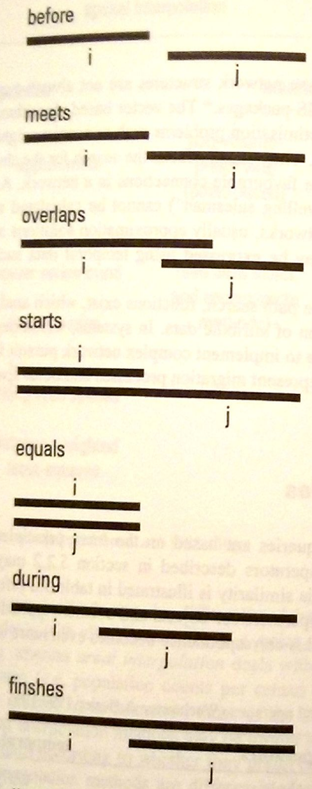

Fig. 5.7 Relations between linear time intervals (adopted from Frank 1998:41)

Computer scientists have laid the foundations for temporal queries by developing a large number of languages such as TSQL, a superset of the structured query language used to retrieve data from relational databases. The functions provided by TSQL include comparing time intervals, computing the intersections between time periods, analysing time discontinuities, aggregating over time periods and choosing the length of a time interval. Since TSQL is an extension of SQL, it provides an obvious starting point to integrate time-based queries into the majority of existing GIS packages. The objects in the GIS need to be time-stamped with a begin- and end-time; single points in time are represented by a zero duration time interval, i.e. begin-time equals end-time (see table 5.3).

Table 5.3 Time-stamp- and event-based TSQL operators (derived from Claramunt & Thériault 1995:35)

(a) time-stamp-based operators

BEFORE	[a,b] BEFORE [c,d]	$b<c$
AFTER	[a,b] AFTER [c,d]	$a>d$
DURING	[a,b] DURING [c,d]	$(a\geq c)$ AND $(b\leq d)$
EQUIVALENT	[a,b] EQUIVALENT [c,d]	$(a=c)$ AND $(b=d)$
ADJACENT	[a,b] ADJACENT [c,d]	$(c-b=1) \mid (a-d=1)$
OVERLAP	[a,b] OVERLAP [c,d]	$(a\leq d)$ AND $(c\leq d)$
FOLLOWS	[a,b] FOLLOWS [c,d]	$(a-d=1)$
PRECEDES	[a,b] PRECEDES [c,d]	$(c-b=1)$
STARTS	[a,b] STARTS [c,d]	$a=c$
FINISHES	[a,b] FINISHES [c,d]	$b=d$

[a,b] and [c,d] symbolize the two periods begin- and end-time.

(b) events-based operators

EVOLUTION	[InstanceA1] CHANGES TO [InstanceA2]	A1=A2
SUCCESSION	[InstanceA] REPLACED BY [InstanceB]	A≠B
PRODUCTION	[InstanceA] PRODUCES [InstanceB]	A≠B
REPRODUCTION	[InstanceA] GENERATES [InstanceB]	A≠B
TRANSMISSION	[InstanceA] TRANSMITS [InstanceB]	A≠B

The symbol A1=A2 means that the operator is restricted to two versions of the same entity, while A≠B implies two different entities.

The time-stamp-based operators (a) are used to compare time periods. They do not provide an explicit way to model and distinguish evolution, succession, production, reproduction or transmission processes. Indeed, time-stamp-based operators use time measurements to compute relative positions between potentially independent entities as opposite to the topological operators that link interdependent entities (b). In this case "instance" has the meaning of a generalized data type in the temporal domain (Claramunt & Thériault 1995:36; see figure 5.8):

- The CHANGES TO operator returns "true" when InstanceA2 represents a mutation immediately following InstanceA1.
- The REPLACED BY operator returns "true" when InstanceB is an immediate successor of InstanceA. Both instances may survive the replacement with Instance A being permuted to another position. The succession process is encoded as a *1:n* or a *n:1* relationship. If a relocation process of the *n:m* type is required, this can be modelled using a *n:1* followed by a *1:n* relationship applied to an intermediate virtual object.