MODELING AND QUERYING HISTORY OF MOVEMENT:

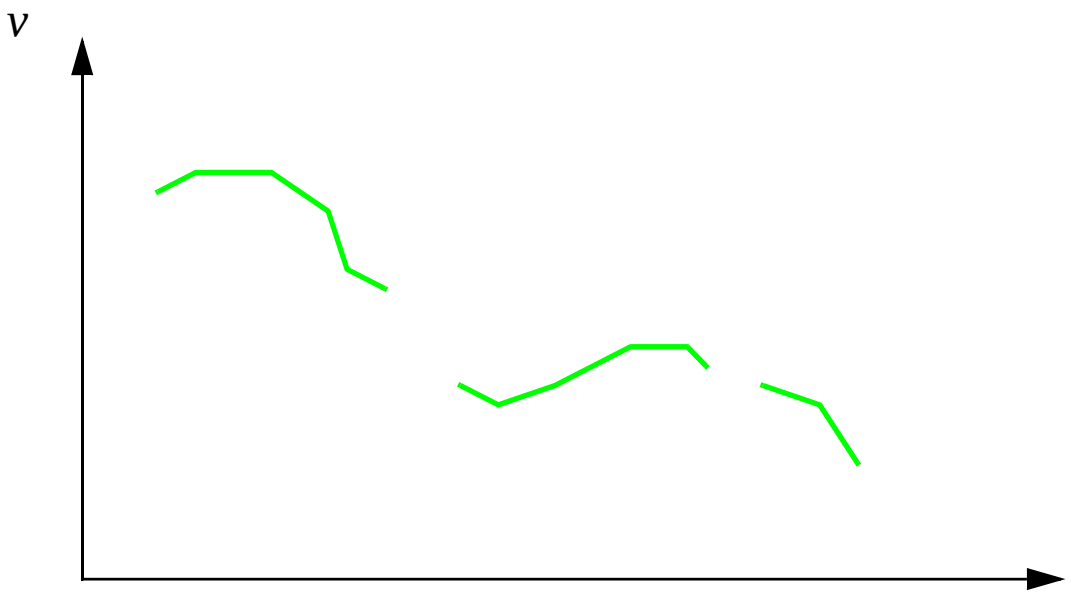
ABSTRACT DATA MODEL

Part 2

Operations on Temporal Types: Projection to Domain/Range

Values of these types are partial functions

f: $A_{\underline{instant}} \rightarrow A_{\alpha}$



moving(α)	→ *periods*	**deftime**
moving(α)	→ *range*(α)	**rangevalues** [1D]
moving(*point*)	→ *points*	**locations**
moving(*points*)	→ *points*	
moving(*point*)	→ *line*	**trajectory**
moving(*points*)	→ *line*	
moving(*line*)	→ *line*	**routes**
moving(*line*)	→ *region*	**traversed**
moving(*region*)	→ *region*	

Operations on Temporal Types: Projection to Domain/Range

Values of these types are partial functions

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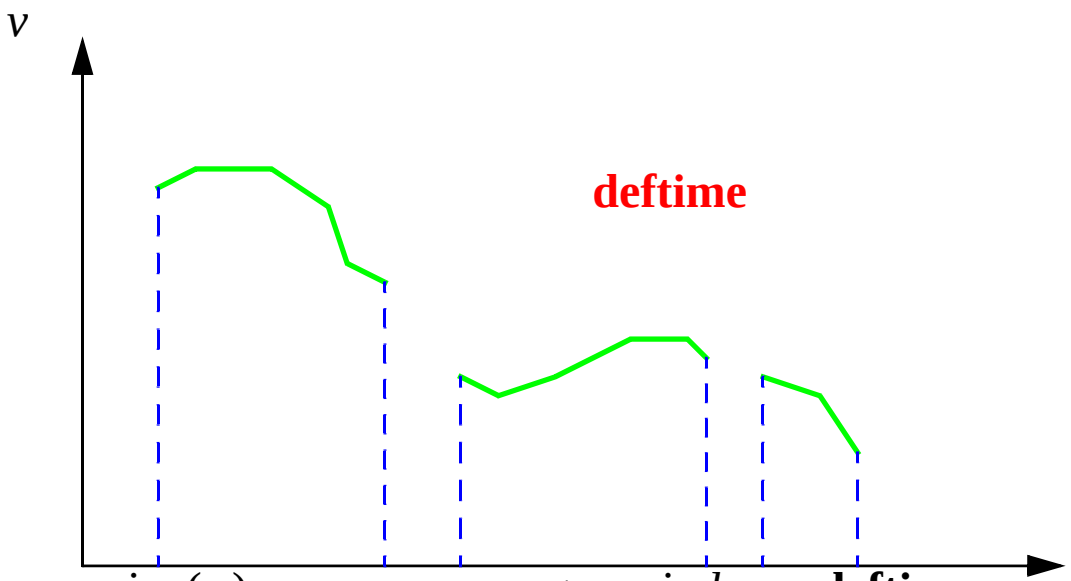

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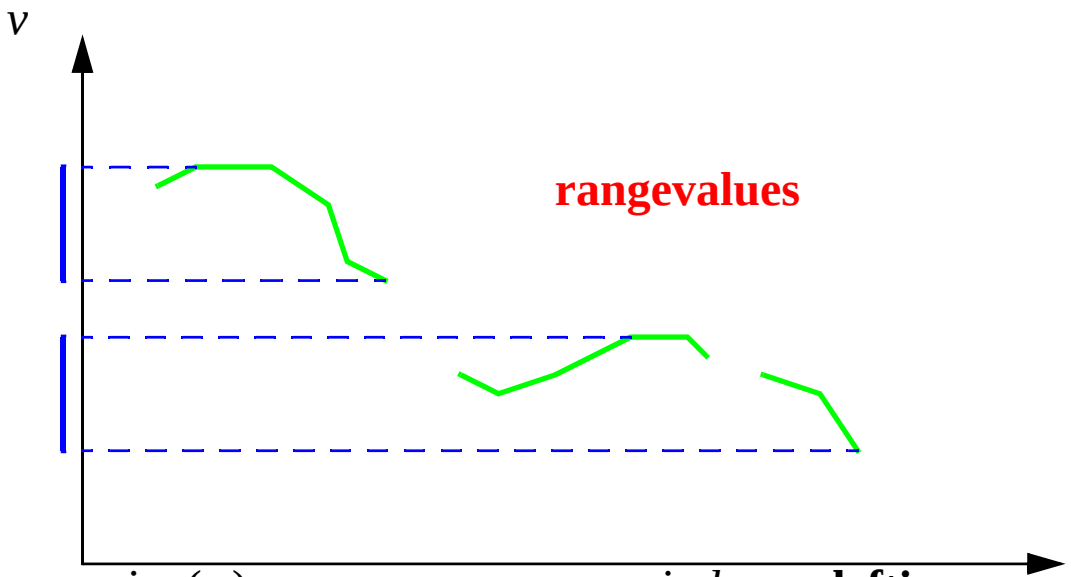

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moving(*point*)	→ *line*	**trajectory**
moving(*points*)	→ *line*	
moving(*line*)	→ *line*	**routes**
moving(*line*)	→ *region*	**traversed**
moving(*region*)	→ *region*	

Example:

```
weather(id:string,kind:string,area:mregion)
country(name:string, area:region)
```

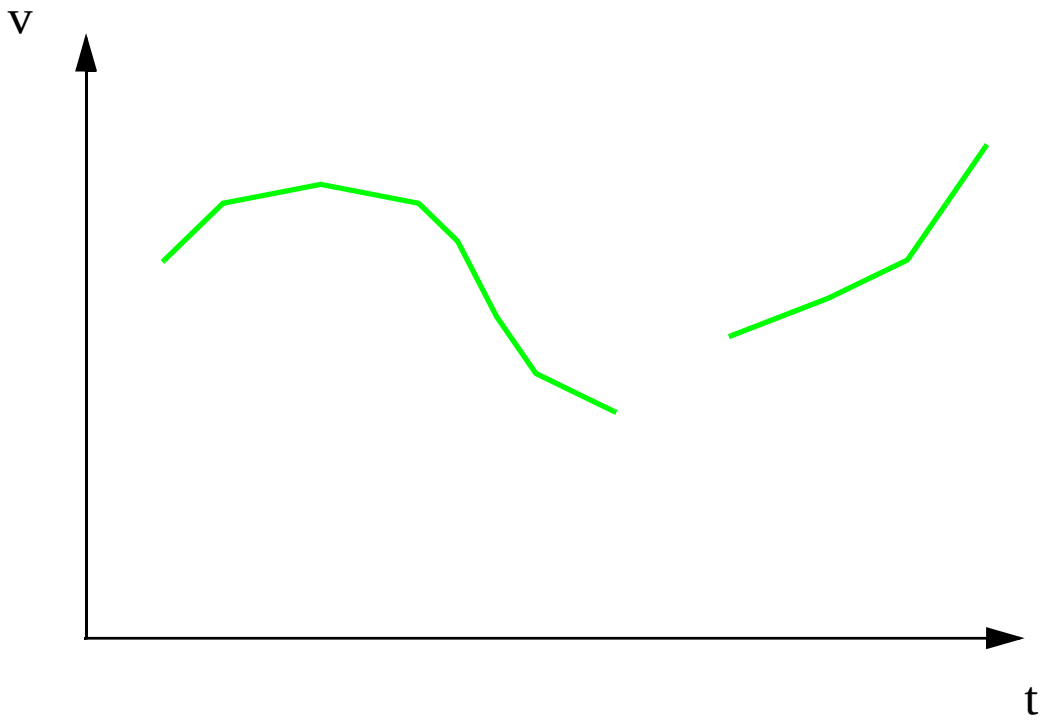
“How large was the area within France affected by hurricane Lizzy?”

```
LET Lizzy = ELEMENT(
  SELECT area FROM weather WHERE id = ’Lizzy’);
LET France = ELEMENT(
  SELECT area FROM country WHERE name=’France’);
area(intersection(traversed(Lizzy), France))
```

“At what time did hurricane Lizzy start?”

```
start(deftime(Lizzy))
```

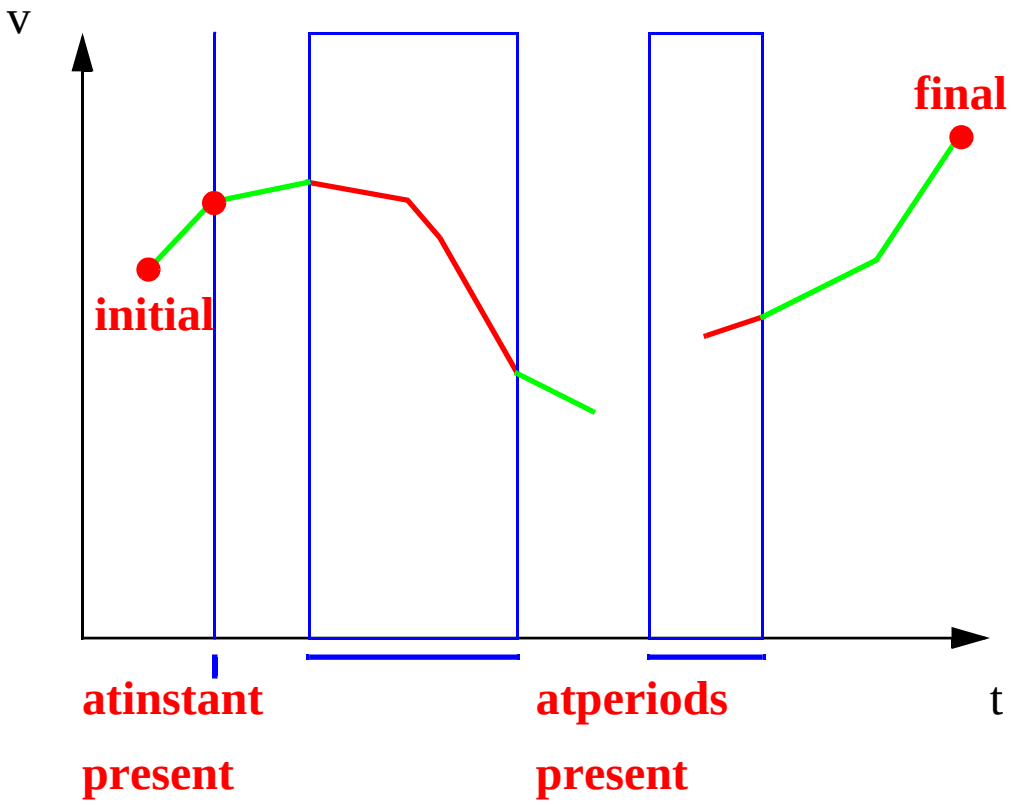
Operations on Temporal Types: Interaction with Points and Point Sets in Domain and Range



moving(α) × *instant*	→ *intime*(α)	**atinstant**
moving(α) × *periods*	→ *moving*(α)	**atperiods**
moving(α)	→ *intime*(α)	**initial**, **final**
moving(α)× *instant*	→ *bool*	**present**
moving(α)× *periods*	→ *bool*	

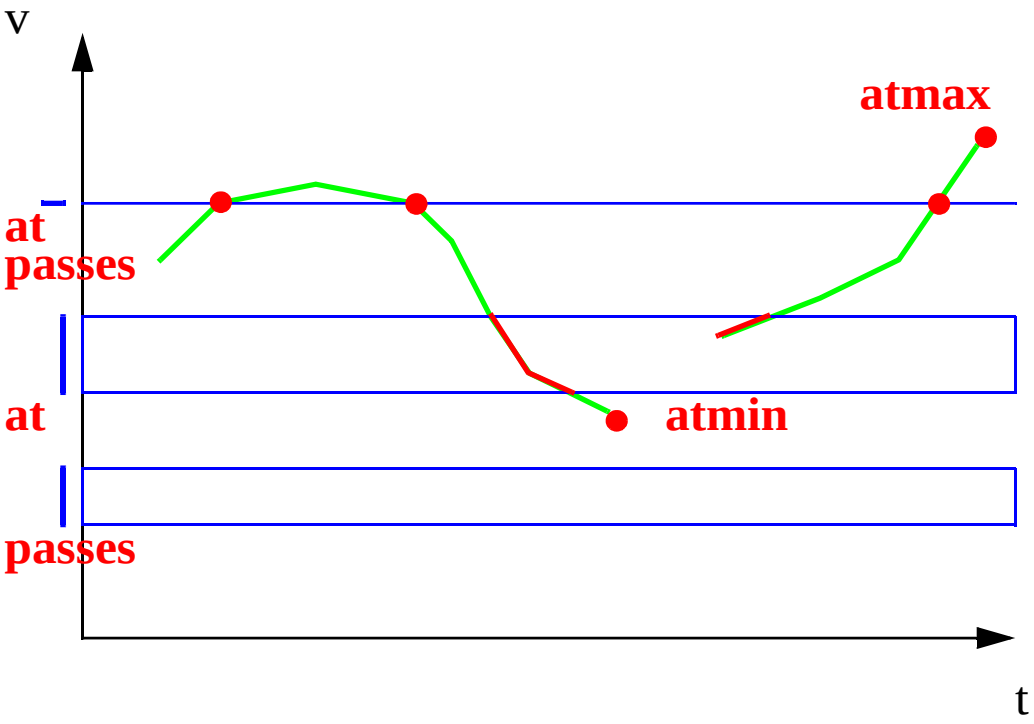
moving(α) × β	→ *moving*(α)	**at** [1D]
moving(α) × β	→ *moving*(min(α, β))	**at** [2D]
moving(α)	→ *moving*(α)	**atmin**, **atmax** [1D]
moving(α) × β	→ *bool*	**passes**

Operations on Temporal Types: Interaction with Points and Point Sets in Domain and Range



moving(α) × *instant*	→ *intime*(α)	**atinstant**
moving(α) × *periods*	→ *moving*(α)	**atperiods**
moving(α)	→ *intime*(α)	**initial, final**
moving(α)× *instant*	→ *bool*	**present**
moving(α)× *periods*	→ *bool*	

Operations on Temporal Types: Interaction with Points and Point Sets in Domain and Range



$\underline{moving}(\alpha) \times \beta \rightarrow \underline{moving}(\alpha)$	**at** [1D]
$\underline{moving}(\alpha) \times \beta \rightarrow \underline{moving}(\min(\alpha, \beta))$	**at** [2D]
$\underline{moving}(\alpha) \rightarrow \underline{moving}(\alpha)$	**atmin**, **atmax** [1D]
$\underline{moving}(\alpha) \times \beta \rightarrow \underline{bool}$	**passes**

Example:

```
flight(id:string,from:string,to:string,route:mpoint)
weather(id:string,kind:string,area:mregion)
```

“For how long was hurricane Lizzy over France?”

```
LET LizzyTime = deftime(at(Lizzy, France));
duration(LizzyTime);
```

“Where was flight KLM066 while Lizzy was over France?”

```
LET KLM066 = ELEMENT
(SELECT route FROM flight WHERE id = ’KLM066’);
trajectory(atperiods(KLM066, LizzyTime));
```

Operations on Temporal Types: Rate of Change

mreal	→ *mreal*	**derivative**
mpoint	→ *mreal*	**speed**
mpoint	→ *mreal*	**mdirection**
mpoint	→ *mreal*	**turn**

Example:

"At what time did the area of hurricane Lizzy shrink?"

```
LET LizzyArea = ..........
LET negative = open(range(minreal, 0));
deftime(at(derivative(LizzyArea), negative))
```

"Show the parts of the route of flight KLM066, when the airplane's speed was at least 800 km/h?"

```
LET r = ELEMENT(SELECT route FROM flight
                WHERE id = 'KLM066');
LET rSpeed = speed(r);
LET rRange = range(800, maxreal);
LET r_atPeriods =
atperiods(r, deftime(at(rSpeed, rRange)));
LET trajectoryKLM066 = trajectory(r_atPeriods);
```

Operations on Temporal Types: Rate of Change (cont.)

Semantics of rate of change operations

$$f'(t) = \lim_{\Delta t \to 0} \frac{f(t + \Delta t) - f(t)}{\Delta t}$$

mreal → *mreal* **derivative**

μ' where $\mu'(t) = \lim_{\delta \to 0} (\mu(t+\delta) - \mu(t)) / \delta$

mpoint → *mreal* **speed**

μ' where $\mu'(t) = \lim_{\delta \to 0} f_{\text{distance}}(\mu(t+\delta), \mu(t)) / \delta$

mpoint → *mreal* **mdirection**

μ' where $\mu'(t) = \lim_{\delta \to 0} f_{\text{direction}}(\mu(t+\delta), \mu(t)) / \delta$

mpoint → *mreal* **turn**

μ' where $\mu'(t)$
$= \lim_{\delta \to 0} (f_{\text{mdirection}}(\mu(t+\delta)) - f_{\text{mdirection}}(\mu(t))) / \delta$