United States Patent [19]

Ebersole et al.

[11] **Patent Number: 5,041,963**

[45] **Date of Patent: Aug. 20, 1991**

[54] **LOCAL AREA NETWORK WITH AN ACTIVE STAR TOPOLOGY COMPRISING RING CONTROLLERS HAVING RING MONITOR LOGIC FUNCTION**

[75] Inventors: **Ronald J. Ebersole**, Beaverton; **Frederick J. Pollack**, Portland, both of Oreg.

[73] Assignee: **Intel Corporation**, Santa Clara, Calif.

[21] Appl. No.: **291,700**

[22] Filed: **Dec. 29, 1988**

[51] **Int. Cl.^{5}** **G06F 15/16**; G06F 11/30; G06F 13/36; G06F 13/00

[52] **U.S. Cl.** **364/200**; 364/221.6; 364/221.7; 364/229.3; 364/230; 364/240; 364/240.7; 364/241.1; 364/241.8; 364/242; 364/242.95; 370/60; 370/94.1

[58] **Field of Search** 364/200, 900; 370/85, 370/86, 60, 94.1

[56] **References Cited**

U.S. PATENT DOCUMENTS

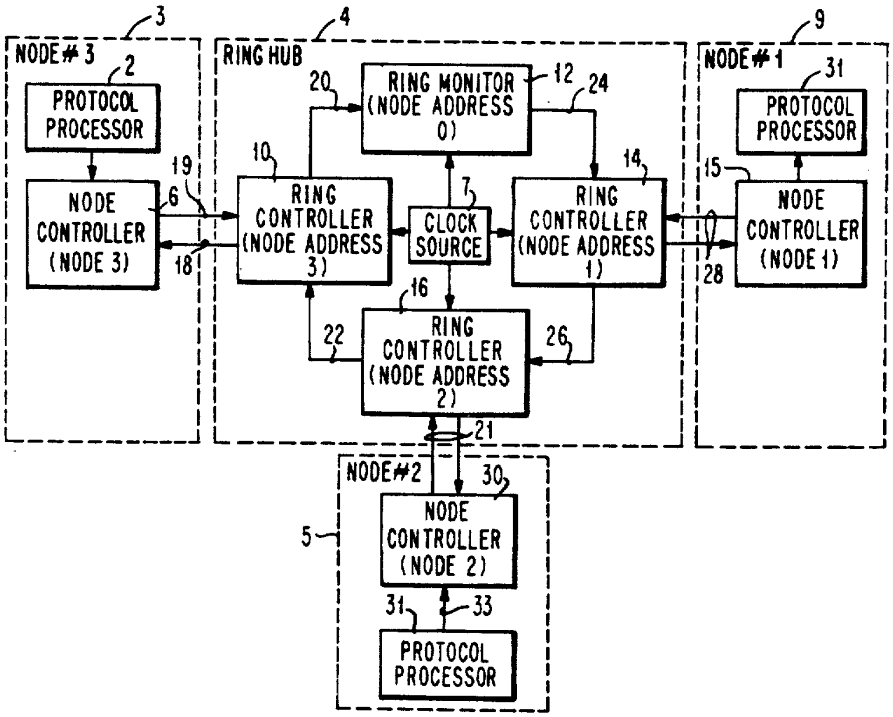
4,334,305 6/1982 Girardi 370/86
4,482,980 11/1984 Korowitz et al. 364/900
4,489,379 12/1984 Lanier et al. 364/200
4,493,021 1/1985 Agrawal et al. 364/200
4,539,655 9/1985 Trussell et al. 364/900
4,754,395 6/1988 Weisshaar et al. 364/200
4,771,391 9/1988 Blasbalg 364/200
4,777,591 10/1988 Chang et al. 364/200
4,835,673 5/1989 Rushby et al. 364/200
4,888,726 12/1989 Struger et al. 364/900

Primary Examiner—Stuart N. Hecker
Assistant Examiner—George C. Pappas
Attorney, Agent, or Firm—Owen L. Lamb

[57] **ABSTRACT**

A star local area network includes a ring bus hub (**4**) capable of being connected to a plurality of nodes (**3, 5, 9**) geographically distant from the hub by means of low speed serial links (**18, 19, 21, 28**). The nodes include processor means (**2, 30, 31**) for creating messages for transfer on the network. A plurality of duplex communication links (**18, 19, 21, 28**) connect the nodes to the ring bus hub (**4**). The hub (**40**) is comprised of a plurality of ring controllers (**10, 12, 14, 16**) driven by a common clock source (**7**). Each ring controller is connected by means of a number of parallel lines to other ring controllers in series to form a closed ring. Each one (**3**) of the plurality of nodes is geographically distant from the hub (**4**) and is connected to a corresponding one (**10**) of the ring controllers by means of one (**18, 19**) of the duplex communication links. The node controllers including node interface means (**40**) for transmitting the messages as a contiguous stream of words on the duplex communication link. The ring controllers include ring bus interface means (**42**) for forming the messages into discrete data packets for insertion onto the ring bus and means (**32, 34**) for bufferring data messages received form the node and over the ring bus.

10 Claims, 2 Drawing Sheets



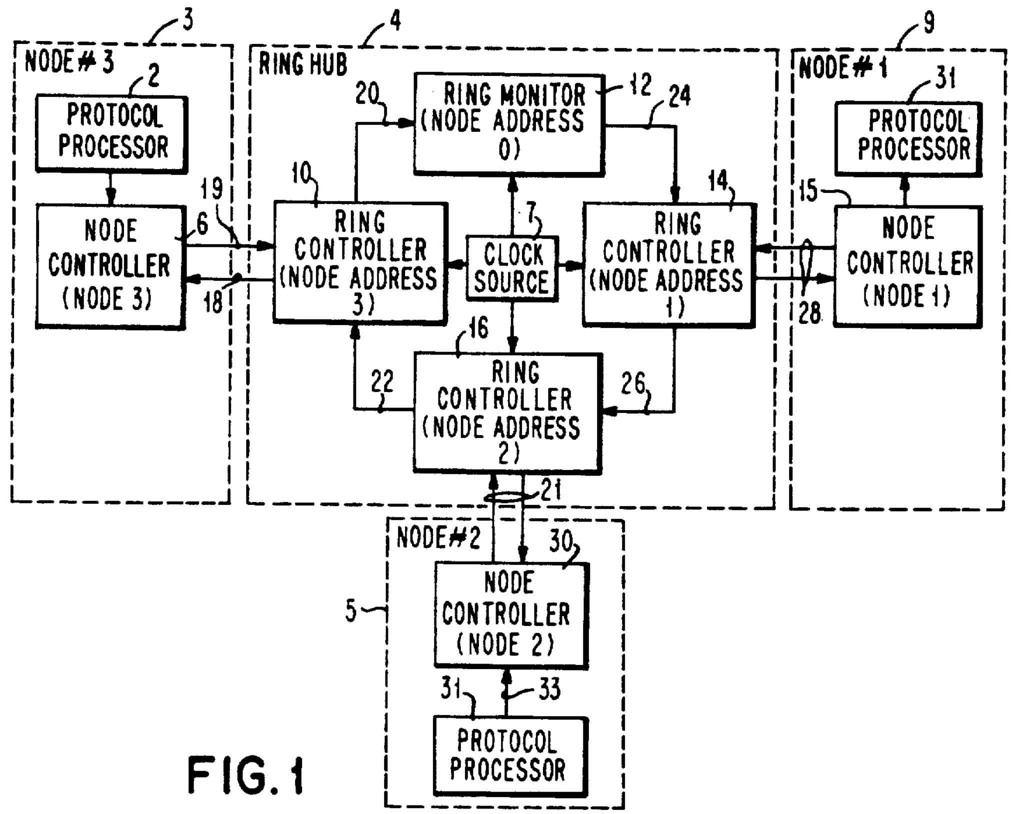

NODE # 3
3
PROTOCOL PROCESSOR
2
NODE CONTROLLER (NODE 3)
19
6
18
RING HUB
4
20
RING MONITOR (NODE ADDRESS 0)
12
24
10
RING CONTROLLER (NODE ADDRESS 3)
CLOCK SOURCE
7
RING CONTROLLER (NODE ADDRESS 1)
14
16
22
RING CONTROLLER (NODE ADDRESS 2)
26
21
NODE # 1
9
PROTOCOL PROCESSOR
31
15
NODE CONTROLLER (NODE 1)
28
NODE#2
5
30
NODE CONTROLLER (NODE 2)
31
33
PROTOCOL PROCESSOR

FIG. 1

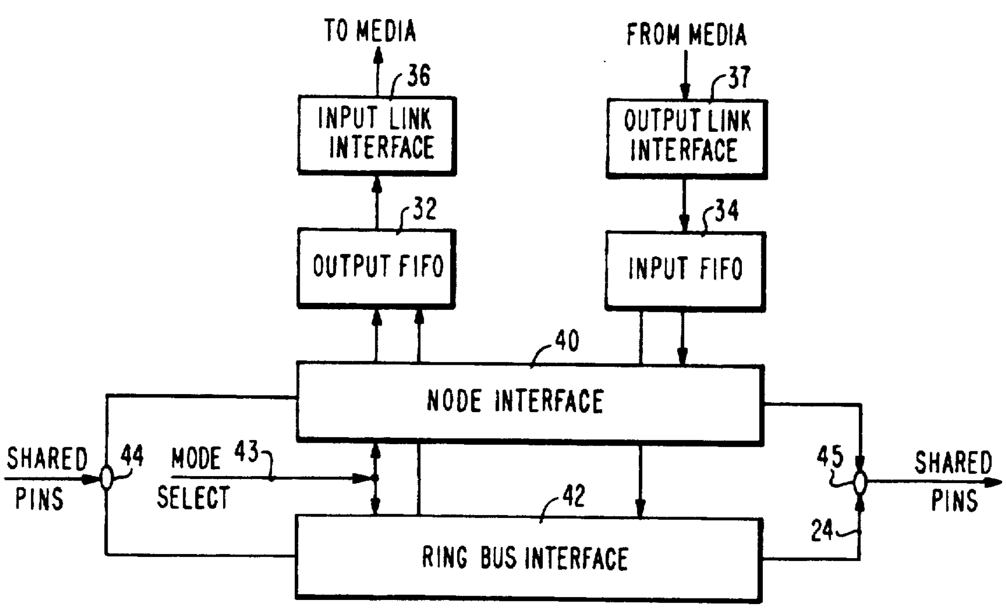

TO MEDIA
36
INPUT LINK INTERFACE
32
OUTPUT FIFO
FROM MEDIA
37
OUTPUT LINK INTERFACE
34
INPUT FIFO
40
NODE INTERFACE
SHARED PINS
44
MODE SELECT
43
42
RING BUS INTERFACE
45
24
SHARED PINS

FIG. 2

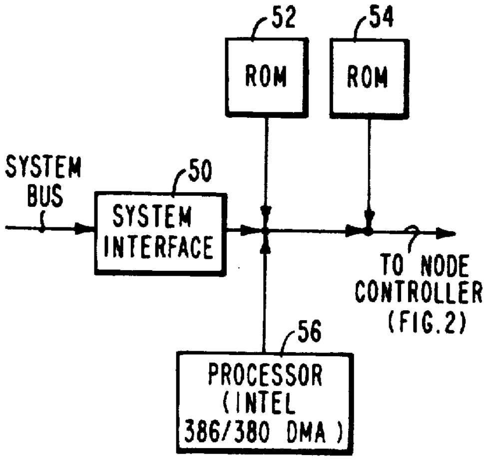


FIG.3

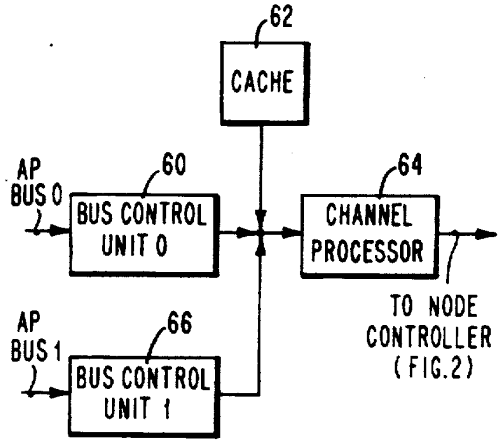


FIG.4

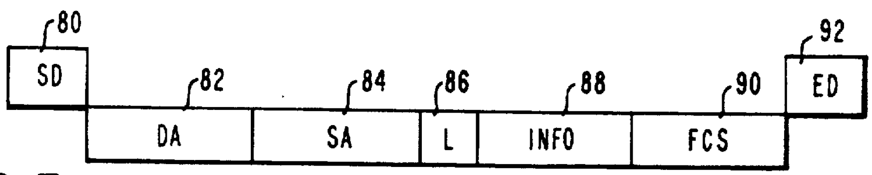


FIG.5 MESSAGE FORMAT

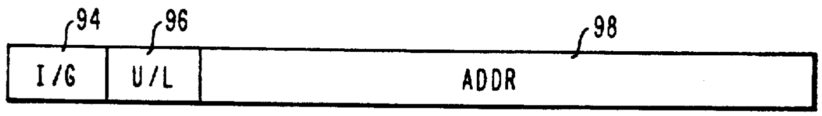


FIG.6a IEEE 802.3 STANDARD INDIVIDUAL MESSAGE FORMAT

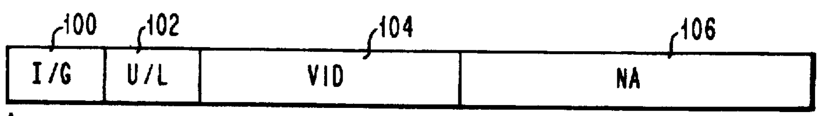


FIG.6b IEEE 802.3 STANDARD GROUP MESSAGE FORMAT

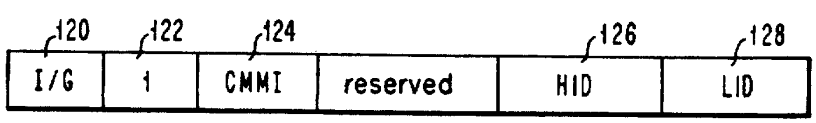


FIG.7a INDIVIDUAL LOCAL ADDRESS FORMAT

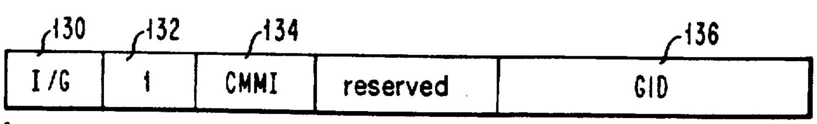


FIG.7b GROUP LOCAL ADDRESS FORMAT

LOCAL AREA NETWORK WITH AN ACTIVE STAR TOPOLOGY COMPRISING RING CONTROLLERS HAVING RING MONITOR LOGIC FUNCTION

CROSS REFERENCES TO RELATED APPLICATIONS

This application is related to U.S. Pat. No. 4,939,724, granted on July 3, 1990 "Cluster Link Interface⇄ of Ronald Ebersole, "Ring Bus Hub for a Star Local Area Net-work" Ser. No. 07/291,756 of Ronald Ebersole now abandoned and "Node Controller for a Local Area Network" Ser. No. 07/291,640 now abandoned of Ronald Ebersole, all filed concurrently herewith and assigned to Intel Corporation.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to data processing systems and more particularly to a method and apparatus for interconnecting a plurality of computer workstations with I/O devices and other workstations which allows the users to share I/O resources.

2. Description of the Related Art

A Local Area Network, or LAN, is a data communications system which allows a number of independent devices to communicate with each other within a moderately-sized geographical area. The term LAN is used to describe networks in which most of the processing tasks are performed by a workstation such as a personal computer rather than by a shared resource such as a main frame computer system.

With the advent of the inexpensive personal computer workstation, LANs equipped with various kinds of desktop computers are beginning to replace centralized main frame computer installations. The economic advantage of a LAN is that it permits a number of users to share the expensive resources, such as disk storage or laser printers, that are only needed occasionally.

In a typical LAN network a desktop workstation performs processing tasks and serves as the user's interface to the network. A wiring system connects the workstations together, and a software operating system handles the execution of tasks on the network. In addition to the workstations, the LAN is usually connected to a number of devices which are shared among the workstations, such as printers and diskstorage devices. The entire system may also be connected to a larger computer to which users may occasionally need access. Personal computers are the most popular desktop workstations used with LANs.

The configuration of the various pieces of the network is referred to as the topology. In a star topology a switching controller is located at the center or hub of the network with all of the attached devices, the individual workstations, shared peripherals, and storage devices, on individual links directly connected to the central controller. In the star configuration, all of these devices communicate with each other through the central controller which receives signals and transmits them out to their appropriate destinations.

A second kind of topology is the bus topology. In this topology, wiring connects all of the devices on the LAN to a common bus with the communications signal sent from one end of the bus to the other. Each signal has an address associated with it which identifies the particular device that is to be communicated with. Each device recognizes only its address.

The third topology employs a circular bus route known as a ring. In a ring configuration, signals pass around the ring to which the devices are attached.

Both bus and ring networks are flexible in that new devices can be easily added and taken away. But because the signal is passed from end to end on the bus, the length of the network cable is limited. Star topologies have the advantage that the workstations can be placed at a considerable distance from the central controller at the center of the star. A drawback is that star topologies tend to be much slower than bus topologies because the central controller must intervene in every transmission.

In a star configuration, the signaling method is different than in bus or ring configurations. In the star configuration the processor central controller processes all of the communication signals. In a bus topology there is no central controller. Each device attempts to send signals and enter onto the bus when it needs to. If some other device trys to enter at the same time, contention occurs. To avoid interference between two competing signals, bus networks have signaling protocols that allow access to the bus by only one device at a time. The more traffic a network has, the more likely a contention will occur. Consequently, the performance of a bus network is degraded if it is overloaded with messages.

Ring bus configurations have even more complex signaling protocols. The most widely accepted method in ring networks is known as the token ring, a standard used by IBM. An electronic signal, called a token, is passed around the circuit collecting and giving out message signals to the addressed devices on the ring. There is no contention between devices for access to the bus because a device does not signal to gain access to the ring bus; it waits to be polled by the token. The advantage is that heavy traffic does not slow down the network. However, it is possible that the token can be lost or it may become garbled or disabled by failure of a device on the network to pass the token on.

The physical line which connects the components of a LAN is called the network medium. The most commonly used media are wire, cable, and fiber optics. Coaxial cable is the traditional LAN medium and is used by Ethernet TM, the most widely recognized standard. The newest LAN transmission medium is fiber-optic cable which exhibits a superior performance over any of the other media.

The Fiber Distributed Data Interface (FDDI) is another standard. FDDI is a token-ring-implementation fiber media that provides a 100 m-bit/second data rate.

There is an increasing need for high-performance-internode communication, that is broader I/O bandwidth. The mainframe computer is being extended or replaced by department computers, workstations, and file servers. This decentralization of computers increases the amount of information that needs to be transferred between computers on a LAN. As computers get faster, they handle data at higher and higher rates. The Ethernet TM standard is adequate for connecting 20–30 nodes, each with a performance in the range of 1 to 5 mips. Ethernet TM is inadequate when the performance of these nodes ranges from 5 to 50 mips.

An I/O connectivity problem also exists that concerns I/O fanout and I/O bandwidth. The bandwidth problem was discussed above with respect to internode communication. The I/O fanout problem is related to the fact that central processing systems are getting smaller and faster. As the computing speed increases, the system is capable of handling more and more I/O. However, as the systems get smaller, it becomes harder to physically connect the I/O to the processors and memory. Even when enough I/O can be configured in the system, the I/O connectivity cost can be prohibitive. The reason is that the core system (processors and memory) must be optimized for high-speed processors and memory interconnect. The cost of each high-speed I/O connection to the core is relatively expensive. Thus, cost-effective I/O requires that the connection cost be spread over several I/O devices. On mainframe computers, the solution to the connectivity problem is solved by using a channel processor. A channel processor is a sub-processor that controls the transfer of data between several I/O devices at a time by executing channel instructions supplied by the main processor. The main processor system is connected to several of these channel processors. Several channels can share one core connection.

It is therefore an object of the present invention to provide an improved LAN that allows high performance interdevice communication and has the ability to connect a number of I/O devices to the network.

SUMMARY OF THE INVENTION

The above object is accomplished in accordance with the present invention by providing a LAN which combines the advantages of a star LAN with a ring bus LAN. The star configuration provides links to nodes at the relatively slow bandwith of the node link. The hub of the star uses the relatively high bandwidth of a ring bus.

Nodes attach to the hub of the star through duplex communication links. Messages transferred between nodes are passed through the hub, which is responsible for arbitration and routing of messages. Unlike the prior bus topology, or ring topology, each node of the active star responds only to those messages that are intended for it. Routing of messages is accomplished by a destination address in the header of the message. These addresses are unique to each node and provide the means by which the hub keeps the communication between nodes independent.

The active star configuration of the present invention has the advantage that it increases network bandwidth. In typical networks the performance of the node's means of attachment to the network is equivalent to the network bandwidth. This is because messages can be transferred only at the rate of the media, and only one message can be transferred at a time. Ethernet, Star Lan, FDDI, all exhibit this characteristic as they are essentially broadcast buses, in which every node sees every other node's traffic.

In the active star configuration of the present invention, every data communication is an independent communication between two nodes. Simultaneous, independent communication paths between pairs of nodes can be established at the same time. Each path can handle data transfers at the link media transmission speed, providing a substantial increase in the total network bandwidths. When two nodes want to communicate with the same destination, the hub arbitrates between them and buffers the message from the node that is locked out.

An addressing mechanism maintains a consistent address environment across the complete network that facilitates routing. Each node address is composed of two fields, one field providing a node address relative to the hub it is attached to, and the other field, a hub address relative to the other hubs in the network. The combination of these two fields is a unique network address that is used to route any message to its ultimate destination.

The foregoing and other objects, features, and advantages of the invention will be apparent from the following more particular description of a preferred embodiment of the invention as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a functional block diagram of the Local Area Network of the present invention;

FIG. 2 is a functional block diagram of the interface controller shown in FIG. 1 used in one mode of operation as a node controller and in another mode of operation as a ring controller;

FIG. 3 is a diagram of a micro based subsystem;

FIG. 4 is a block diagram of a cluster I/O subsystem;

FIG. 5 illustrates the message format;

FIGS. 6*a* and 6*b* illustrates the IEEE 802.3 standard message format; and,

FIGS. 7*a* and 7*b* show the structure of the Local address field for a native Cluster node address.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The interconnect architecture shown in FIG. 1 is designed to transfer blocks of data, called messages, between nodes attached to it. The interconnect function is implemented in a single VLSI component known as the Cluster Interface Controller (CLIC), shown in FIG. 2. The transfer of messages between nodes attached to the Cluster is controlled by a protocol running in each of the nodes, which maintains the orderly access and use of the network.

The present application defines the Cluster architecture. The CLIC component is described in application Ser. No. 07/291,640. The link between the node controller and the ring controller is more fully described in U.S. Pat. No. 4,939,724.

The LAN architecture is based on an active star topology, as illustrated in FIG. 1. Nodes attach to the hub (4) of the star through duplex communication links. Messages transferred between nodes all pass through the hub, which is responsible for arbitration and routing of messages. Unlike Ethernet TM or token rings, each node sees only those messages that are intended for it. Routing of messages is determined by a destination address in the header of the message. These addresses are unique to each node and provide the means for the hub to keep the communication between nodes independent.

The active star configuration increases network bandwidth. In typical networks, the performance of the node's attachment to the network is equivalent to the network bandwidth. This is because messages can be transferred only at the rate of the media, and only one can be transferred at a time. Ethernet TM, Starlan TM, FDDI, etc. all exhibit this characteristic as they are essentially broadcast buses, in which every node sees every other node's traffic.

Hub-to-hub connectivity extends the capability of the network, providing for a much wider variety of configurations. The network addressing mechanism maintains a consistent address environment across the complete

DOCKET ALARM

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts

Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research

With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips

Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.

WHAT WILL YOU BUILD? | **sales@docketalarm.com** | **1-866-77-FASTCASE**

fastcase®
Smarter legal research.