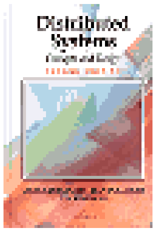

Archive material from *Edition 2* of Distributed Systems: Concepts and Design

© George Coulouris, Jean Dollimore & Tim Kindberg 1994

Permission to copy for all non-commercial purposes is hereby granted

Originally published at pp. 81-82 of Coulouris, Dolllimore and Kindberg, Distributed Systems, Edition 2, 1994.

Token ring

Token rings were explored early in the development of local network technologies [Farmer and Newhall 1969, Farber and Larson 1972, Pierce 1972] but their exploitation has been slower than that of the other local network technologies. Nevertheless, they have been used in several commercial products and IBM has adopted a token ring that conforms to the IEEE/ISO 802.5 Standard [IEEE 1985c] as a basis for distributed system products. Messages of almost any length can be transmitted as single packets. This is achieved with the help of a single permanently-circulating *token packet* that has a distinguished format.

An analogy with the transport of freight by train may be helpful in understanding the operation of token rings. The analogy has the token packet as a locomotive that is everlastingly circulating around a looped track (like a circular shuttle service) and the data packets as freight wagons. The locomotive is marked as 'busy' or 'free'. When there are no wagons attached it is free, otherwise it is busy. Wagons containing data can be attached to the locomotive whenever it passes a station and it is not busy. When wagons are attached the locomotive is marked as busy and the destination address of wagons is marked on the locomotive. The destination station must detach the wagons as they pass and mark the locomotive as free.

A single token is used in most token rings. It circulates continuously and there is a monitor station that injects a free token if it is missing (to initialize the network and to guard against loss of the token when a station fails). In the IEEE Token Ring the token occupies 3 bytes and a single bit in the token is used to indicate whether it is busy or free. When the token is free, no other data circulates in the ring. When it is busy, the token is followed by a sequence of address and data field bytes. The formats of packets and tokens are shown below.

3 bytes	*6 bytes*	*6 bytes*	*≤ 5000 bytes*	*4 bytes*	*1 byte*	*1 byte*
Token	Destination address	Source address	Data for transmission	Frame check seq.	End delimiter	Frame status

A token has the following format:

1 byte	*1 byte*	*1 byte*
Starting delimiter	Access control	Frame control

The *starting delimiter* byte has a fixed bit pattern that enables stations to recognize the start of a frame and synchronize to the data transmission rate. The 8 bits in the *access control* field are used to distinguish between busy and free tokens, to identify the priority of the frame that is being transmitted (3 bits) and to reserve the next free frame with a given priority (3 bits). The monitor station uses the eighth bit to help it to check that the ring is functioning correctly.

The operation of the token ring follows the pattern defined in our 'freight train' analogy. A station wishing to send a message checks the access control field and sets the busy bit if it is free. The source and destination address fields are inserted by the sending station, and the message data is appended to them, followed by the frame check sequence and the end delimiter. The destination station sets the access control field to free and removes all of the trailing fields from the token.

We will not detail the use of the priority and reservation bits in the access control field; their purpose is to enable a variety of regimes for sharing of the channel capacity among the stations on the network. One important consequence is that they can be used to ensure a fair distribution of the channel capacity among stations waiting to transmit messages, preventing the hogging of the available bandwidth by one or two stations.

The token ring does not suffer from the drawbacks of small or fixed-size packets (the packets may in principle be of almost any length; the limitation to 5000 bytes is a default value for a parameter that can be configured on a per-installation basis). The requirement for a monitor station is the most severe remaining drawback.

References

[Farber and Larson 1972] Farber, D.J. and Larson, K.C. (1972). The system architecture of the distributed computer system – the communications network. *Proc. Sym. on Computer Networks*, Polytechnic Institute of Brooklyn.

Farmer and Newhall 1969] Farmer, W.D. and Newhall, E.E. (1969). An experimental distributed switching system to handle bursty computer traffic. *Proc. ACM Sym. on Problems in Optimization of Data Communication Systems*, ACM, pp. 1–33.

IEEE 1985c Institute of Electrical and Electronic Engineers (1985). *Local Area Network – Token Ring Access Method and Physical Layer Specifications*. American National Standard ANSI/IEEE 802.5, IEEE Computer Society.

[Pierce 1972] Pierce, J., (1972). How far can data loops go? *IEEE Trans. Communications*, vol. COM-20, pp. 527–30.

Archive material from Edition 2 of Distributed Systems – Concepts and Design © George Coulouris, Jean Dollimore & Tim Kindberg 1994