Virtual circuit

A **virtual circuit** (**VC**) is a means of transporting data over a packet-switched network in such a way that it appears as though there is a dedicated physical link between the source and destination end systems of this data. The term virtual circuit is synonymous with **virtual connection**.

Before a connection or virtual circuit may be used, it must be established between two or more nodes or software applications by means of call setup. After that, a bit stream or 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.

Many virtual circuit protocols, but not all, provide reliable communication service through the use of data retransmissions invoked by error detection and automatic repeat request (ARQ).

An alternate network configuration to virtual circuit is datagram.[1]

Contents

Comparison with circuit switching

Virtual circuit communication resembles circuit switching, since both are 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, etc.

Virtual call capability

In telecommunication, a **virtual call capability**, sometimes called a **virtual call facility**, is a service feature in which:

- a call set-up procedure and a call disengagement procedure determine the period of communication between two DTEs in which user data are transferred by a packet switched network
- end-to-end transfer control of packets within the network is required
- data may be delivered to the network by the call originator before the call access phase is completed, but the data are not delivered to the call receiver if the call attempt is unsuccessful
- the network delivers all the user data to the call receiver in the same sequence in which the data are received by the network
- multi-access DTEs may have several virtual calls in progress at the same time.

An alternative network configuration to virtual calls is connectionless communication using datagrams.[1]

Layer 4 virtual circuits

Connection oriented transport layer protocols such as TCP[2][3] may rely on a connectionless packet switching network layer protocol such as IP, 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][4][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 and network layer virtual circuit protocols are based on connection-oriented 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 (QoS) possible. For example, a constant bit rate QoS class may be provided, resulting in emulation of 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 (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 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, modern IP routers may today be faster than switches for connection-oriented protocols.

Example protocols

Examples of transport layer protocols that provide a virtual circuit:

- 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 address pair, i.e. the sender and receiver IP address and port number. Guaranteed QoS is not provided.

- 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, where the VC is identified by a virtual channel identifier (VCI). X.25 provides reliable node-to-node communication and guaranteed QoS.
- Frame relay, where the VC is identified by a DLCI. Frame relay is unreliable, but may provide guaranteed QoS.
- Asynchronous Transfer Mode (ATM), where the circuit is identified by a virtual path identifier (VPI) and virtual channel identifier (VCI) pair. The ATM layer provides unreliable virtual circuits, but the ATM protocol provides for reliability through the ATM adaptation layer (AAL) Service Specific Convergence Sublayer (SSCS) (though it uses the terms "assured" and "non-assured" rather than "reliable" and "unreliable").[6][7]
- General Packet Radio Service (GPRS)
- 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 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 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) endpoints.

A permanent virtual circuit (PVC) is a virtual circuit established for repeated/continuous use between the same DTE. In a PVC, the long-term association is identical to the data transfer phase of a virtual call. Permanent virtual circuits eliminate the need for repeated call set-up and clearing.

- Frame relay is typically used to provide PVCs.
- ATM provides both **switched virtual connections** and **permanent virtual connections**, as they are called in ATM terminology.
- 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 (DLCI)
- Label switching
- Traffic flow (computer networking)

References

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