**Virtual circuit**

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|  | This article **may be too technical for most readers to understand**. Please [help improve it](https://en.wikipedia.org/w/index.php?title=Virtual_circuit&action=edit) to [make it understandable to non-experts](https://en.wikipedia.org/wiki/Wikipedia:Make_technical_articles_understandable), without removing the technical details. *(August 2012) (*[*Learn how and when to remove this template message*](https://en.wikipedia.org/wiki/Help:Maintenance_template_removal)*)* |

A **virtual circuit** (**VC**) is a means of transporting data over a [packet-switched network](https://en.wikipedia.org/wiki/Packet-switched_network) in such a way that it appears as though there is a dedicated [physical link](https://en.wikipedia.org/wiki/Physical_link) between the source and destination [end systems](https://en.wikipedia.org/wiki/End_system) of this data. The term virtual circuit is synonymous with **virtual connection**. A [virtual channel](https://en.wikipedia.org/wiki/Virtual_channel) is a type of virtual circuit.

Before a connection or virtual circuit may be used, it must be established between two or more [nodes](https://en.wikipedia.org/wiki/Node_(networking)) or [software applications](https://en.wikipedia.org/wiki/Application_software) by means of [call setup](https://en.wikipedia.org/w/index.php?title=Call_setup&action=edit&redlink=1). After that, a [bit stream](https://en.wikipedia.org/wiki/Bit_stream) or [byte stream](https://en.wikipedia.org/wiki/Byte_stream) may be delivered between the nodes; hence, a virtual circuit protocol allows higher-level protocols to avoid dealing with the division of data into [Protocol data units](https://en.wikipedia.org/wiki/Protocol_data_unit).

Many virtual circuit protocols, but not all, provide [reliable](https://en.wikipedia.org/wiki/Reliability_(computer_networking)) communication service through the use of data retransmissions invoked by [error detection](https://en.wikipedia.org/wiki/Error_detection) and [automatic repeat request](https://en.wikipedia.org/wiki/Automatic_repeat_request) (ARQ).

An alternate network configuration to virtual circuit is [datagram](https://en.wikipedia.org/wiki/Datagram).[[1]](https://en.wikipedia.org/wiki/Virtual_circuit#cite_note-tanenbaum-1)



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**Comparison with circuit switching**

Virtual circuit communication resembles [circuit switching](https://en.wikipedia.org/wiki/Circuit_switching), since both are [connection oriented](https://en.wikipedia.org/wiki/Connection_oriented), meaning that in both cases data is delivered in correct order, and signalling overhead is required during a connection establishment phase. However, circuit switching provides a constant bit rate and latency, while these may vary in a virtual circuit service due to factors such as:

* varying packet queue lengths in the network nodes,
* varying bit rate generated by the application,
* varying load from other users sharing the same network resources by means of [statistical multiplexing](https://en.wikipedia.org/wiki/Statistical_multiplexing), etc.

**Virtual call capability**

In [telecommunication](https://en.wikipedia.org/wiki/Telecommunication), a **virtual call capability**, sometimes called a **virtual call facility**, is a [service feature](https://en.wikipedia.org/wiki/Service_feature) in which:

* a [call](https://en.wikipedia.org/wiki/Telephone_call) set-up procedure and a call disengagement procedure determine the period of communication between two [DTEs](https://en.wikipedia.org/wiki/Data_terminal_equipment) in which [user](https://en.wikipedia.org/wiki/User_(telecommunications)) data are transferred by a [packet switched](https://en.wikipedia.org/wiki/Packet_switched) network
* end-to-end [transfer](https://en.wikipedia.org/wiki/Call_transfer) control of packets within the network is required
* data may be delivered to the network by the [call originator](https://en.wikipedia.org/wiki/Call_originator) before the call [access phase](https://en.wikipedia.org/w/index.php?title=Access_phase&action=edit&redlink=1) is completed, but the data are not delivered to the [call receiver](https://en.wikipedia.org/w/index.php?title=Call_receiver&action=edit&redlink=1) if the [call attempt](https://en.wikipedia.org/w/index.php?title=Call_attempt&action=edit&redlink=1) is unsuccessful
* the network delivers all the user data to the call receiver in the same [sequence](https://en.wikipedia.org/wiki/Sequence) in which the data are received by the network
* multi-access DTEs may have several virtual calls in progress at the same [time](https://en.wikipedia.org/wiki/Time).

An alternate network configuration to virtual calls is [connectionless communication](https://en.wikipedia.org/wiki/Connectionless_communication) using [datagrams](https://en.wikipedia.org/wiki/Datagram).[[1]](https://en.wikipedia.org/wiki/Virtual_circuit#cite_note-tanenbaum-1)

**Layer 4 virtual circuits**

Connection oriented [transport layer](https://en.wikipedia.org/wiki/Transport_layer) protocols such as [TCP](https://en.wikipedia.org/wiki/Transmission_Control_Protocol)[[2]](https://en.wikipedia.org/wiki/Virtual_circuit#cite_note-2)[[3]](https://en.wikipedia.org/wiki/Virtual_circuit#cite_note-rfc1180-3) may rely on a connectionless packet switching network layer protocol such as [IP](https://en.wikipedia.org/wiki/Internet_Protocol), where different packets may be routed over different paths, and thus be delivered out of order. However, it is possible to use TCP as a virtual circuit,[[3]](https://en.wikipedia.org/wiki/Virtual_circuit#cite_note-rfc1180-3)[[4]](https://en.wikipedia.org/wiki/Virtual_circuit#cite_note-4)[[5]](https://en.wikipedia.org/wiki/Virtual_circuit#cite_note-5) since TCP includes segment numbering that allows reordering on the receiver side to accommodate out-of-order delivery.

**Layer 2/3 virtual circuits**

[Datalink layer](https://en.wikipedia.org/wiki/Datalink_layer) and [network layer](https://en.wikipedia.org/wiki/Network_layer) virtual circuit protocols are based on connection-oriented [packet switching](https://en.wikipedia.org/wiki/Packet_switching), meaning that data is always delivered along the same network path, i.e., through the same nodes. Advantages with this over connectionless packet switching are:

* Bandwidth reservation during the connection establishment phase is supported, making guaranteed [Quality of Service](https://en.wikipedia.org/wiki/Quality_of_Service) (QoS) possible. For example, a [constant bit rate](https://en.wikipedia.org/wiki/Constant_bit_rate) QoS class may be provided, resulting in emulation of [circuit switching](https://en.wikipedia.org/wiki/Circuit_switching).
* Less overhead is required since the packets are not routed individually and complete addressing information is not provided in the header of each data packet. Only a small [virtual channel identifier](https://en.wikipedia.org/wiki/Virtual_channel_identifier) (VCI) is required in each packet. Routing information is only transferred to the network nodes during the connection establishment phase.
* The network nodes are faster and have higher capacity in theory since they are switches that only perform routing during the connection establishment phase, while connectionless network nodes are routers that perform routing for each packet individually. Switching only involves looking up the virtual channel identifier in a table rather than analyzing a complete address. Switches can easily be implemented in [ASIC](https://en.wikipedia.org/wiki/Application-specific_integrated_circuit) hardware, while routing is more complex and requires software implementation. However, because of the large market of IP routers, and because advanced IP routers support [layer 3 switching](https://en.wikipedia.org/wiki/Layer_3_switching), modern IP routers may today be faster than switches for connection-oriented protocols.

**Examples of protocols that provide virtual circuits**

Examples of transport layer protocols that provide a virtual circuit:

* [Transmission Control Protocol](https://en.wikipedia.org/wiki/Transmission_Control_Protocol) (TCP), where a reliable virtual circuit is established on top of the underlying unreliable and connectionless IP protocol. The virtual circuit is identified by the source and destination [network socket](https://en.wikipedia.org/wiki/Network_socket) address pair, i.e. the sender and receiver IP address and port number. Guaranteed QoS is not provided.
* [Stream Control Transmission Protocol](https://en.wikipedia.org/wiki/Stream_Control_Transmission_Protocol) (SCTP), where a virtual circuit is established on top of the IP protocol.

Examples of network layer and datalink layer virtual circuit protocols, where data always is delivered over the same path:

* [X.25](https://en.wikipedia.org/wiki/X.25), where the VC is identified by a [virtual channel identifier](https://en.wikipedia.org/wiki/Virtual_channel_identifier) (VCI). X.25 provides reliable node-to-node communication and guaranteed QoS.
* [Frame relay](https://en.wikipedia.org/wiki/Frame_relay), where the VC is identified by a DLCI. Frame relay is unreliable, but may provide guaranteed QoS.
* [Asynchronous Transfer Mode](https://en.wikipedia.org/wiki/Asynchronous_Transfer_Mode) (ATM), where the circuit is identified by a [virtual path identifier](https://en.wikipedia.org/wiki/Virtual_path_identifier) (VPI) and [virtual channel identifier](https://en.wikipedia.org/wiki/Virtual_channel_identifier) (VCI) pair. The [ATM layer](https://en.wikipedia.org/wiki/Asynchronous_Transfer_Mode#Reference_model) provides unreliable virtual circuits, but the ATM protocol provides for reliability through the [ATM adaptation layer](https://en.wikipedia.org/wiki/ATM_adaptation_layer) (AAL) Service Specific Convergence Sublayer (SSCS) (though it uses the terms "assured" and "non-assured" rather than "reliable" and "unreliable").[[6]](https://en.wikipedia.org/wiki/Virtual_circuit#cite_note-I.363.3-6)[[7]](https://en.wikipedia.org/wiki/Virtual_circuit#cite_note-I.363.5-7)
* [General Packet Radio Service](https://en.wikipedia.org/wiki/General_Packet_Radio_Service) (GPRS)
* [Multiprotocol label switching](https://en.wikipedia.org/wiki/Multiprotocol_label_switching) (MPLS), which can be used for IP over virtual circuits. Each circuit is identified by a label. MPLS is unreliable but provides eight different QoS classes.

**Permanent and switched virtual circuits in ATM, frame relay, and X.25**

**Switched virtual circuits** (**SVCs**) are generally set up on a per-[call](https://en.wikipedia.org/wiki/Telephone_call) basis and are disconnected when the call is terminated; however, a **permanent virtual circuit** (**PVC**) can be established as an option to provide a [dedicated circuit](https://en.wikipedia.org/wiki/Dedicated_circuit) [link](https://en.wikipedia.org/wiki/Data_link) between two facilities. PVC configuration is usually preconfigured by the service provider. Unlike SVCs, PVC are usually very seldom broken/disconnected.

A switched virtual circuit (SVC) is a virtual circuit that is dynamically established on demand and is torn down when transmission is complete, for example after a phone call or a file download. SVCs are used in situations where data transmission is sporadic and/or not always between the same data terminal equipment ([DTE](https://en.wikipedia.org/wiki/Data_terminal_equipment)) endpoints.

A permanent virtual circuit (PVC) is a virtual circuit established for repeated/continuous use between the same [DTE](https://en.wikipedia.org/wiki/Data_terminal_equipment). In a PVC, the long-term association is identical to the data transfer phase of a [virtual call](https://en.wikipedia.org/w/index.php?title=Virtual_call&action=edit&redlink=1). Permanent virtual circuits eliminate the need for repeated call set-up and [clearing](https://en.wikipedia.org/wiki/Clearing_(telecommunications)).

* [Frame relay](https://en.wikipedia.org/wiki/Frame_relay) is typically used to provide PVCs.
* [ATM](https://en.wikipedia.org/wiki/Asynchronous_Transfer_Mode) provides both **switched virtual connections** and **permanent virtual connections**, as they are called in ATM terminology.
* [X.25](https://en.wikipedia.org/wiki/X.25) provides both **virtual calls** and PVCs, although not all X.25 service providers or DTE implementations support PVCs as their use was much less common than SVCs

**See also**

* [Data link connection identifier](https://en.wikipedia.org/wiki/Data_link_connection_identifier) (DLCI)
* [Label switching](https://en.wikipedia.org/wiki/Label_switching)
* [Traffic flow (computer networking)](https://en.wikipedia.org/wiki/Traffic_flow_(computer_networking))

**References**

 Andrew S. Tanenbaum, David J. Wetherall (2011, Fifth Edition. International Edition), "Computer Networks". page 361 [ISBN](https://en.wikipedia.org/wiki/ISBN_(identifier)) [978-0-13-255317-9](https://en.wikipedia.org/wiki/Special:BookSources/978-0-13-255317-9)

  [RFC 793](https://tools.ietf.org/html/rfc793)

  [RFC 1180](https://tools.ietf.org/html/rfc1180)

  [RFC 955](https://tools.ietf.org/html/rfc955)

  [RFC 1644](https://tools.ietf.org/html/rfc1644)

  ITU-T, *B-ISDN ATM Adaptation Layer specification: Type 3/4 AAL*, Recommendation I.363.3 (08/96), International Telecommunication Union, 1996, p5.

* 1.  ITU-T, *B-ISDN ATM Adaptation Layer specification: Type 5 AAL*, Recommendation I.363.5 (08/96), International Telecommunication Union, 1996, p5.
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