Rendezvous

New standard networking technology that connects computers and electronic devices automatically, without any configuration.

Features

Revolutionary networking

- Creates instant IP-based networks of computers and devices without any configuration
- Makes the services offered by devices dynamically discoverable by other devices on a network, enabling innovative ways of sharing files, media, printers, and other devices
- Works with standard, nonproprietary IP networking technologies and equipment
- Keeps network traffic to a minimum using efficient networking algorithms

Open and standard

- Automatic networking configuration and service discovery
- Open IETF standards for link-local addressing, Multicast DNS, and DNS service discovery
- Apple participation in the IETF to ensure full device interoperability

Open source

- Easy for developers to use Rendezvous technology in their network devices or applications
- Freely available source code, including software for systems and devices using UNIX, Linux, VxWorks, Windows, Windows CE, Pocket PC 2003, and other operating systems
- Used by many innovative Apple applications, including iChat AV, the Finder, and iTunes
- Supported by major manufacturers and developers of network printers, consumer electronics, enterprise database management systems, educational applications, and more

Rendezvous is an open, standards-based networking technology that automatically connects electronic devices on a network, allowing them to interoperate seamlessly without any user configuration. It is the first technology to deliver true zero-configuration networking over the standard and ubiquitous IP networking protocol, providing automatic Internet Protocol (IP) network configuration and dynamic discoverability of services.

Rendezvous simplifies traditional networking activities like file sharing and printing. It also enables innovative solutions such as music playlist sharing with iTunes and automatic buddy discovery with iChat AV—just two examples of the exciting new ways for devices to communicate with one another.

Instant Networking and Dynamic Service Discovery

With Rendezvous, you can easily network an electronic device, like a computer, to an existing wired or wireless Ethernet network or create instant networks of multiple devices without any additional network configuration. Rendezvous configures each device's IP settings and then makes the services available on each device easily discoverable by all the devices on the network. Rendezvous works on a network subnet, making it ideal for ad hoc local area networking. Simply bring your Mac into range of another AirPort-enabled Mac or plug in an Ethernet cable, and Rendezvous configures your computer and allows it to discover the services and capabilities of the other computers available on the network. Rendezvous does all this over the worldwide standard IP networking protocol.

With Rendezvous, you can share nearly anything, including files, media, printers, and other devices, in innovative and easier ways. It simplifies traditional network-based activities like file sharing and printing by providing dynamic discoverability of file servers and Rendezvous-enabled network printers. It also enables new solutions, such as iTunes playlist sharing, which allows music streaming on a home network between two Mac computers or to a home stereo through a TiVo system. And Rendezvous allows for the automatic discovery of buddies on your local network in iChat AV, eliminating the need to set them up manually in advance.

Rendezvous also opens up exciting new possibilities for device-to-device interaction. In addition to computers, Rendezvous enables automatic configuration and communication between many kinds of "smart" devices. Home stereos, televisions, and media devices are all potential Rendezvous-enabled consumer electronic devices. As devices become easier to connect and configure, new features and services become not only possible but also practical for everyone.

Why Rendezvous Is Important

Networks emerged at the local, corporate level as a way for users to communicate and share information. These networks used protocols like AppleTalk, NetBEUI, Novell, and Banyan to transmit data. Each protocol provided facilities for network configuration, data transmission, and discoverability of network services like file servers and printers. These protocols worked well within a single organization, but users and businesses required the ability to communicate with people outside the network and access data on other networks. Email became extremely popular as a means of communication inside a company, and people wanted to extend that capability to friends and colleagues on other networks. But the protocols that worked so well on small networks couldn't scale to meet the needs of a large global network and were often incompatible. Internet Protocol (IP) became the single, global standard for local and wide area networking because it could scale with large networks.

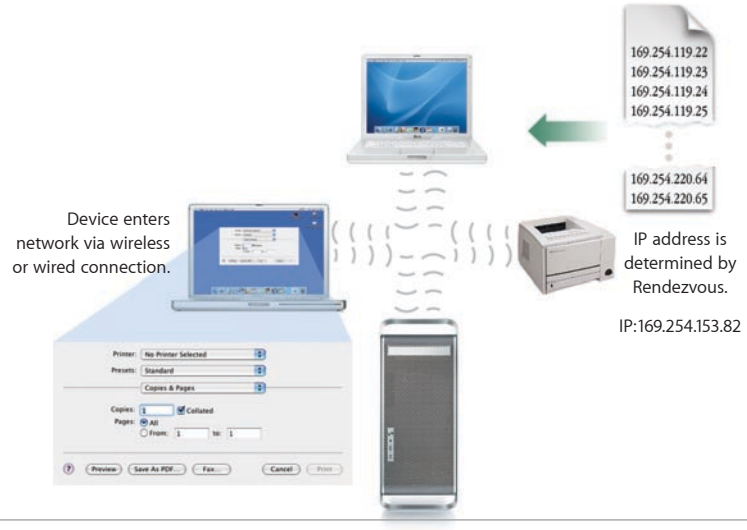
IP has provided a standard means for people to communicate across a global network, but it fails to deliver some of the features that made its predecessors so popular, like automatic network configuration and dynamic discovery. While attempts have been made, no protocol has been able to blend the usability offered by earlier protocols with the global communication capabilities of IP. Rendezvous fills that gap, making IP networking configuration automatic and providing facilities that allow computers and other electronic devices to discover and share their unique services.

How Rendezvous Works

Rendezvous begins by simplifying the otherwise complex process of configuring devices for a network. To communicate with other devices using IP, a device needs special information like an IP address, a subnet mask, DNS addresses, a DNS name, and preconfigured search paths. Divining these cryptic details and performing the subsequent configuration can be a daunting task for the average user.

When a new computer or device is added to a network without any other means of autoconfiguration, like a DHCP server, Rendezvous configures the device using a technique called link-local addressing. (If a DHCP server is in use, Rendezvous uses the assigned IP address.) With link-local addressing, the computer randomly selects an IP address from a predefined range of addresses set aside by the Internet Assigned Numbers Authority (IANA) for link-local addressing and assigns that address to itself (addresses are in the range 169.254.xxx.xxx). The device then sends a message out on the network to determine whether another device is already using the address; if the address is in use, the device randomly selects addresses until it finds one that is available. When the device has assigned itself an IP address, it is ready to send and receive IP traffic on the network.

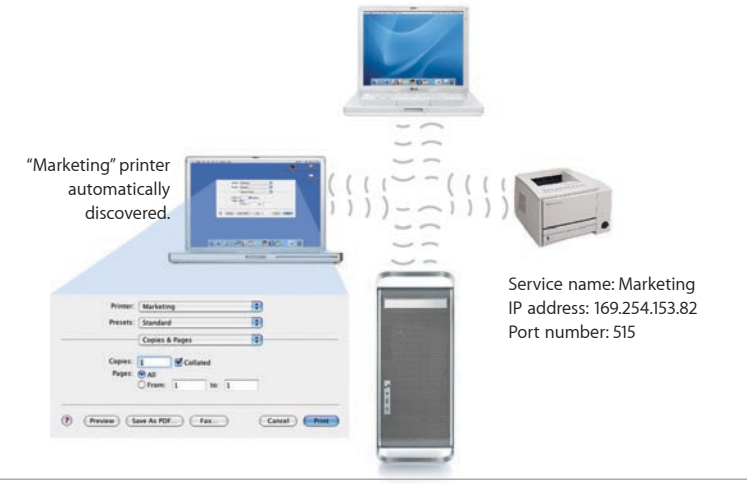
How Rendezvous Works: The printer is configured for an IP network.



Once a device has been automatically configured to work on the network, it needs a way to discover services being offered by other devices on the network, as well as a way to tell other devices what services it offers. To share services, a device must create a unique name for each of its services and let the other devices on the network know of their existence. To do this, Rendezvous uses Domain Name System (DNS), another well-known standard. DNS servers provide the naming functionality used on the Internet by translating the English-language addresses users enter to the numbered IP addresses needed to route requests across the Internet. On the Internet and in large managed networks, system administrators maintain central DNS servers.

Rendezvous is designed for local and ad hoc networks that don't have central DNS servers and aren't managed by IT professionals. To perform name services, Rendezvous uses a variant of DNS called Multicast DNS–Service Discovery (mDNS-SD). A device "advertises" its service by issuing an mDNS-SD notification that includes the type of service (such as IPP printing), the name of the service (such as "Marketing"), IP and port addresses, and other optional information (such as the correct PPD file). Each device on the network receives the notification and stores the information. Applications running on the device can use this information to create a list of services in their custom interface for the user to choose a service.

How Rendezvous Works: The printer advertises its service via mDNS.

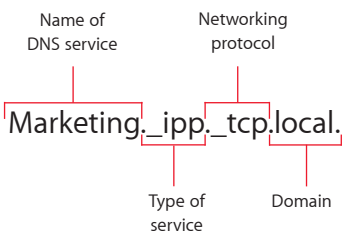


Rendezvous communication
Rendezvous query and response packets contain the information needed for service discovery. An application running on a device may want to find out about other devices that have services it can use. To do this, it transmits a multicast query and receives responses from the devices running the appropriate services. The query/response transaction follows the standard DNS format for naming and lookup. For example, a device may send a query for all devices that are IPP (Internet Printing Protocol) capable printers:

mDNS-SD query
._ipp._tcp.local. PTR?

mDNS-SD responses (the name)
Marketing._ipp._tcp.local.
Engineering._ipp._tcp.local.
Asian Sales._ipp._tcp.local.
Copy Room._ipp._tcp.local.

What's in the name
Marketing = The name of the service.
._ipp = The type of service, in this case, IPP printing.
._tcp = Generic networking protocol identifier; this is the same for all services and is either _tcp or _udp.
.local. = The local lookup domain.



Once the device has the names of the services on the network, it performs a DNS lookup to determine the IP address, port number, and other configuration information for the computer on which the service is running.

DNS lookup
Marketing._ipp._tcp.local. SRV?
Marketing._ipp._tcp.local. TXT?

DNS response
SRV - 0 0 515 host.local.
TXT - rn=Marketing
host.local. - 169.254.153.82

The DNS response has three pieces of important information:

- The SRV record contains information about the port the service is running on.
- The TXT record contains additional information to help in service configuration, as may be needed on a service-by-service basis. For example, for printers, the TXT record indicates the page description language(s) the printer supports, the name of the PostScript PPD file if appropriate, and so on.
- The IP address of the device.

Of course, the device may also want to know about services offered by the other devices on the network. When a user adds a device to the network and requests information about a certain type of service, the device queries the network for any services of that type. For example, the device may want to know what printers are available so it can create a list of printers for the user. The device queries the network for devices that offer printing services. The device receives responses from the devices that can print using the specified printing protocol and uses that information to create a list of printers for the user.

Efficient Networking

Early protocols like AppleTalk and NetBEUI generated heavy network traffic. AppleTalk, for example, was a broadcast-query-only protocol that required computers to send messages on the network repeatedly to discover other computers. These requests happened nearly every second. Duplicate responses were not suppressed, so computers that had already identified themselves continued to respond to queries. The traffic generated by all of these messages quickly burdened the lower-capacity networks in existence when AppleTalk first appeared.

Rendezvous uses a range of innovative techniques to minimize network traffic while achieving timely notification and discovery of services on a local network. The multicast protocol itself is designed to reduce network traffic by issuing only one packet on the network that can be "heard" by all devices, saving the overhead caused by traditional query-based protocols that require every computer to provide every other computer with the same information. When a device queries the network for information, and the other devices on the network respond, all the devices receive all the responses. Since each device receives the response, it doesn't need to query again, resulting in the suppression of duplicate queries and responses, and ultimately a reduction in network traffic.

Queries also happen only when a device needs to know about a certain service. For example, a computer does not request available file servers until the user wants to see a list of file servers. When a file server is added to the network, it sends a multicast message to the network informing the other computers that a new file server is available. The computer then updates the user's view of the file servers on the network. Because the list of available file servers on the network fluctuates, a computer will want to keep its view of the available file servers current, so it queries the network for an update. Rendezvous employs a method called "exponential back-off," which exponentially increases the gap between queries to minimize traffic while keeping the user's view as fresh as possible.

Leveraging Existing Network Protocols

Rendezvous is designed specifically to provide automatic IP configuration and service discovery. Once Rendezvous has accomplished these two tasks, services that wish to interact with one another can communicate using well-known, standard protocols. Rather than inventing new solutions for problems the computer industry has already solved, Rendezvous leverages the same networking protocols that have provided the foundation of interdevice communication for years. For example, Rendezvous does not require a new printing protocol so that devices can interoperate with Rendezvous-enabled printers. It allows devices to use any of the many existing IP-based printing protocols, such as IPP, to communicate. Devices needing to share files can use one of the many well-established IP-based file sharing protocols, such as AFP or SMB. Rendezvous will inspire new ideas for device-to-device interaction that will spawn new IP-based communication protocols, all of which will work with Rendezvous.

Security

Rendezvous was designed with security as a top priority. The rate-limiting and exponential back-off mechanisms employed in Rendezvous to reduce network traffic also virtually eliminate the possibility that a rogue programmer can exploit the Rendezvous process for launching denial-of-service attacks. Because the frequency of queries and responses issued by any device degrades exponentially, the gap between transmissions grows quickly, making it ineffective as a mechanism for rapidly issuing DNS messages.

Open source software offers important security benefits, because the source code can be viewed by the thousands of developers in the open source community. Developers can scrutinize the code, identify bugs, illuminate security issues, and ultimately make changes that are released back into the community to the benefit of all.

Because Rendezvous does not introduce new networking protocols, but rather relies on open, industry-standard protocols like AFP, SMB, IPP, and HTTP, users benefit from the high level of security that has been built into these protocols through years of development.

Rendezvous exposes the services running on a device to all the devices that can "see" that device on the network. You might assume that this diminishes one of the most relied-on security mechanisms in use today—security through obscurity—but this is a fallacy. Security through obscurity is a highly unreliable and insecure method of protecting a device. Services are obscure to those who don't search for them, but rogue programmers or crackers intent on gaining illegal access to devices use widely available software tools, like port scanners, to discover the services running on a device in hopes of finding unsecured ports or services with known exploits. In fact, Rendezvous can enhance security by exposing running services, ensuring that only sanctioned services are running on a device.

Rendezvous Uses in Mac OS X

Rendezvous is used throughout Mac OS X to provide innovative ways to share files, printers, and music and to contact other people on the network.

- **iChat AV.** iChat AV uses Rendezvous to create an automatic buddy list of friends and colleagues on your local network, without having to know their Instant Messenger (IM) screen names in advance, and even lets you see who is available to chat.
- **Safari.** Apple's web browser uses Rendezvous to find any web addresses on your local network. This is particularly useful for configuring devices that use built-in web servers for configuration, such as printers, routers, and network-based webcams.
- **iTunes.** The iTunes playlist sharing feature uses Rendezvous to allow you to stream your music on your home network between two Macintosh computers or to your home stereo through a TiVo personal video recorder.
- **File sharing.** The Personal File Sharing feature in Mac OS X uses Rendezvous to tell other users on the network that files are available for them to access. Rendezvous makes sharing files between computers on an ad hoc network easy. For example, in a meeting room with people using PowerBook computers, simply waking your PowerBook from sleep creates an instant network via wired Ethernet or wireless AirPort connections, linking your computer with the others in the room. Users on the new network will see your computer in their "Connect to" dialog and be able to access files you've made available through Personal File Sharing. Likewise, you can access files on the other computers in the room.

- **Printers.** Mac OS X Print Center (Printer Setup Utility in Mac OS X Panther) uses Rendezvous to discover Rendezvous-enabled printers on the network. When you access a network, Print Center automatically discovers the available printers; you simply select the one you want to use and start printing. You can also add a printer to the network and, without any configuration, it appears in the Print Center of the computers on the network.
- **Mac OS X Server print queues.** Mac OS X Server includes a print server that advertises its print queues using Rendezvous. Like stand-alone network printers, Mac OS X Server print queues dynamically appear in the Mac OS X client's Print Center. When a computer is moved to a new network, the available print queues on the network automatically appear in Print Center.
- **AirPort.** The AirPort Base Station was the first Rendezvous-enabled hardware device and is now joined by dozens of other Rendezvous-enabled hardware devices including printers, personal video recorders, and storage devices. Using the AirPort Admin Utility included in Mac OS X version 10.3, you can easily discover base stations, connect to them, and configure them.

Mac OS X Version 10.3 "Panther": Power of UNIX, Simplicity of Macintosh

With Rendezvous, Mac OS X Panther provides an open, standards-based networking technology that automatically connects electronic devices on a network, allowing them to interoperate seamlessly without any user configuration. In addition, Panther offers more than 150 new features and innovations, including iChat AV for personal video conferencing, Exposé for instantly finding any window, and a new Finder for easy access to everything you need. It's like having an all-new Mac.

For More Information

For more information about Rendezvous and Mac OS X, visit www.apple.com/macosx.

Additional resources
Apple is committed to making core protocols freely available as open standards and open source code. Developers can find more information about Rendezvous at developer.apple.com/darwin/projects/rendezvous.

To access the source code under the Apple Public Source License, go to www.opensource.apple.com/projects/rendezvous.

Other resources include www.zeroconf.org and www.dns-sd.org.

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