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G. Fairhurst
University of Aberdeen

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The Datagram Congestion Control Protocol (DCCP) Service Codes

Abstract

This document describes the usage of Service Codes by the Datagram Congestion Control Protocol, RFC 4340. It motivates the setting of a Service Code by applications. Service Codes provide a method to identify the intended service/application to process a DCCP connection request. This provides improved flexibility in the use and assignment of port numbers for connection multiplexing. The use of a DCCP Service Code can also enable more explicit coordination of services with middleboxes (e.g., network address translators and firewalls). This document updates the specification provided in RFC 4340.

Status of This Memo

This document specifies an Internet standards track protocol for the Internet community, and requests discussion and suggestions for improvements. Please refer to the current edition of the "Internet Official Protocol Standards" (STD 1) for the standardization state and status of this protocol. Distribution of this memo is unlimited.

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1. Introduction

DCCP specifies a Service Code as a 4-byte value (32 bits) that describes the application-level service to which a client application wishes to connect ([RFC4340], Section 8.1.2). A Service Code identifies the protocol (or the standard profile, e.g., [RTP-DCCP]) to be used at the application layer. It is not intended to be used to specify a variant of an application or a specific variant of a protocol (Section 2.2).

The Service Code mechanism allows an application to declare the set of services that are associated with server port numbers. This can affect how an application interacts with DCCP. It also allows decoupling of the role of port numbers to indicate a desired service from the role of port numbers in demultiplexing and state management. A DCCP application identifies the requested service by the Service Code value in a DCCP-Request packet. Each application therefore associates one or more Service Codes with each listening port ([RFC4340], Section 8.1.2).

The use of Service Codes can assist in identifying the intended service by a firewall and may assist other middleboxes (e.g., a proxy server or network address translator (NAT) [RFC2663]). Middleboxes that desire to identify the type of data a flow claims to transport should utilize the Service Code for this purpose. When consistently used, the Service Code can provide a more specific indication of the actual service (e.g., indicating the type of multimedia flow or intended application behaviour) than deriving this information from the server port value.

The more flexible use of server ports can also offer benefits to applications where servers need to handle very large numbers of simultaneous-open ports to the same service.

RFC 4340 omits a description of the motivation behind Service Codes, and it does not properly describe how Well Known and Registered server ports relate to Service Codes. The intent of this document is to clarify these issues.

RFC 4340 states that Service Codes are not intended to be DCCP-specific. Service Codes, or similar concepts, may therefore also be useful to other IETF transport protocols.

1.1. History

It is simplest to understand the motivation for defining Service Codes by describing the history of the DCCP protocol.

Most current Internet transport protocols (TCP [RFC793], UDP [RFC768], SCTP (the Stream Control Transmission Protocol) [RFC4960], and UDP-Lite [RFC3828]) use "Published" port numbers from the Well Known or Registered number spaces [RFC814]. These 16-bit values indicate the application service associated with a connection or message. The server port must be known to the client to allow a connection to be established. This may be achieved using out-of-band signalling (e.g., described using SDP [RFC4566]), but more commonly a Published port is allocated to a particular protocol or application; for example, HTTP commonly uses port 80 and SMTP commonly uses port 25. Making a port number Published [RFC1122] involves registration with the Internet Assigned Numbers Authority (IANA), which includes defining a service by a unique keyword and reserving a port number from among a fixed pool [IANA].

In the earliest draft of DCCP, the authors wanted to address the issue of Published ports in a future-proof manner, since this method suffers from several problems:

- The port space is not sufficiently large for ports to be easily allocated (e.g., in an unregulated manner). Thus, many applications operate using unregistered ports, possibly colliding with use by other applications.

- The use of port-based firewalls encourages application writers to disguise one application as another in an attempt to bypass firewall filter rules. This motivates firewall writers to use deep packet inspection in an attempt to identify the service associated with a port number.

- ISPs often deploy transparent proxies, primarily to improve performance and reduce costs. For example, TCP requests destined to TCP port 80 are often redirected to a web proxy.

These issues are coupled. When applications collide on the same Published-but-unregistered port, there is no simple way for network security equipment to tell them apart, and thus it is likely that problems will be introduced through the interaction of features.

There is little that a transport protocol designer can do about applications that attempt to masquerade as other applications. For ones that are not attempting to hide, the problem may be simply that they cannot trivially obtain a Published port. Ideally, it should be sufficiently easy that every application writer can request a Well Known or Registered port and receive one instantly with no questions asked. The 16-bit port space traditionally used is not large enough to support such a trivial allocation of ports.

Thus, the designers of DCCP sought an alternative solution. The idea was simple. A 32-bit server port space should be sufficiently large to enable use of very simple allocation policies. However, overhead considerations made a 32-bit port value undesirable (DCCP needed to be useful for low-rate applications).

The solution in DCCP to this problem was to use a 32-bit Service Code [RFC4340] that is included only in the DCCP-Request packet. The use of a 32-bit value was intended to make it trivially simple to obtain a unique value for each application. Placing the value in a DCCP-Request packet requires no additional overhead for the actual data flow. It is however sufficient for both the end systems, and provides any stateful middleboxes along the path with additional information to understand what applications are being used.

Early discussion of the DCCP protocol considered an alternative to the use of traditional ports; instead, it was suggested that a client use a 32-bit identifier to uniquely identify each connection and that the server listen on a socket bound only to a Service Code. This solution was unambiguous; the Service Code was the only identifier for a listening socket at the server side. The DCCP client included a Service Code in the request, allowing it to reach the corresponding listening application. One downside was that this prevented deployment of two servers for the same service on a single machine, something that is trivial with ports. The design also suffered from the downside of being sufficiently different from existing protocols that there were concerns that it would hinder the use of DCCP through NATs and other middleboxes.

RFC 4340 abandoned the use of a 32-bit connection identifier in favor of two traditional 16-bit port values, one chosen by the server and one by the client. This allows middleboxes to utilize similar techniques for DCCP, UDP, TCP, etc. However, it introduced a new problem: "How does the server port relate to the Service Code?" The intent was that the Service Code identified the application or protocol using DCCP, providing middleboxes with information about the intended use of a connection, and that the pair of ports effectively formed a 32-bit connection identifier, which was unique between a pair of end systems.

The large number of available, unique Service Code values allows all applications to be assigned a unique Service Code. However, there remained a problem: the server port was chosen by the server, but the client needed to know this port to establish a connection. It was undesirable to mandate out-of-band communication to discover the server port. The chosen solution was to register DCCP server ports. The limited availability of DCCP server ports appears to contradict the benefits of DCCP Service Codes because, although it may be

trivial to obtain a Service Code, it has not traditionally been trivial to obtain a Registered port from IANA and, in the long-run, it may not be possible to allocate a unique Registered DCCP port to new applications. As port numbers become scarce, this motivates the need to associate more than one Service Code with a listening port (e.g., two different applications could be assigned the same server port and need to run on the same host at the same time, differentiated by their different associated Service Codes).

Service Codes provide flexibility in the way clients identify the server application to which they wish to communicate. The mechanism allows a server to associate a set of server ports with a service. The set may be common with other services available at the same server host, allowing a larger number of concurrent connections for a particular service than possible when the service is identified by a single Published port number.

1.2. Conventions Used in This Document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

2. An Architecture for Service Codes

DCCP defines the use of a combination of ports and Service Codes to identify the server application ([RFC4340], Section 8.1.2). These are described in the following sections.

2.1. IANA Port Numbers

In DCCP, the packets belonging to a connection are demultiplexed based on a combination of four values {source IP address, source port, dest IP address, dest port}, as in TCP. An endpoint address is associated with a port number (e.g., forming a socket) and a pair of associations uniquely identifies each connection. Ports provide the fundamental per-packet demultiplexing function.

The Internet Assigned Numbers Authority currently manages the set of globally reserved port numbers [IANA]. The source port associated with a connection request, often known as the "ephemeral port", is traditionally in the range 49152-65535 and also includes the range 1024-49151. The value used for the ephemeral port is usually chosen by the client operating system. It has been suggested that a randomized choice port number value can help defend against "blind" attacks [Rand] in TCP. This method may be applicable to other IETF-defined transport protocols, including DCCP.

Traditionally, the destination (server) port value associated with a service is determined either by an operating system index that points to a copy of the IANA table (e.g., getportbyname() in Unix, which indexes the /etc/services file) or by the application specifying a direct mapping.

The UDP and TCP port number space: 0..65535, is split into three ranges [RFC2780]:

- 0..1023 "Well Known", also called "system" ports,
- 1024..49151 "Registered", also called "user" ports, and
- 49152..65535 "Dynamic", also called "private" ports.

DCCP supports Well Known and Registered ports. These are allocated in the DCCP IANA Port Numbers registry ([RFC4340], Section 19.9). Each Registered DCCP port MUST be associated with at least one pre-defined Service Code.

Applications that do not need to use a server port in the Well Known or Registered range SHOULD use a Dynamic server port (i.e., one not required to be registered in the DCCP Port registry). Clients can identify the server port value for the services to which they wish to connect using a range of methods. One common method is by reception of an SDP record (Section 2.6) exchanged out-of-band (e.g., using SIP [RFC3261] or the Real Time Streaming Protocol (RTSP) [RFC2326]). DNS SRV resource records also provide a way to identify a server port for a particular service based on the service's string name [RFC2782].

Applications that do not use out-of-band signalling can still communicate, provided that both client and server agree on the port value to be used. This eliminates the need for each registered Service Code to be allocated to an IANA-assigned server port (see also Section 2.7).

2.2. DCCP Service Code Values

DCCP specifies a 4-byte Service Code ([RFC4340], Section 8.1.2) represented in one of three forms: a decimal number (the canonical method), a 4-character ASCII string [ANSI.X3-4.1986], or an 8-digit hexadecimal number. All standards assigned Service Codes, including all values assigned by IANA, are required to use a value that may be represented using a subset of the ASCII character set. Private Service Codes do not need to follow this convention, although RFC 4340 suggests that users choose Service Codes that may also be represented in ASCII.

The Service Code identifies the application-level service to which a client application wishes to connect. For example, services have been defined for the Real-Time Protocol (RTP) [RTP-DCCP]. In a different example, Datagram Transport Layer Security (DTLS) [RFC5238] provides a transport-service (not an application-layer service); therefore, applications using DTLS are individually identified by a set of corresponding Service Code values.

Endpoints MUST associate a Service Code with every DCCP socket [RFC4340], both actively and passively opened. The application will generally supply this Service Code. A single passive-listening port may be associated with more than one Service Code value. The set of Service Codes could be associated with one or more server applications. This permits a more flexible correspondence between services and port numbers than is possible using the corresponding socket pair (4-tuple of layer-3 addresses and layer-4 ports). In the currently defined set of packet types, the Service Code value is present only in DCCP-Request ([RFC4340], Section 5.2) and DCCP-Response packets ([RFC4340], Section 5.3). Note that new DCCP packet types (e.g., [RFC5596]) could also carry a Service Code value.

2.2.1. New Versions of Applications or Protocols

Applications/protocols that provide version negotiation or indication in the protocol operating over DCCP do not require a new server port or new Service Code for each new protocol version. New versions of such applications/protocols SHOULD continue to use the same Service Code. If the application developers feel that the new version provides significant new capabilities (e.g., that will change the behavior of middleboxes), they MAY allocate a new Service Code associated with the same or different set of Well Known ports. If the new Service Code is associated with a Well Known or Registered port, the DCCP Ports registry MUST also be updated to include the new Service Code value, but MAY share the same server port assignment(s).

2.3. Service Code Registry

The set of registered Service Codes specified for use within the general Internet are defined in an IANA-controlled name space. IANA manages new allocations of Service Codes in this space [RFC4340]. Private Service Codes are not centrally allocated and are denoted by the decimal range 1056964608-1073741823 (i.e., 32-bit values with the high-order byte equal to a value of 63, corresponding to the ASCII character '?').

Associations of Service Code with Well Known ports are also defined in the IANA DCCP Port registry (Section 2.1).

2.4. Zero Service Code

A Service Code of zero is "permanently reserved (it represents the absence of a meaningful Service Code)" [RFC4340]. This indicates that no application information was provided. RFC 4340 states that applications MAY be associated with this Service Code in the same way as other Service Code values. This use is permitted for any server port.

This document clarifies Section 19.8 of RFC 4340 by adding the following:

> Applications SHOULD NOT use a Service Code of zero.
>
> Application writers that need a temporary Service Code value SHOULD choose a value from the private range (Section 2.3).
>
> Applications intended for deployment in the Internet are encouraged to use an IANA-defined Service Code. If no specific Service Code exists, they SHOULD request a new assignment from the IANA.

2.5. Invalid Service Code

RFC 4340 defines the Service Code value of 4294967295 in decimal (0xFFFFFFFF) as "invalid". This is provided so implementations can use a special 4-byte value to indicate "no valid Service Code". Implementations MUST NOT accept a DCCP-Request with this value, and SHOULD NOT allow applications to bind to this Service Code value [RFC4340].

2.6. SDP for Describing Service Codes

Methods that currently signal destination port numbers, such as the Session Description Protocol (SDP) [RFC4566], require an extension to support DCCP Service Codes [RTP-DCCP].

2.7. A Method to Hash the Service Code to a Dynamic Port

Applications that do not use out-of-band signalling or an IANA-assigned port still require both the client and server to agree on the server port value to be used. This section describes an optional method that allows an application to derive a default server port number from the Service Code. The returned value is in the Dynamic port range [RFC4340]:

```
int s_port; /* server port */
s_port = ((sc[0]<<7)^(sc[1]<<5)^(sc[2]<<3)^sc[3]) | 0xC000;
if (s_port==0xFFFF) {s_port = 0xC000;}
```

where sc[] represents the 4 bytes of the Service Code, and sc[3] is the least significant byte. For example, this function associates SC:fdpz with the server port 64634.

This algorithm has the following properties:

- It identifies a default server port for each service.
- It seeks to assign different Service Codes to different ports, but does not guarantee an assignment is unique.
- It preserves the 4 lowest bits of the final bytes of the Service Code, which allows many common series of Service Codes to be mapped to a set of adjacent port numbers, e.g., Foo1, and Foo2; Fooa and Foob would be assigned adjacent ports. (Note: this consecutive numbering only applies to characters in the range 0-9 and A-O and P-Z. When the characters cross a range boundary, the algorithm introduces a discontinuity, resulting in mapping to non-consecutive ports. Hence, Fooo and Foop respectively map to the decimal values of 65015 and 65000).
- It avoids the port 0xFFFF, which is not accessible on all host platforms.

Applications and higher-layer protocols that have been assigned a Service Code (or use a Service Code from the unassigned private space) may use this method. It does not preclude other applications using the selected server port, since DCCP servers are differentiated by the Service Code value.

3. Use of the DCCP Service Code

The basic operation of Service Codes is as follows:

A client initiating a connection:

- issues a DCCP-Request with a Service Code and chooses a destination (server) port number that is expected to be associated with the specified Service Code at the destination.

A server that receives a DCCP-Request:

- determines whether an available service matching the Service Code is supported for the specified destination server port. The session is associated with the Service Code and a corresponding server. A DCCP-Response is returned.

- if the service is not available, the session is rejected and a DCCP-Reset packet is returned.

3.1. Setting Service Codes at the Client

A client application MUST associate every DCCP connection (and hence every DCCP active socket) with a single Service Code value [RFC4340]). This value is used in the corresponding DCCP-Request packet.

3.2. Using Service Codes in the Network

DCCP connections identified by the Service Code continue to use IP addresses and ports, although neither port number may be Published.

Port numbers and IP addresses are the traditional methods to identify a flow within an IP network. Middlebox [RFC3234] implementors therefore need to note that new DCCP connections are identified by the pair of server port and Service Code in addition to the IP address. This means that the IANA may allocate a server port to more than one DCCP application [RFC4340].

Network address and port translators, known collectively as NATs [RFC2663], may interpret DCCP ports ([RFC2993] and [RFC5597]). They may also interpret DCCP Service Codes. Interpreting DCCP Service Codes can reduce the need to correctly interpret port numbers, leading to new opportunities for network address and port translators. Although it is encouraged to associate specific delivery properties with the Service Code, e.g., to identify the real-time nature of a flow that claims to be using RTP, there is no guarantee that the actual connection data corresponds to the associated Service Code. A middlebox implementor may still use deep packet inspection, and other means, in an attempt to verify the content of a connection.

The use of the DCCP Service Code can potentially lead to interactions with other protocols that interpret or modify DCCP port numbers [RFC3234]. The following additional clarifications update the description provided in Section 16 of RFC 4340:

- A middlebox that intends to differentiate applications SHOULD test the Service Code in addition to the destination or source port of a DCCP-Request or DCCP-Response packet.

- A middlebox that does not modify the intended application (e.g., NATs [RFC5597] and Firewalls) MUST NOT change the Service Code.

- A middlebox MAY send a DCCP-Reset in response to a packet with a Service Code that is considered unsuitable.

3.3. Using Service Codes at the Server

The combination of the Service Code and server port disambiguates incoming DCCP-Requests received by a server. The Service Code is used to associate a new DCCP connection with the corresponding application service. Four cases can arise when two DCCP server applications passively listen on the same host:

- The simplest case arises when two servers are associated with different Service Codes and are bound to different server ports (Section 3.3.1).

- Two servers may be associated with the same DCCP Service Code value but be bound to different server ports (Section 3.3.2).

- Two servers could use different DCCP Service Code values and be bound to the same server port (Section 3.3.1).

- Two servers could attempt to use the same DCCP Service Code and bind to the same server port. A DCCP implementation MUST disallow this, since there is no way for the DCCP host to direct a new connection to the correct server application.

RFC 4340 (Section 8.1.2) states that an implementation:

- MUST associate each active socket with exactly one Service Code on a specified server port.

In addition, Section 8.1.2 of RFC 4340 also states:

- Passive sockets MAY, at the implementation's discretion, be associated with more than one Service Code; this might let multiple applications, or multiple versions of the same application, listen on the same port, differentiated by Service Code.

This document updates the above text from RFC 4340 by replacing it with the following:

- An implementation SHOULD allow more than one Service Code to be associated with a passive server port, enabling multiple applications, or multiple versions of an application, to listen on the same port, differentiated by the associated Service Code.

It also adds:

- An implementation SHOULD provide a method that informs a server of the Service Code value that was selected by an active connection.

A single passively opened (listening) port MAY therefore be associated with multiple Service Codes, although an active (open) connection can only be associated with a single Service Code. A single application may wish to accept connections for more than one Service Code using the same server port. This may allow a server to offer more than the limit of 65,536 services depending on the size of the Port field. The upper limit is based solely on the number of unique connections between two hosts (i.e., 4,294,967,296).

3.3.1. Reception of a DCCP-Request

When a DCCP-Request is received and the specified destination port is not bound to a server, the host MUST reject the connection by issuing a DCCP-Reset with the Reset Code "Connection Refused". A host MAY also use the Reset Code "Too Busy" ([RFC4340], Section 8.1.3).

When the requested destination port is bound to a server, the host MUST also verify that the server port is associated with the specified Service Code (there could be multiple Service Code values associated with the same server port). Two cases can occur:

- If the receiving host is listening on a server port and the DCCP-Request uses a Service Code that is associated with the port, the host accepts the connection. Once connected, the server returns a copy of the Service Code in the DCCP-Response packet, completing the initial handshake [RFC4340].

- If the server port is not associated with the requested Service Code, the server SHOULD reject the request by sending a DCCP-Reset packet with the Reset Code 8, "Bad Service Code" ([RFC4340], Section 8.1.2), but MAY use the reason "Connection Refused".

After a connection has been accepted, the protocol control block is associated with a pair of ports, a pair of IP addresses, and a single Service Code value.

3.3.2. Multiple Associations of a Service Code with Ports

DCCP Service Codes are not restricted to specific ports, although they may be associated with a specific Well Known port. This allows the same DCCP Service Code value to be associated with more than one server port (in either the active or passive state).

3.3.3. Automatically Launching a Server

A host implementation may permit a service to be associated with a server port (or range of ports) that is not permanently running at the server. In this case, the arrival of a DCCP-Request may require a method to associate a DCCP-Request with a server that handles the corresponding Service Code. This operation could resemble that of "inetd" [inetd].

As in the previous section, when the specified Service Code is not associated with the specified server port, the connection MUST be aborted and a DCCP Reset message sent [RFC4340].

4. Security Considerations

The security considerations of RFC 4340 identify and offer guidance on security issues relating to DCCP. This document discusses the usage of Service Codes. It does not describe new protocol functions.

All IPsec modes protect the integrity of the DCCP header. This protects the Service Code field from undetected modification within the network. In addition, the IPsec Encapsulated Security Payload (ESP) mode may be used to encrypt the Service Code field, hiding the Service Code value within the network and also preventing interpretation by middleboxes. The DCCP header is not protected by application-layer security (e.g., the use of DTLS [RFC5238] as specified in DTLS/DCCP [RFC4347]).

There are four areas of security that are important:

1. Server Port number reuse (Section 4.1).

2. Interaction with NATs and firewalls (Section 3.2 describes middlebox behavior). Requirements relating to DCCP are described in [RFC5597].

3. Interpretation of DCCP Service Codes overriding traditional use of reserved/Well Known port numbers (Section 4.2).

4. Interaction with IPsec and DTLS security (Section 4.3).

4.1. Server Port Number Reuse

Service Codes are used in addition to ports when demultiplexing incoming connections. This changes the service model to be used by applications and middleboxes. The Port Numbers registry already contains instances of multiple application registrations for a single port number for TCP and UDP. These are relatively rare. Since the DCCP Service Code allows multiple applications to safely share the same port number, even on the same host, server port number reuse in DCCP may be more common than in TCP and UDP.

4.2. Association of Applications with Service Codes

The use of Service Codes provides more ready feedback that a concrete service is associated with a given port on a server than for a service that does not employ Service Codes. By responding to an inbound connection request, systems not using these codes may indicate that some service is, or is not, available on a given port, but systems using this mechanism immediately provide confirmation (or denial) that a particular service is present. This may have implications in terms of port scanning and reconnaissance.

Care needs to be exercised when interpreting the mapping of a Service Code value to the corresponding service. The same service (application) may be accessed using more than one Service Code. Examples include the use of separate Service Codes for an application layered directly upon DCCP and one using DTLS transport over DCCP [RFC5238]. Other possibilities include the use of a private Service Code to map to an application that has already been assigned an IANA-defined Service Code value, or multiple Service Code values that map to a single application providing more than one service. Different versions of a service (application) may also be mapped to a corresponding set of Service Code values.

Processing of Service Codes may imply more processing than currently associated with incoming port numbers. Implementors need to guard against increasing opportunities for Denial of Service attacks.

4.3. Interactions with IPsec

The Internet Key Exchange protocol (IKEv2) does not currently specify a method to use DCCP Service Codes as a part of the information used to set up an IPsec security association.

IPsec uses port numbers to perform access control in transport mode [RFC4301]. Security policies can define port-specific access control (PROTECT, BYPASS, DISCARD) as well as port-specific algorithms and keys. Similarly, firewall policies allow or block traffic based on port numbers.

Use of port numbers in IPsec selectors and firewalls may assume that the numbers correspond to Well Known services. It is useful to note that there is no such requirement; any service may run on any port, subject to mutual agreement between the endpoint hosts. Use of the Service Code may interfere with this assumption both within IPsec and within other firewall systems, but it does not add a new vulnerability. New implementations of IPsec and firewall systems may interpret the Service Code when implementing policy rules, but should not rely on either port numbers or Service Codes to indicate a specific service.

5. IANA Considerations

This document does not update the IANA allocation procedures for the DCCP Port Number and DCCP Service Codes Registries as defined in RFC 4340.

For completeness, the document notes that it is not required to supply an approved document (e.g., a published RFC) to support an application for a DCCP Service Code or port number value, although RFCs may be used to request Service Code values via the IANA Considerations section. A specification is however required to allocate a Service Code that uses a combination of ASCII digits, uppercase letters, and character space, '-', '.', and '/') [RFC4340].

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Author's Address

Godred Fairhurst,
School of Engineering,
University of Aberdeen,
Kings College,
Aberdeen, AB24 3UE,
UK
EMail: gorry@erg.abdn.ac.uk
URL: http://www.erg.abdn.ac.uk/users/gorry