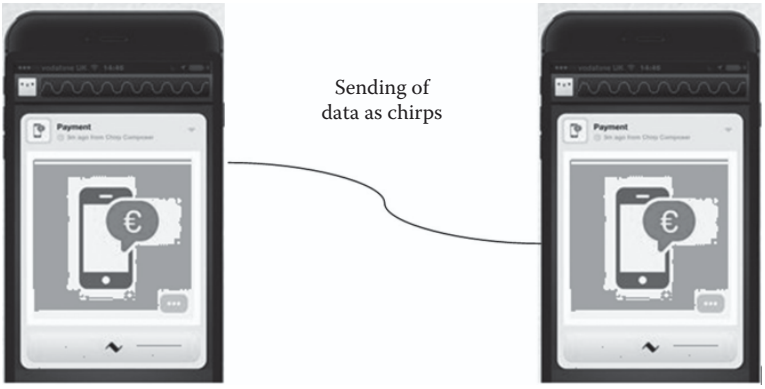

Figure 3.14 Working of chirp.

from iOS and Android operating systems. Chirp allows devices that lack traditional network connections to create an Internet made of sound.

How Chirp Works

- Chirp contains a short string of data, which has been encoded using alphabets of electronic birdsong that includes 32 semitone pitches.
- Encoding and decoding of data are done locally by each mobile device, and hence it is not necessary to have an Internet connection for basic exchange. What is required is just a speaker to send data and a microphone to receive data.
- Instead of splitting huge amounts of data into chirps, there exists an option for the device to upload files to a cloud server and then tweet out a URL that will contain chirps.
- Chirps are highly reliable over short distances in locations that are quiet without much of background noise (Figure 3.14).

Protocols for IoT Service Discovery

The protocols that are prominently used in the IoT service discovery space are the following:

- DNS service discovery (DNS-SD)
- multicast domain name system (mDNS)
- Simple service discovery protocol (part of UPnP)

multicast Domain Name System (mDNS)

Multicast Domain Name System (mDNS) is a service that can work like a unicast DNS server. This approach is very flexible because of the fact that DNS namespace can be used locally without any additional configuration. mDNS is an apt choice for embedded Internet-based devices because of the following reasons:

- No manual configuration or administration is required to manage devices.
- It is possible to run this without any additional infrastructure.
- High level of fault tolerance because of the capability to function even if infrastructure failure happens.

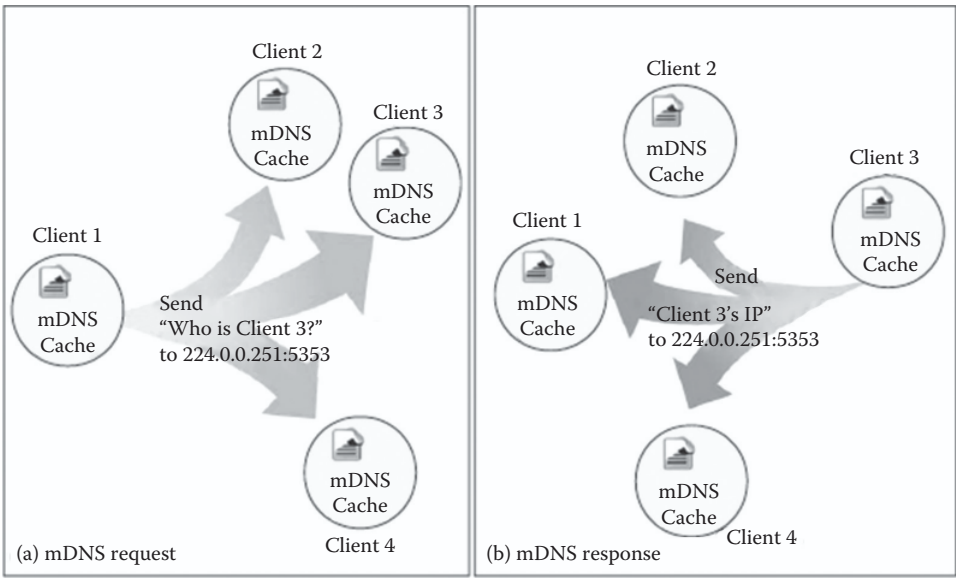

Figure 3.15 Working of multicast domain name system (mDNS).

A service of IoT that wants to use service discovery using mDNS first inquires names by sending an IP multicast message to all the nodes that are present in the local domain. This message is a query, using which the client asks the devices with a specific name to respond back. When the target device receives a message, which contains its name, it sends a multicast response message that contains its IP address. All devices that are a part of the network update their local cache with the target device's name and corresponding IP address that can be used for service request at a later point in time (Figure 3.15).

DNS Service Discovery

This protocol helps the clients to discover a set of desired services that are present in a network with the help of standard DNS messages. This protocol also helps to connect devices without any external administration or configuration. DNS service discovery (DNS-SD) typically uses mDNS to send DNS packets to specific multicast destinations using UDP. Service discovery is a two-step process:

1. Finding host names of required services (in the example given below, it is a printer service)
2. Pairing IP addresses with their host names using mDNS

It is very critical to find host names of devices because IP addresses may change, whereas host names will not change. The pairing function multicasts network related details like IP address and port number to each related host in the same network. With the help of DNS-SD, the host names of the devices in the network can be kept constant so that the same host name can be used later on without decrease of trust and reliability.

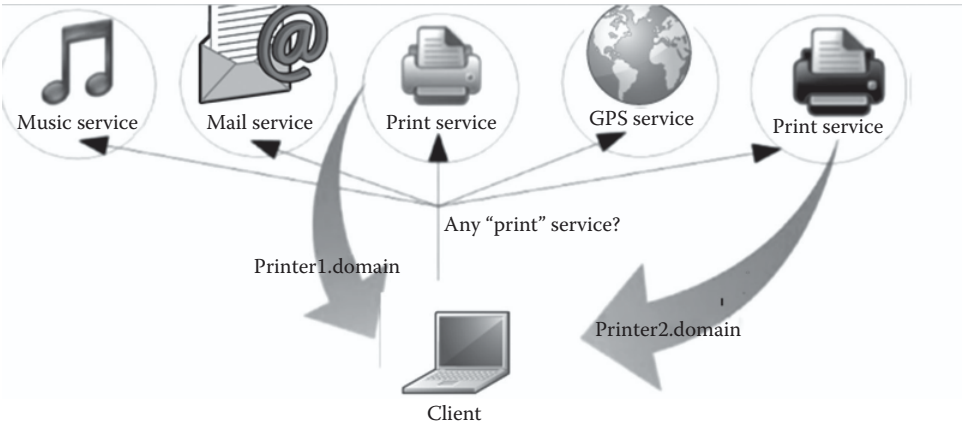

Figure 3.16 Service discovery of a printer service using DNS-SD protocol.

The example given in Figure 3.16 illustrates service discovery of a printer service using DNS-SD protocol.

Universal Plug and Play

Universal Plug and Play (UPnP) is a collection of networking protocols that was devised by UPnP forum. The main features of UPnP that makes it suitable for service discovery of IoT devices are the following:

- Capability of a UPnP device to join a network dynamically (automatically) and obtain IP addresses of other devices and at the same time convey its capabilities to other devices
- Zero configuration and administration

The three basic components of a UPnP network are the following:

- Devices
- Services
- Control points
  - *Device*: It is a container for services and other nested devices, which are part of the network. A service basically is the most granular unit of control that offers a set of actions.
  - *Control points*: This provides the feature of device discovery and control by receiving device and service descriptions and by invoking service actions.
  - *Services*: The set of services that are offered by UPnP devices.

The protocol that offers service discovery feature for a UPnP network is the simple service discovery protocol (SSDP). SSDP is based on multicast-based discovery of devices that form a part of the network.

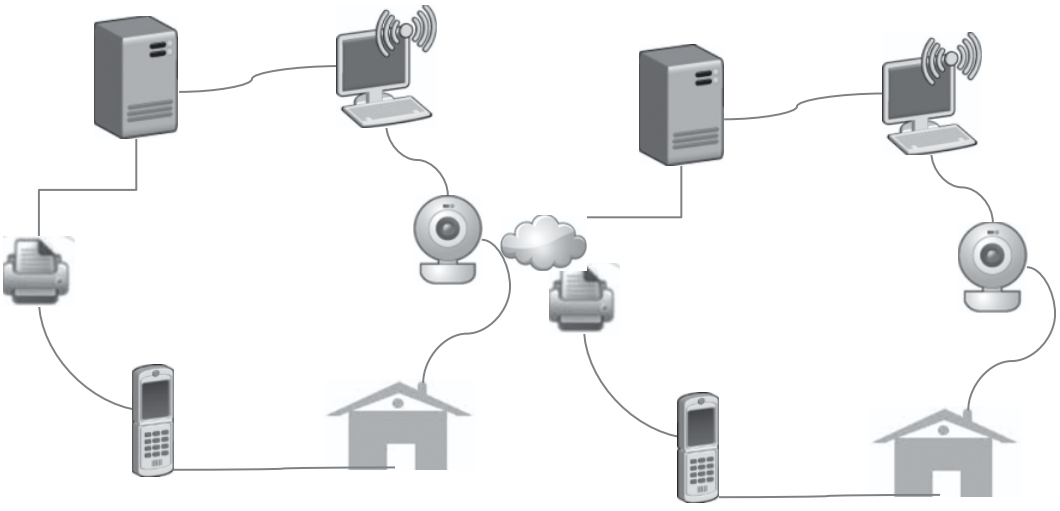

Figure 3.17 Working of UPnP.

The SSDP lets a control point look for devices and services, and it also allows a device to announce its availability. A UPnP control point sends an SSDP search request in order to discover devices and services that are available on a specific network. A UPnP device in turn listens to the multicast port.

Remote access feature of UPnP networks enables a remote UPnP device or UPnP control point to connect home or any other small business network to interact with a UPnP device or control point that is present in another home or small business network. This remote access support and flexible connectivity options offered by the UPnP make it very suitable for service discovery and interconnection of multiple IoT networks.

A typical example is depicted in the graphic shown in Figure 3.17 where two gateway devices connect two home or small business networks to the Internet through an access network and establishes a remote connection with a remote network using a public Internet backbone and through the gateway that is located in the remote network.

Prominent IoT Service Discovery Products Available in the Market

Bonjour

Bonjour is a suite of zero-configuration networking and service discovery protocols from Apple. Bonjour's networking architecture provides features that help to publish and discover TCP or IP-based services that are available in a Local Area Network and WAN. For example, Bonjour will help to connect a printer to a network without having to assign an IP address to it. Because of the zero configuration feature provided by Bonjour, computers can automatically discover the printer's IP address. Mobile apps can also leverage the services of Bonjour to detect presence of other app instance on the network. For example, two users who are using an iOS photo sharing app can share photos using Bluetooth without the need for manual configuration of IP addresses. Bonjour supports advertising and discovery services in a network using mDNS and link local addressing if required.