview recordation is otherwise provided for in Section 812.01 of the Manual of Patent Examining Procedure, or pointing out typographical errors or unreadable script in Office actions or the like, are excluded from the interview recordation procedures below. Where the substance of an interview is completely recorded in an Examiners Amendment, no separate Interview Summary Record is required.

The Interview Summary Form shall be given an appropriate Paper No., placed in the right hand portion of the file, and listed on the "Contents" section of the file wrapper. In a personal interview, a duplicate of the Form is given to the applicant (or attorney or agent) at the conclusion of the interview. In the case of a telephone or video-conference interview, the copy is mailed to the applicant's correspondence address either with or prior to the next official communication. If additional correspondence from the examiner is not likely before an allowance or if other circumstances dictate, the Form should be mailed promptly after the interview rather than with the next official communication.

The Form provides for recordation of the following information:
- Application Number (Series Code and Serial Number)
- Name of applicant
- Name of examiner
- Date of interview
- Type of interview (telephonic, video-conference, or personal)
- Name of participant(s) (applicant, attorney or agent, examiner, other PTO personnel, etc.)
- An indication whether or not an exhibit was shown or a demonstration conducted
- An identification of the specific prior art discussed
- An indication whether an agreement was reached and if so, a description of the general nature of the agreement (may be by attachment of a copy of amendments or claims agreed as being allowable). Note: Agreement as to allowability is tentative and does not restrict further action by the examiner to the contrary.
- The signature of the examiner who conducted the interview (if Form is not an attachment to a signed Office action)

It is desirable that the examiner orally remind the applicant of his or her obligation to record the substance of the interview of each case. It should be noted, however, that the Interview Summary Form will not normally be considered a complete and proper recordation of the interview unless it includes, or is supplemented by the applicant or the examiner to include, all of the applicable items required below concerning the substance of the interview.

A complete and proper recordation of the substance of any interview should include at least the following applicable items:
1) A brief description of the nature of any exhibit shown or any demonstration conducted,
2) an identification of the claims discussed,
3) an identification of the specific prior art discussed,
4) an identification of the principal proposed amendments of a substantive nature discussed, unless these are already described on the Interview Summary Form completed by the Examiner,
5) a brief identification of the general thrust of the principal arguments presented to the examiner,
   (The identification of arguments need not be lengthy or elaborate. A verbatim or highly detailed description of the arguments is not required. The identification of the arguments is sufficient if the general nature or thrust of the principal arguments made to the examiner can be understood in the context of the application file. Of course, the applicant may desire to emphasize and fully describe those arguments which he or she feels were or might be persuasive to the examiner.)
6) a general indication of any other pertinent matters discussed, and
7) if appropriate, the general results or outcome of the interview unless already described in the Interview Summary Form completed by the examiner.

Examiners are expected to carefully review the applicant's record of the substance of an interview. If the record is not complete and accurate, the examiner will give the applicant an extendable one month time period to correct the record.

Examiner to Check for Accuracy

If the claims are allowable for other reasons of record, the examiner should send a letter setting forth the examiner's version of the statement attributed to him or her. If the record is complete and accurate, the examiner should place the indication, "Interview Record OK" on the paper recording the substance of the interview along with the date and the examiner's initials.

Cloudflare, Inc. Exhibit 1003 Page 1687

Notice of References Cited	Application/Control No. 09/715,813	Applicant(s)/Patent Under Reexamination COHEN, DONALD N.	
	Examiner Ronald Baum	Art Unit 2135	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
	A	US-5,581,559	12-1996	Crayford et al.	370/392
	B	US-6,044,402	03-2000	Jacobson et al.	709/225
	C	US-5,455,865	10-1995	Perlman, Radia J.	713/153
	D	US-6,353,353	10-1994	Vijeh et al.	380/29
	E	US-5,850,516	12-1998	Lo et al.	714/43
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	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.

TE

L Number	Hits	Search Text	DB	Time stamp
1	10	5581559.pn. or 6044402.pn. or 5455865.pn. or 5353353.pn. or 5850515.pn.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/02/23 15:51
2	1	(5581559.pn. or 6044402.pn. or 5455865.pn. or 5353353.pn. or 5850515.pn.) and firewall$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/02/23 15:51
3	4	370/229-240.ccls. and packet with flooding and router	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/02/23 16:04
4	17	370/229-240.ccls. and router and denial adj1 service and bandwidth	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/02/23 16:10
5	5	370/229-240.ccls. and router and denial adj1 service and bandwidth and firewall	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/02/23 16:10
-	2070	713/201.ccls.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/02/23 14:42
-	3	713/201.ccls. and packet with flooding and router	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 11:56
-	3	713/201.ccls. and packet with flooding and router	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 11:56
-	94	packet with flooding and router	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/02/23 16:03
-	5	packet with flooding and router and denial and bandwidth	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 11:57
-	495	router and denial and bandwidth	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 11:59
-	471	router and denial adj1 service	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 11:59
-	329	router and denial adj1 service and bandwidth	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/02/23 16:06

-	64	router and denial and bandwidth and transmi$ adj1 rate	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:00
-	8	router and denial and bandwidth and send$ adj1 rate	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:00
-	982	network same router and flood$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:01
-	118	network same router and flood$ and defen$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:01
-	130	router and flood$ and defen$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:01
-	91	ddos	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:02
-	30	packet adj1 class$ and denial adj1 service	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:02
-	6	throttl$ with bandwidth and denial	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:03
-	8	709/238-244.ccls. and denial and allocate	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:05
-	4	709/238-244.ccls. and flood$ with rate	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:07
-	241	709/238-244.ccls. and transmi$ with rate	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:07
-	126	router with flow adj1 control	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:08
-	7	packet adj1 flood$ and defense	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:08

-	446	packet with overload$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:16
-	50	packet adj2 overload$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:17
-	96	packet adj1 flood$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:33
-	568	packet with flow adj2 (control or allocat$) and router$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:34
-	67	packet with flow adj2 (control or allocat$) and router$ and (defense or denial)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:50
-	25	router with flow adj2 (control or allocat$) and (defense or denial)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:54
-	2	5367523.pn.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 13:06
-	2	5007052.pn.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 13:09
-	2	5699513.pn.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 13:12
-	2	6412000.pn.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 13:15
-	2	5434860.pn.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 13:17
-	2	20020032871.pn.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 13:19
-	2	4817080.pn.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 13:21

-	2	6088804.pn.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 13:21

OIPE JC161
MAY 03 2004
PATENT & TRADEMARK OFFICE

#7

Applicant: Donald N. Cohen
Serial No.: 09/715,813
Examiner: Baum, Ronald
Art Unit 2135
Filed: November 16, 2000
Docket: 02-322-B

CERTIFICATE OF FIRST CLASS MAILING UNDER 37 CFR 1.8

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Technology Center 2100

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2. Return Receipt Postcard

are being deposited with the U.S. Postal Service on the date subscribed below, with sufficient postage as first class mail, in an envelope addressed to the Mail Stop Non-Fee Amendment, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450

Donna Miller Date: 4-29-04
Donna Miller

B

OIPE JC151
MAY 03 2004
PATENT & TRADEMARK OFFICE

2135

PATENT
02-322-B
Formerly Q982-DB

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

7/B
5-18-04

Applicant:	Cohen	Examiner:	Baum
Serial No.:	09/715,813	Group Art Unit:	2135
Title:	**PACKET FLOODING DEFENSE SYSTEM**		
Filed:	11/16/2000		

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O.K. to enter 6/6/04 DB

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Donna Miller Date: 4-29-04
Donna Miller

AMENDMENT

This document is being submitted in response to the Office Action mailed 03/01/2004. Please amend the above referenced application as follows.

Amendments to the claims are reflected in the listing of claims which begins on page 2 of this paper.

Remarks begin on page 4 of this paper.

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Amendments to the claims:

This listing will replace all prior listings in this application.

Listing of claims

Claims 1-6 (cancelled)

Claim 7 (original) A packet flooding defense system for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets, said system comprising:

at least one firewall, said firewall comprising:

hardware and software serving to control packet transmission between said network and a host computer connected to an internal network;

means for classifying data packets received at said firewall;

means for associating a maximum acceptable transmission rate with each class of data packet received at said firewall;

means for said firewall to find information for packets it receives regarding the path by which said packets came to said firewall; and

whereby, said firewall can use said information to allocate the transmission rate for each ~~class in a desired way.~~

Claim 8 (original) A packet flooding defense system for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets, said system comprising:

at least one firewall, said firewall comprising:

hardware and software serving to control packet transmission between said network and a host computer connected to an internal network;

means for classifying data packets received at said firewall;

means for associating a maximum acceptable transmission rate with each class of data packet received at said firewall;

means for said firewall to determine the rate at which data packets of each class are transmitted from a router to said firewall;

means for said router to receive information regarding maximum acceptable transmission rate for data packets being transmitted to said firewall;

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means for said router to control the rate of transmission of data packets from said router to said firewall; and

whereby, the rate of data packet transmissions received at said firewall is kept below the maximum acceptable transmission rate for each data packet class by said control of the rate of transmission of data packets from said router, thereby freeing a portion of the network providing data packet transmission to said firewall.

Claim 3 (original) A packet flooding defense system as described in Claim 1, wherein:

said router is capable of receiving information regarding maximum acceptable transmission rate for each class of data packet being transmitted to said firewall; and

said router is capable of controlling the rate of transmission of each class of data packets to said firewall.

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REMARKS

The Examiner rejected claims 1-6 stating that he found the arguments presented in Applicant's Request for Reconsideration submitted 01/19/2004 to be unpersuasive. Applicant has cancelled claims 1-6.

The Examiner has allowed the remaining claims 7-9.

In view of the above listed amendments this application is now in condition for allowance. Applicant therefore requests that a timely Notice of Allowance be issued for this application.

Respectfully submitted,

David A. Belasco
Applicant's Attorney
Registration No. 41,609

BELASCO JACOBS & TOWNSLEY, LLP
Howard Hughes Center
6100 Center Drive, Suite 630
Los Angeles, CA 90045
Phone: (310) 743-1188
Fax: (310) 743-1189

B

Notice of Allowability	Application No.	Applicant(s)	
	09/715,813	COHEN, DONALD N.	
	Examiner	Art Unit	
	Ronald Baum	2136	

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

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to 5/3/2004.

2. ☒ The allowed claim(s) is/are 7-9.

3. ☐ The drawings filed on _____ are accepted by the Examiner.

4. ☐ 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 the:
      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)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

6. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

7. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☒ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☐ Information Disclosure Statements (PTO-1449 or PTO/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application (PTO-152)
6. ☒ Interview Summary (PTO-413), Paper No./Mail Date 8.
7. ☒ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

AYAZ SHEIKH
SUPERVISORY PATENT EXAMINER
TECHNOLOGY CENTER 2100

Cloudflare, Inc. Exhibit 1003 Page 1698

#8/C 6-8-04

EXAMINER'S AMENDMENT

An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

Authorization for this examiner's amendment was given in a telephone interview with David A. Belasco, Reg. No. 41,609 on 6/1/2004.

1. Replace claim 7 with (changes "*can use* said information" to "*uses* said information"):

A packet flooding defense system for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets, said system comprising: at least one firewall, said firewall comprising:

hardware and software serving to control packet transmission between said network and a host computer connected to an internal network;

means for classifying data packets received at said firewall;

means for associating a maximum acceptable transmission rate with each class of data packet received at said firewall;

means for said firewall to find information for packets it receives regarding the path by which said packets came to said firewall; and

whereby, said firewall uses said information to allocate the transmission rate for each class in a desired way.

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Examiner's Statement of Reasons for Allowance

2. Claims 6-9 are allowed over prior art.

3. This action is in reply to applicant's correspondence of 03 May 2004.

4. The following is an examiner's statement of reasons for the indication of allowable claimed subject matter.

5. As per examiner amended claims 7-8, prior art of record, Chang et al, U.S. Patent 5,367,523, fails to teach, alone, or in combination, of;

(claim 7) "A packet flooding defense system for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets, said system comprising: at least one firewall, said firewall comprising: hardware and software serving to control packet transmission between said network and a host computer connected to an internal network; means for classifying data packets received at said firewall; means for associating a maximum acceptable transmission rate with each class of data packet received at said firewall; means for said firewall to find information for packets it receives regarding the path by which said packets came to said firewall; and whereby, said firewall uses said information to allocate the transmission rate for each class in a desired way.", and;

(claim 8) "A packet flooding defense system for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets, said system comprising: at least one firewall, said firewall comprising: hardware and software serving to control packet transmission between said network and a host computer connected to an internal network; means for classifying data packets received at said firewall; means for associating a maximum acceptable transmission rate with each class of data packet received at said firewall; means for

said firewall to determine the rate at which data packets of each class are transmitted from a router to said firewall; means for said router to receive information regarding maximum acceptable transmission rate for data packets being transmitted to said firewall; means for said router to control the rate of transmission of data packets from said router to said firewall; and whereby, the rate of data packet transmissions received at said firewall is kept below the maximum acceptable transmission rate for each data packet class by said control of the rate of transmission of data packets from said router, thereby freeing a portion of the network providing data packet transmission to said firewall.". The underlined above claim elements dealing with (claim 7); a (specifically) firewall having "means for associating a *maximum acceptable transmission rate* with each *class* of data packet received at said firewall such that received packet *path information* to *allocate the transmission rate for each class*" , and (claim 8); a (specifically) firewall to router configuration having "means for said *router to control the rate of transmission* of data packets from said *router to said firewall*," and the rate of packets (*received*) at the firewall is kept "*below the maximum acceptable transmission rate for each data packet class* by said *control of the rate of transmission of data packets from said router*, thereby freeing a portion of the network providing data packet transmission to said firewall." serving to patently distinguish the invention from prior art.

Dependent claim 9 is allowable by virtue of their dependencies.

Conclusion

C

6. Any inquiry concerning this communication or earlier communications from examiner should be directed to Ronald Baum, whose telephone number is (703) 305-4276. The examiner can normally be reached Monday through Friday from 8:00 AM to 5:30 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Ayaz Sheikh, can be reached at (703) 305-9648. The Fax number for the organization where this application is assigned is 703-872-9306.

Ronald Baum

Patent Examiner

AYAZ SHEIKH
SUPERVISORY PATENT EXAMINER
TECHNOLOGY CENTER 2100

C

EXAMINER'S AMENDMENT

An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

Authorization for this examiner's amendment was given in a telephone interview with David A. Belasco, Reg. No. 41,609 on 6/1/2004.

1. Replace claim 7 with (changes "*can use* said information" to "*uses* said information"):

7. A packet flooding defense system for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets, said system comprising: at least one firewall, said firewall comprising:

hardware and software serving to control packet transmission between said network and a host computer connected to an internal network;

means for classifying data packets received at said firewall;

means for associating a maximum acceptable transmission rate with each class of data packet received at said firewall;

means for said firewall to find information for packets it receives regarding the path by which said packets came to said firewall; and

whereby, said firewall uses said information to allocate the transmission rate for each class in a desired way.

Examiner's Statement of Reasons for Allowance

2. Claims 6-9 are allowed over prior art.

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(claim 8) "A packet flooding defense system for a network comprising a plurality of host computers, routers, communication lines and transmitted data packets, said system comprising: at least one firewall, said firewall comprising: hardware and software serving to control packet transmission between said network and a host computer connected to an internal network; means for classifying data packets received at said firewall; means for associating a maximum acceptable transmission rate with each class of data packet received at said firewall; means for

said firewall to determine the rate at which data packets of each class are transmitted from a router to said firewall; means for said router to receive information regarding maximum acceptable transmission rate for data packets being transmitted to said firewall; means for said router to control the rate of transmission of data packets from said router to said firewall; and whereby, the rate of data packet transmissions received at said firewall is kept below the maximum acceptable transmission rate for each data packet class by said control of the rate of transmission of data packets from said router, thereby freeing a portion of the network providing data packet transmission to said firewall.". The underlined above claim elements dealing with (claim 7); a (specifically) firewall having "means for associating a *maximum acceptable transmission rate* with each *class* of data packet received at said firewall such that received packet *path information* to *allocate the transmission rate for each class*" , and (claim 8); a (specifically) firewall to router configuration having "means for said *router to control the rate of transmission* of data packets from said *router to said firewall*," and the rate of packets (*received*) at the firewall is kept "*below the maximum acceptable transmission rate for each data packet class* by said *control of the rate of transmission of data packets from said router*, thereby freeing a portion of the network providing data packet transmission to said firewall." serving to patently distinguish the invention from prior art.

Dependent claim 9 is allowable by virtue of their dependencies.

Conclusion

6. Any inquiry concerning this communication or earlier communications from examiner should be directed to Ronald Baum, whose telephone number is (703) 305-4276. The examiner can normally be reached Monday through Friday from 8:00 AM to 5:30 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Ayaz Sheikh, can be reached at (703) 305-9648. The Fax number for the organization where this application is assigned is 703-872-9306.

Ronald Baum

Patent Examiner

AYAZ SHEIKH
SUPERVISORY PATENT EXAMINER
TECHNOLOGY CENTER 2100

Notice of References Cited	Application/Control No. 09/715,813	Applicant(s)/Patent Under Reexamination COHEN, DONALD N.	
	Examiner Ronald Baum	Art Unit 2136	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
	A	US-2004/0015721	01-2004	Eastlake, Donald E. III	713/201
	B	US-			
	C	US-			
	D	US-			
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31718 7590 06/08/2004

BELASCO, JACOBS & TOWNSLEY LLP
HOWARD HUGHES CENTER
6100 CENTER DRIVE
SUITE 630
LOS ANGELES, CA 90045

EXAMINER	
BAUM, RONALD	
ART UNIT	PAPER NUMBER
2136	8

DATE MAILED: 06/08/2004

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/715,813	11/16/2000	Donald N. Cohen	Q982-DB	8097

TITLE OF INVENTION: PACKET FLOODING DEFENSE SYSTEM

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$665	$0	$665	09/08/2004

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATEN PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHT THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPO PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM TH MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. TH STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOV REFLECTS A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE APPLIED IN THIS APPLICATION. THE PTOL-85B (O AN EQUIVALENT) MUST BE RETURNED WITHIN THIS PERIOD EVEN IF NO FEE IS DUE OR THE APPLICATION WIL BE REGARDED AS ABANDONED.

HOW TO REPLY TO THIS NOTICE:

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If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status is changed, pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above and notify the United States Patent and Trademark Office of the change in status, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is n claiming SMALL ENTITY status, check the box below and enclo the PUBLICATION FEE and 1/2 the ISSUE FEE shown above.

☐ Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

II. PART B - FEE(S) TRANSMITTAL should be completed and returned to the United States Patent and Trademark Office (USPTO) w your ISSUE FEE and PUBLICATION FEE (if required). Even if the fee(s) have already been paid, Part B - Fee(s) Transmittal should completed and returned. If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should completed and an extra copy of the form should be submitted.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PTOL 85 (Rev 11/03) Approved for use through 04/30/2004

Cloudflare, Inc. Exhibit 1003 Page 1709

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail Mail Stop ISSUE FEE
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INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 4 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

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31718 7590 06/08/2004

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LOS ANGELES, CA 90045

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(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/715,813	11/16/2000	Donald N. Cohen	Q982-DB	8097

TITLE OF INVENTION: PACKET FLOODING DEFENSE SYSTEM

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$665	$0	$665	09/08/2004

EXAMINER	ART UNIT	CLASS-SUBCLASS
BAUM, RONALD	2136	713-160000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/715,813	11/16/2000	Donald N. Cohen	Q982-DB	8097

31718 7590 06/08/2004

BELASCO, JACOBS & TOWNSLEY LLP
HOWARD HUGHES CENTER
6100 CENTER DRIVE
SUITE 630
LOS ANGELES, CA 90045

EXAMINER	
BAUM, RONALD	

ART UNIT	PAPER NUMBER
2136	8

DATE MAILED: 06/08/2004

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 652 day(s). If the issue fee is paid on the date that is three months after t mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a ha months) after the mailing date of this notice, the Patent Term Adjustment will be 652 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date th determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retriev (PAIR) system (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office Patent Legal Administration at (703) 305-1383. Questions relating to issue and publication fee payments should directed to the Customer Service Center of the Office of Patent Publication at (703) 305-8283.

PTOL 85 (Rev 11/03) Approved for use through 04/30/2004

Cloudflare, Inc. Exhibit 1003 Page 1711

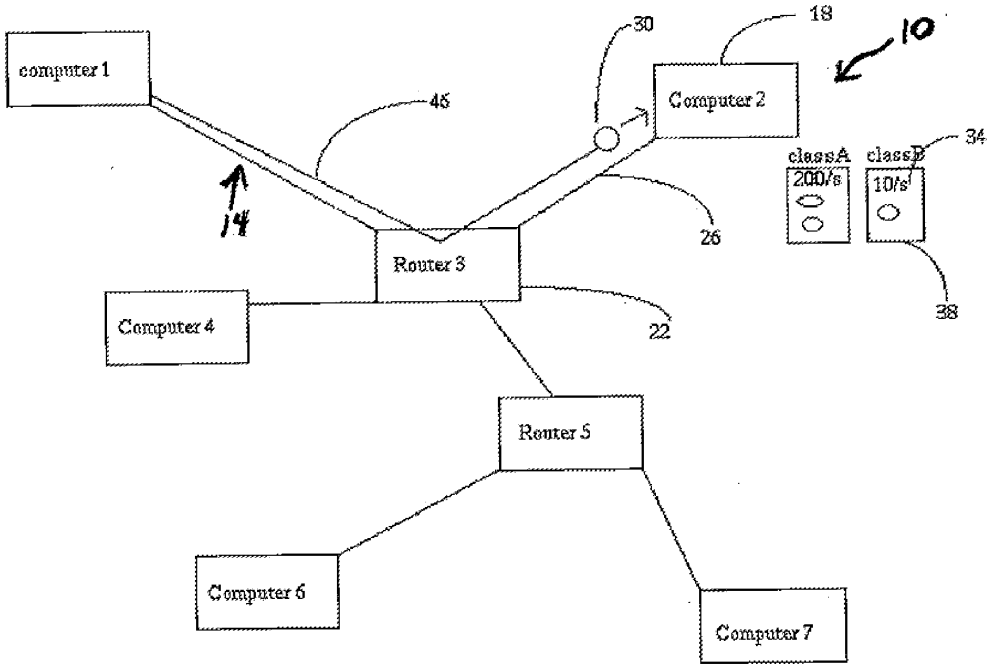
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2	82	(713/201.ccls. or 709/238-244.ccls. or 370/229-240.ccls.) and (router and denial adj1 service and bandwidth)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/01 11:39
3	0	(713/201.ccls. or 709/238-244.ccls. or 370/229-240.ccls.) and (router with flow adj2 (control or allocat$) and (defense or denial)) and firewall$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/01 11:38
4	54	(713/201.ccls. or 709/238-244.ccls. or 370/229-240.ccls.) and (router and denial adj1 service and bandwidth) and firewall$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/01 11:39
5	1	(713/201.ccls. or 709/238-244.ccls. or 370/229-240.ccls.) and (router and denial adj1 service and bandwidth) with firewall$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/01 11:39
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-	3	713/201.ccls. and packet with flooding and router	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 11:56
-	3	713/201.ccls. and packet with flooding and router	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 11:56
-	94	packet with flooding and router	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/02/23 16:03
-	5	packet with flooding and router and denial and bandwidth	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 11:57
-	495	router and denial and bandwidth	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 11:59
-	471	router and denial adj1 service	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 11:59

-	329	router and denial adj1 service and bandwidth	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/02/23 16:06
-	64	router and denial and bandwidth and transmi$ adj1 rate	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:00
-	8	router and denial and bandwidth and send$ adj1 rate	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:00
-	982	network same router and flood$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:01
-	118	network same router and flood$ and defen$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:01
-	130	router and flood$ and defen$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:01
-	91	ddos	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:02
-	30	packet adj1 class$ and denial adj1 service	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:02
-	6	thrott$ with bandwidth and denial	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:03
-	8	709/238-244.ccls. and denial and allocate	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:05
-	4	709/238-244.ccls. and flood$ with rate	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:07
-	241	709/238-244.ccls. and transmi$ with rate	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:07
-	126	router with flow adj1 control	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:08

-	7	packet adj1 flood$ and defense	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:08
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-	50	packet adj2 overload$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:17
-	96	packet adj1 flood$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:33
-	558	packet with flow adj2 (control or allocat$) and router$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:34
-	67	packet with flow adj2 (control or allocat$) and router$ and (defense or denial)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 12:50
-	25	router with flow adj2 (control or allocat$) and (defense or denial)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/01 11:38
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-	2	6088804.pn.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/23 13:21
-	10	5581559.pn. or 6044402.pn. or 5455865.pn. or 5353353.pn. or 5850515.pn.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/02/23 15:51
-	1	(5581559.pn. or 6044402.pn. or 5455865.pn. or 5353353.pn. or 5850515.pn.) and firewall$	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/02/23 15:51
-	4	370/229-240.ccls. and packet with flooding and router	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/02/23 16:04
-	17	370/229-240.ccls. and router and denial adj1 service and bandwidth	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/08/01 11:37
-	5	370/229-240.ccls. and router and denial adj1 service and bandwidth and firewall	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/02/23 16:10

Figure 1

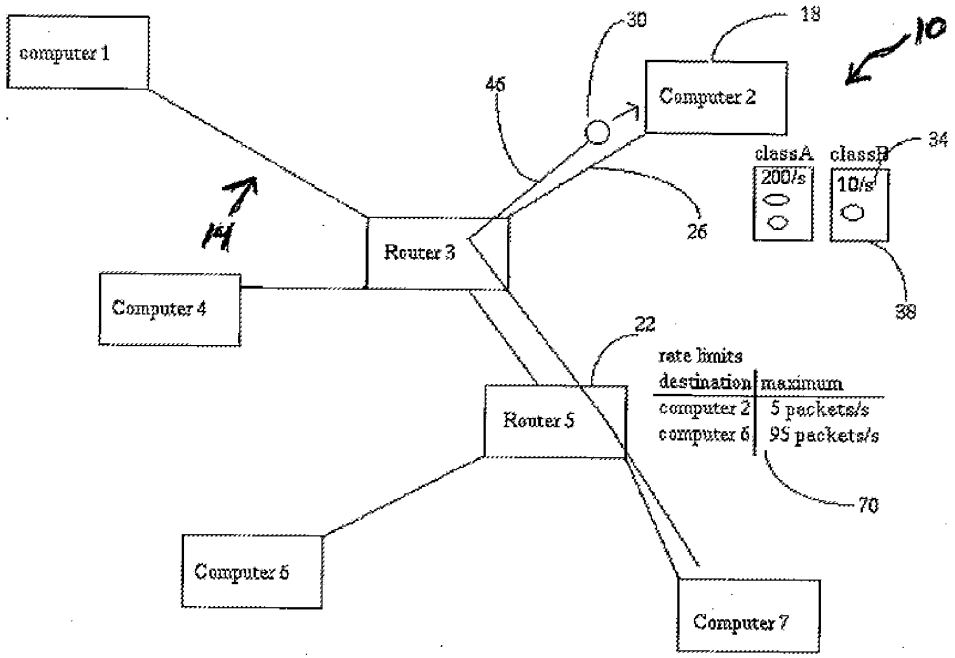


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Cloudflare, Inc. Exhibit 1003 Page 1716

US 9,571,564 B2

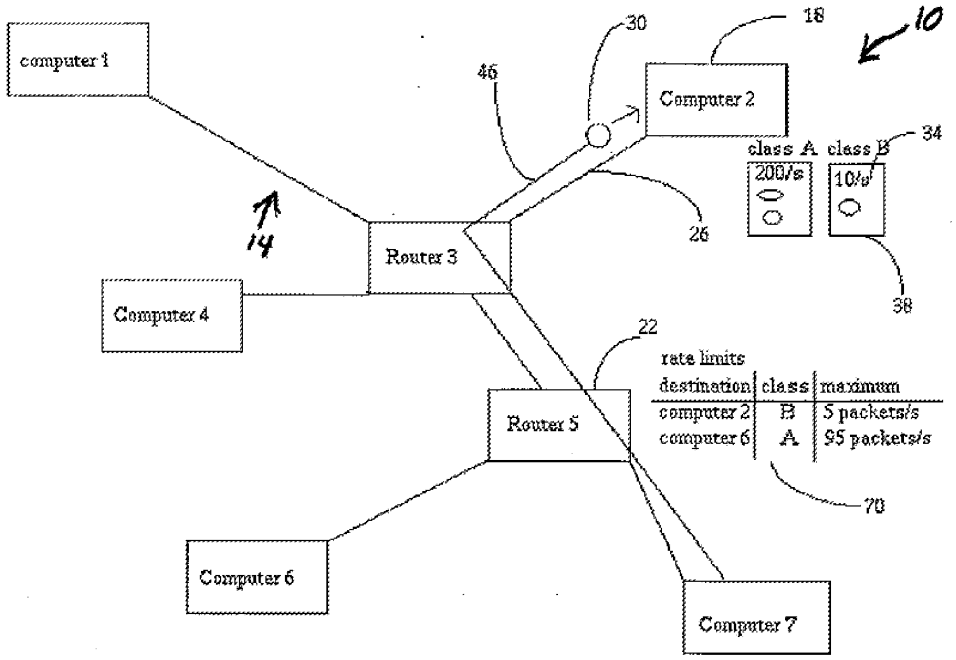
Figure 2



Cloudflare, Inc. Exhibit 1003 Page 1717

DOCKET E1851/60

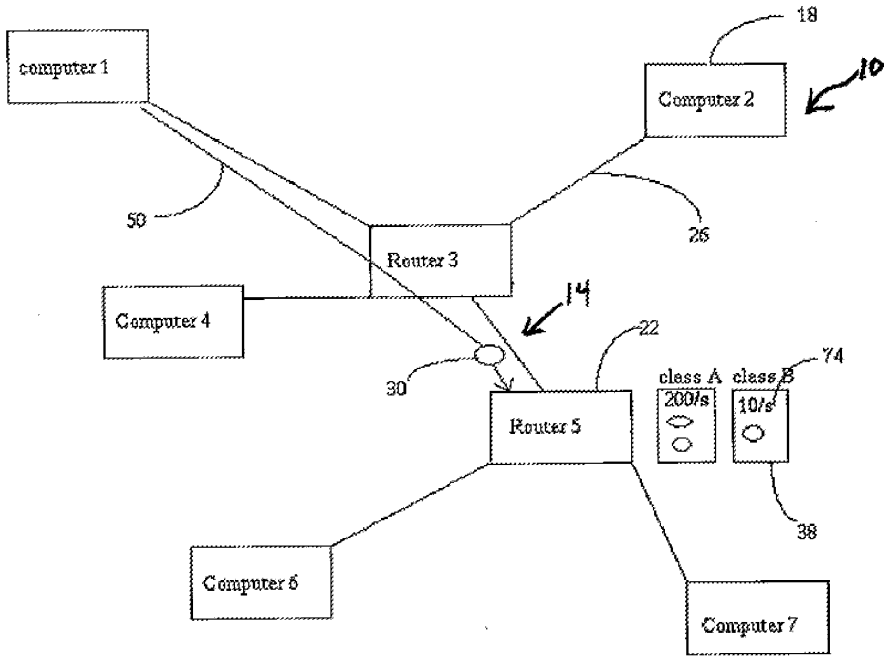
Figure 3



Cloudflare, Inc. Exhibit 1003 Page 1718

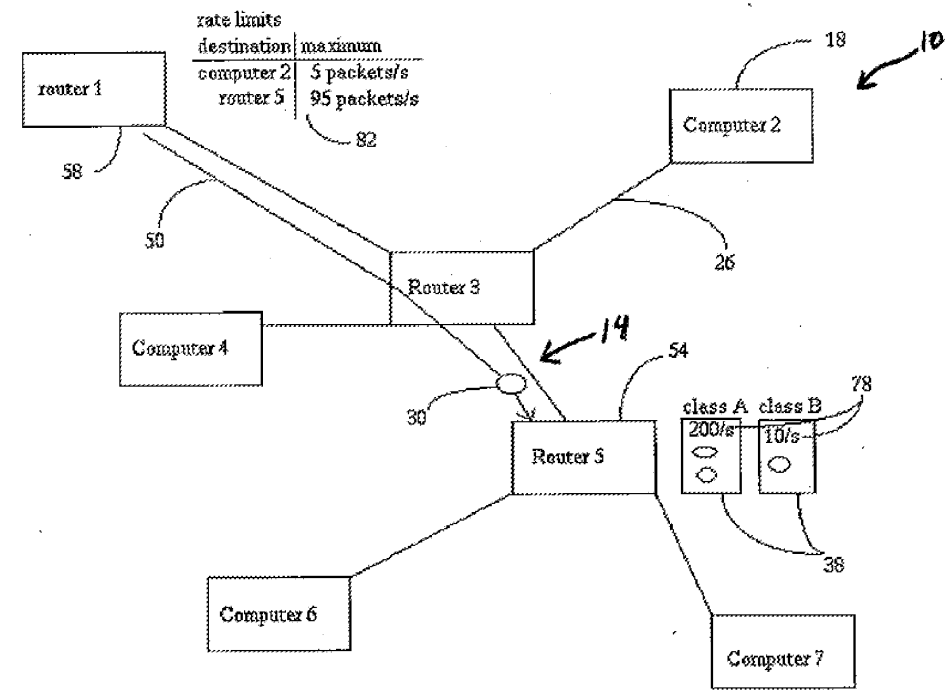
DOCKET ETBST260

Figure 4



Cloudflare, Inc. Exhibit 1003 Page 1719

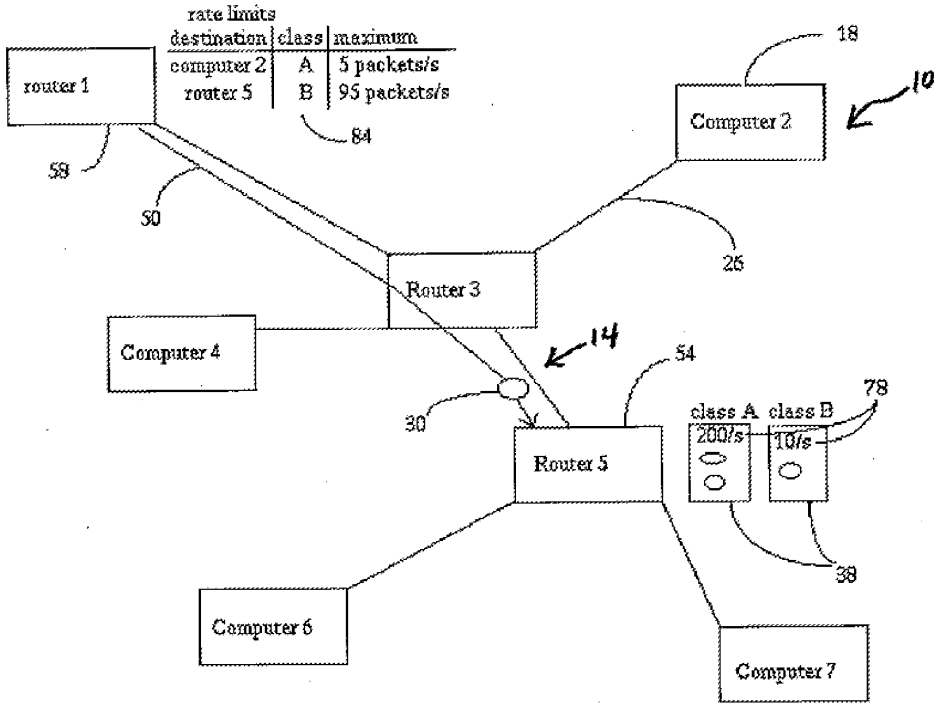
Figure 5



Cloudflare, Inc. Exhibit 1003 Page 1720

US 8,819,760

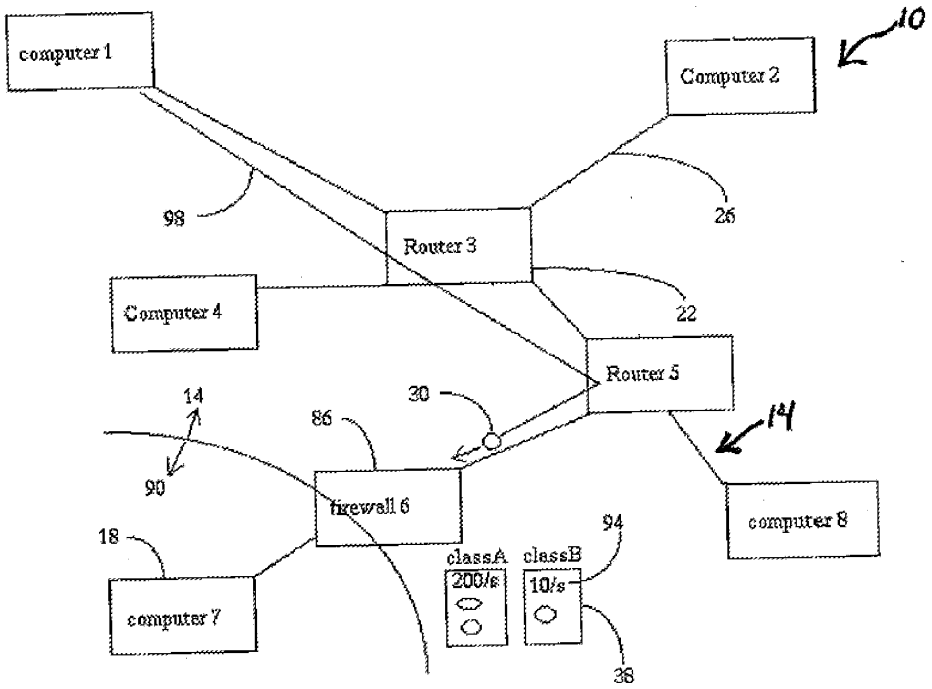
Figure 6



Cloudflare, Inc. Exhibit 1003 Page 1721

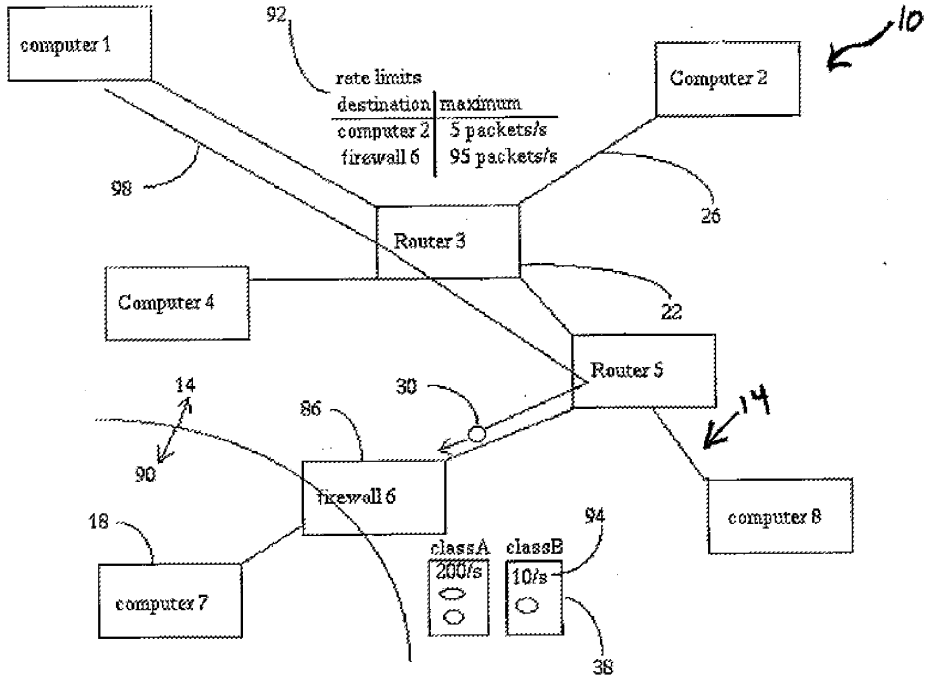
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Figure 7



Cloudflare, Inc. Exhibit 1003 Page 1722

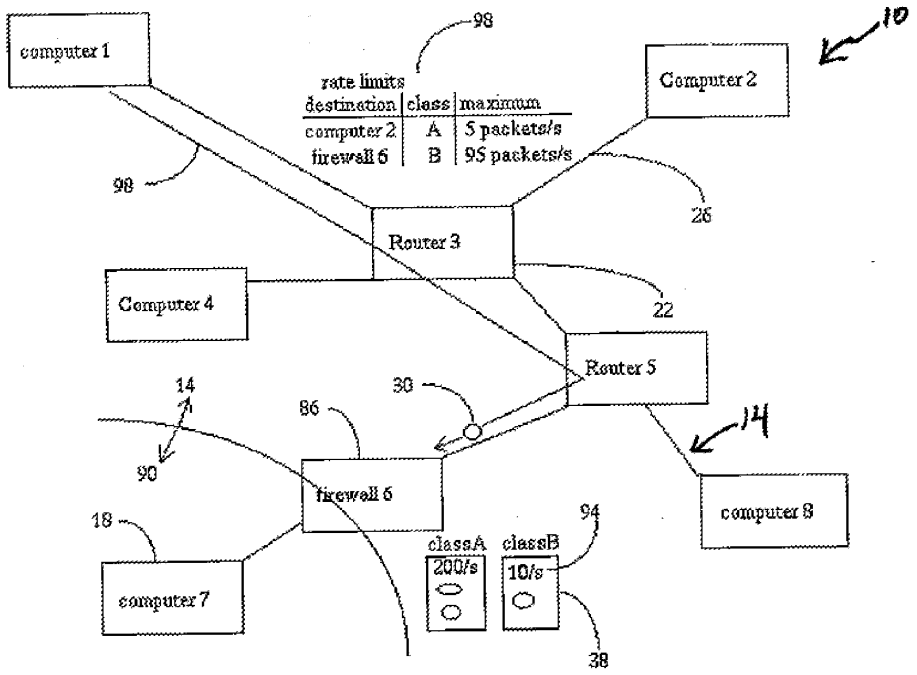
Figure 8



Cloudflare, Inc. Exhibit 1003 Page 1723

0097777 "ET85T260

Figure 9



Cloudflare, Inc. Exhibit 1003 Page 1724



Applicant: Donald N. Cohen
Serial No.: 09/715,813
Examiner: Baum, Ronald
Art Unit 2136
Filed: November 16, 2000
Docket: 02-322-B

CERTIFICATE OF FIRST CLASS MAILING UNDER 37 CFR 1.8

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Donna Miller Date: 7/30/04
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Donna Miller	(Depositor's na
Donna Miller	(Signat
July 30, 2004	(D

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/715,813	11/16/2000	Donald N. Cohen	Q982-DB	8097

TITLE OF INVENTION: PACKET FLOODING DEFENSE SYSTEM

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1 David A. Belasco
2 Belasco Jacobs & Townsley, LLP
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

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(A) NAME OF ASSIGNEE: Computing Services Support Solutions, Inc.

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Los Angeles, California 90045

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ individual ☒ corporation or other private group entity ☐ governm

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(Authorized Signature) _____ (Date) 7/30/04

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08/03/2004 AABSFGE 00000038 09715813
01 FC:2501 665.00 OP

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PATENT APPLICATION FEE DETERMINATION RECORD
Effective October 1, 2000

Application or Docket Number: 09/715,813

CLAIMS AS FILED - PART I

	(Column 1)	(Column 2)
TOTAL CLAIMS		
FOR	NUMBER FILED	NUMBER EXTRA
TOTAL CHARGEABLE CLAIMS	9 minus 20=	* —
INDEPENDENT CLAIMS	1 minus 3 =	* 3
MULTIPLE DEPENDENT CLAIM PRESENT		☐

* If the difference in column 1 is less than zero, enter "0" in column 2.

SMALL ENTITY TYPE ☐		OR	OTHER THAN SMALL ENTITY	
RATE	FEE		RATE	FEE
BASIC FEE	355.00	OR	BASIC FEE	710.00
X$ 9=		OR	X$18=	
X40=	120.	OR	X80=	
+135=		OR	+270=	
TOTAL	475.	OR	TOTAL	

CLAIMS AS AMENDED - PART II

AMENDMENT A

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
X$ 9=		OR	X$18=	
X40=		OR	X80=	
+135=		OR	+270=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT B

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
X$ 9=		OR	X$18=	
X40=		OR	X80=	
+135=		OR	+270=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT C

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
X$ 9=		OR	X$18=	
X40=		OR	X80=	
+135=		OR	+270=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20."
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3."
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Cloudflare, Inc. Exhibit 1003 Page 1727

[redacted]

SEARCHED

Class	Sub.	Date	Exmr.
713	201	10/23/03	
709	238-244	10/23/03	
370	229-240	2/23/04	
713	201	6/1/04	
709	238-244	6/1/04	
370	229-240	6/1/04	

SEARCH NOTES
(INCLUDING SEARCH STRATEGY)

	Date	Exmr.
DOGPILE (NPL) FOR: + DDOS, Packet Flood, + Denial of Service protection + Router, Flow control + Internet Flow control	7/13/03	
INVALIDATE SEARCH	7/13/03	
GOOGLE SEARCH (NPL) + DDOS, "packet" & "DENIAL OF SERVICE" & FIREWALL & DEFENSE	6/1/04	

INTERFERENCE SEARCHED

Class	Sub.	Date	Exmr.
713	201	6/1/04	
709	238-244	〃	〃
370	229-240	6/1/04	

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ISSUE SLIP STAPLE AREA (for additional cross references)

POSITION	INITIALS	ID NO.	DATE
FEE DETERMINATION			
O.I.P.E. CLASSIFIER	MOW	60	12-10-00
FORMALITY REVIEW	CH	71632	2/22/01
RESPONSE FORMALITY REVIEW			

INDEX OF CLAIMS

✔ ..... Rejected
= ..... Allowed
— (Through numeral)... Canceled
÷ ..... Restricted
N ..... Non-elected
I ..... Interference
A ..... Appeal
O ..... Objected

Claim Final	Claim Original	Date
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If more than 150 claims or 10 actions staple additional sheet here

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PATENT APPLICATION

09715813

INITIALS MN

CONTENTS

		Date Received (Incl. C. of M.) or Date Mailed		Date Received (Incl. C. of M.) or Date Mailed
1.	Application 9 papers.		42.	
2.	Fee A	12-16-02	43.	
3.	Pwr Atty	10/30/03	44.	
4.	Chg of Address	12-19-03	45.	
5.	Reconsideration	1-23-04	46.	
6.	Final Rej 3 mo	3/01/04	47.	
7.	Amdt B	5-3-04	48.	
8.	Exs Amdt C	6/8/04	49.	
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