A FRESH LOOK AT THE OBJECT-FIELD DICHOTOMY

MIKE WORBOYS
UNIVS { GREENWICH
EDINBURGH

Models of the world

NOT the world itself

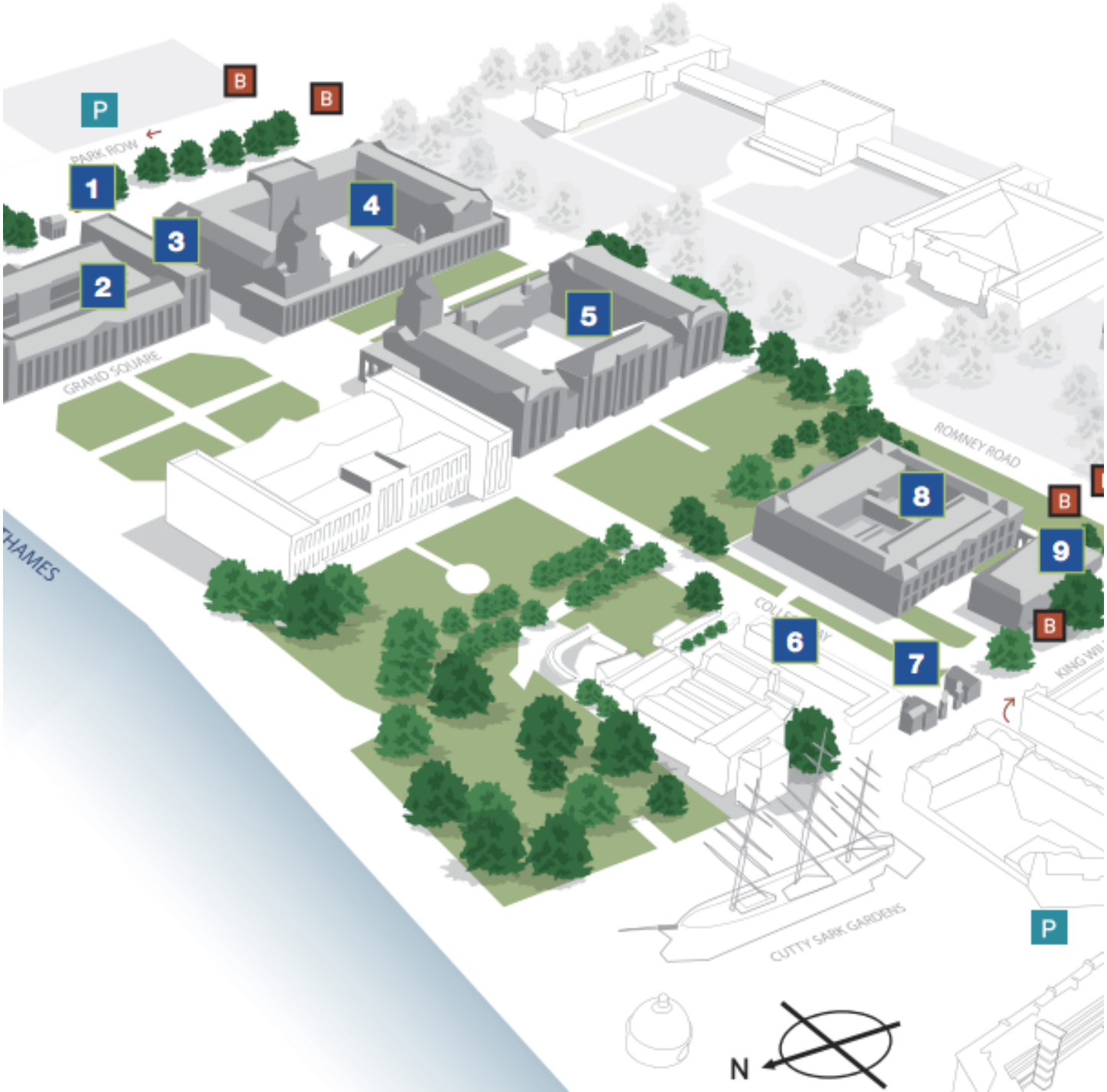
TIMELESS

functional

Object — Entities → Attributes

Entities → Locations

Field — Locations → Attributes


P
B
B
PARK ROW
1
2
3
4
5
GRAND SQUARE
ROMNEY ROAD
8
B
9
B
6
7
CUTTY SARK GARDENS
P
N

Neptune - Selected Time = 17:35 15/3/2009

File Date Tide Heights GPS Wind Waypoints View Configuration Help Tides >> << Tides

Cursor
51.52.20N 000.38.44E

- Choose Working File
- Locate a Waypoint Mark
- Edit or View Waypoint Details
- Copy Between Files
- Create New File
- Mouse Input of Waypoints
- Save Waypoints

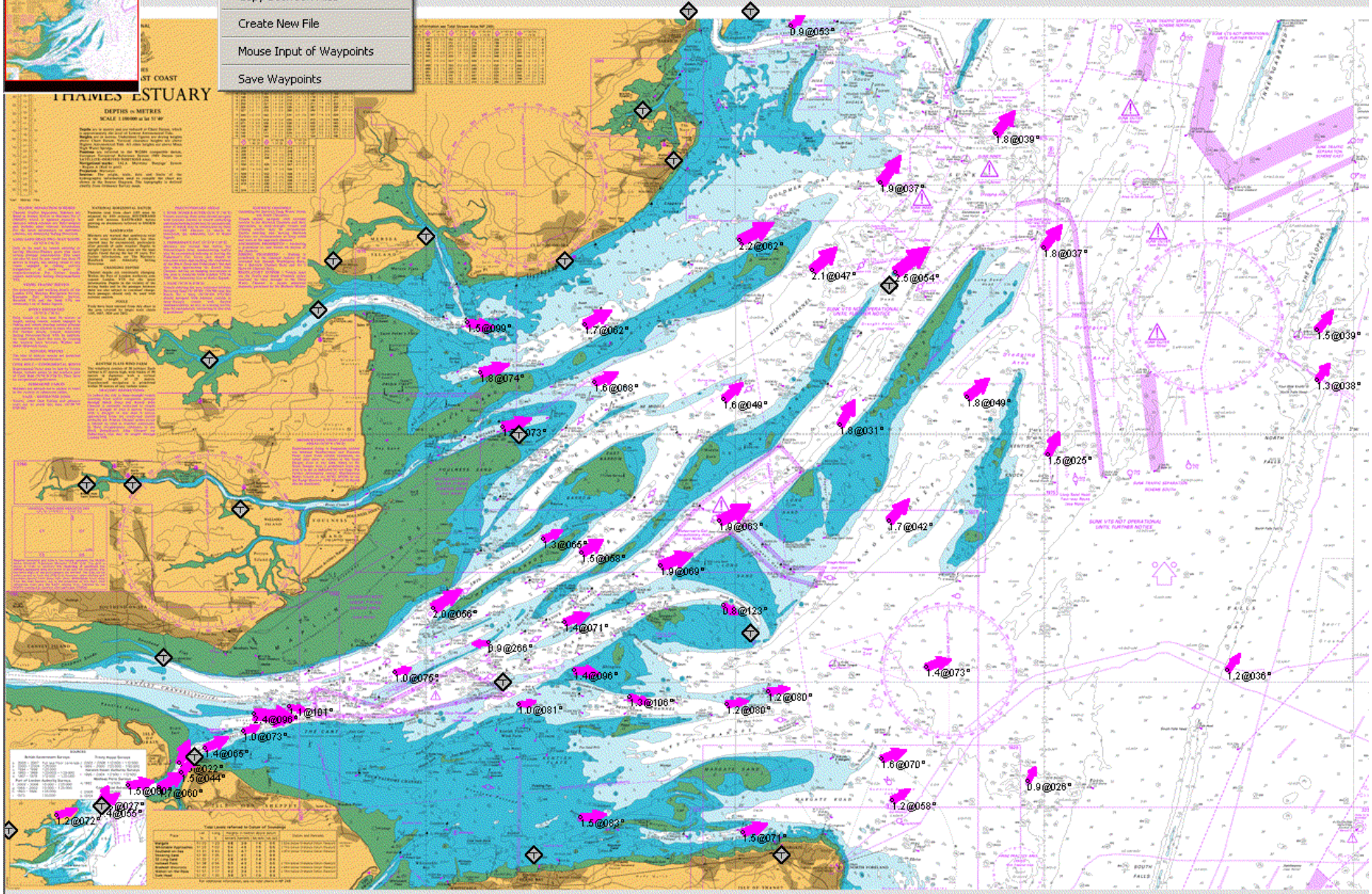


Chart = Thames Estuary 1183-0 | Waypoints = Sample.way

Mathematical structures

$$\langle Set, Op_1, \ldots, Rel^n_1, \ldots \rangle$$

Entities

Attributes

Locations

Mathematical structures

$$\langle Set, Op_1, \ldots, Rel^n_1, \ldots \rangle$$

Entities E

Attributes A

Locations
- Spatial S
- Temporal T
- Spatiotemporal $S \times T$

$$S \begin{cases} \mathbb{R} \times \mathbb{R} \\ \mathbb{N} \times \mathbb{N} \\ \mathcal{P}(\mathbb{R} \times \mathbb{R}) \\ \text{Graphs} \\ \mathbb{R}^3 \\ \ldots \end{cases}$$

$$T \begin{cases} \mathbb{R} \\ \mathbb{N} \\ \text{Allen} \\ \mathbb{R} \times \mathbb{R} \\ \vdots \end{cases}$$

(IJGIS 2007)

Goodchild's geo-atom

$$\langle \underline{x}, Z, z(\underline{x}) \rangle$$

point in space-time

property

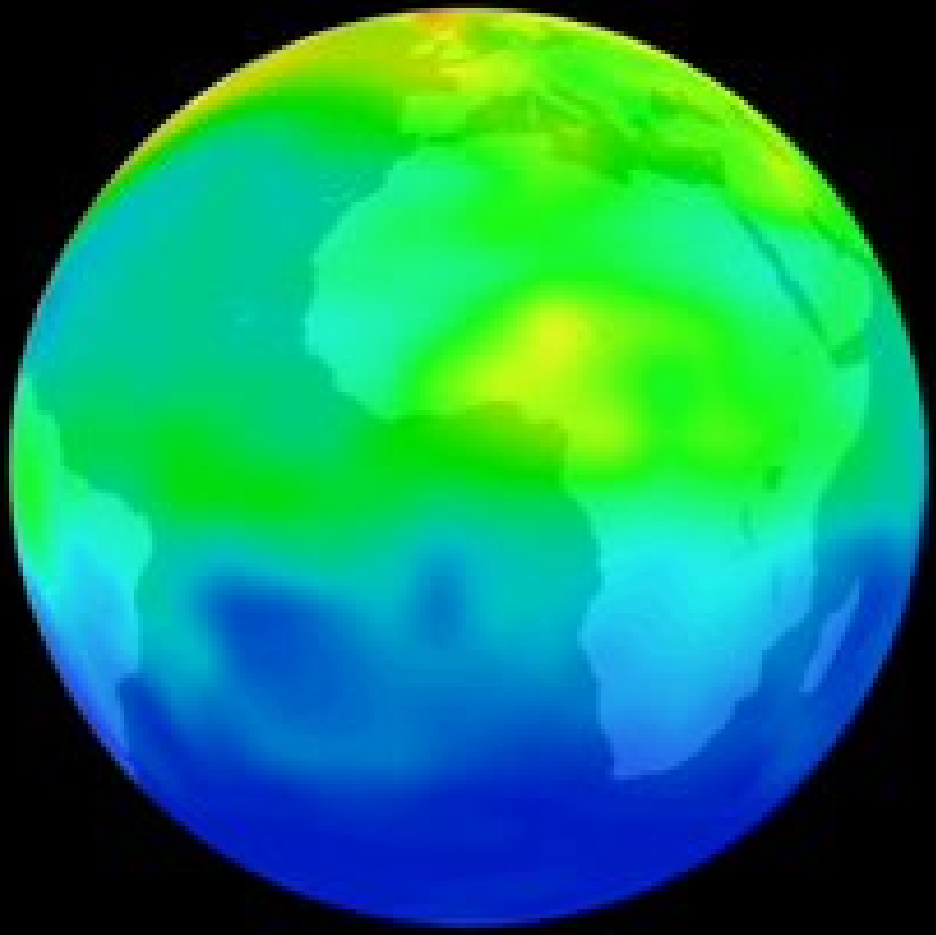
value of property at $\underline{x}$

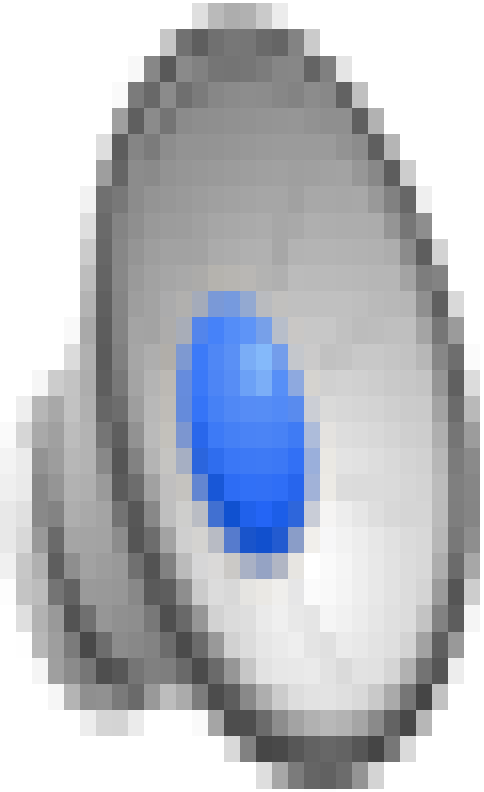
ADDING TIME

Object

$$\begin{tikzcd} & A \times T \\ E \arrow[ur] \arrow[dr] & \\ & S \times T \end{tikzcd}$$

Field $\quad S \times T \longrightarrow A$

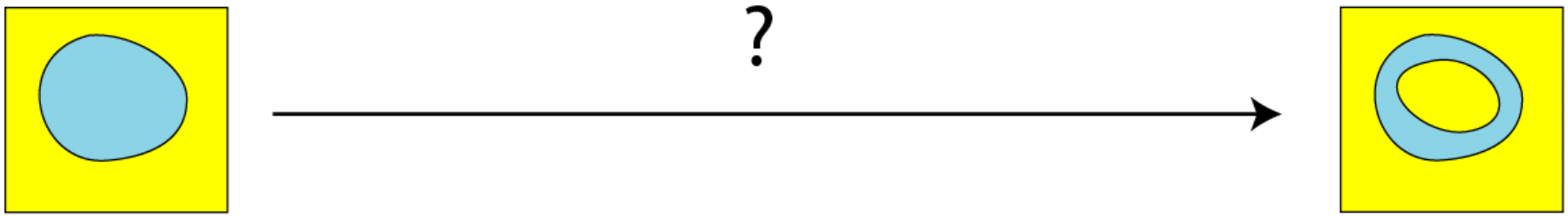


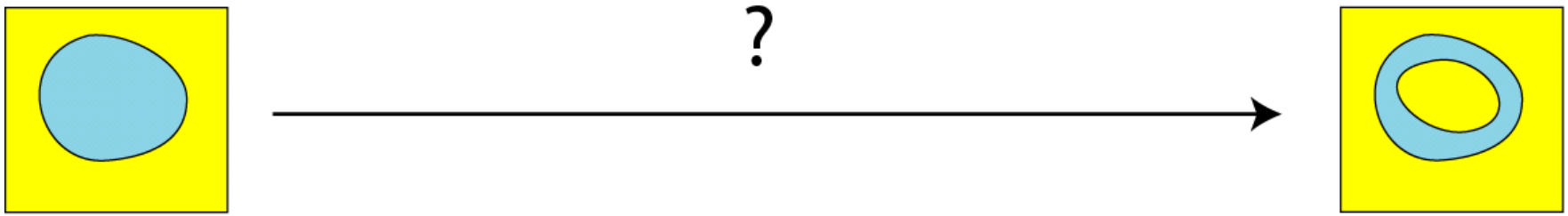


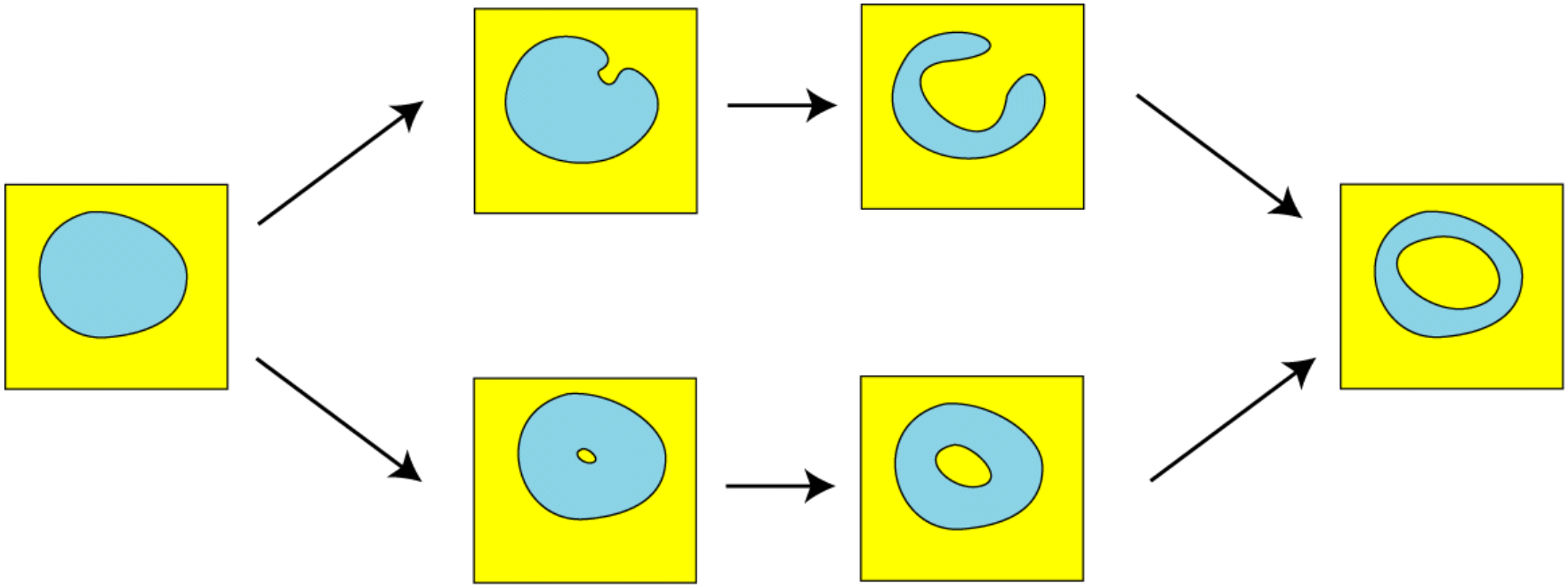
BUT NOW

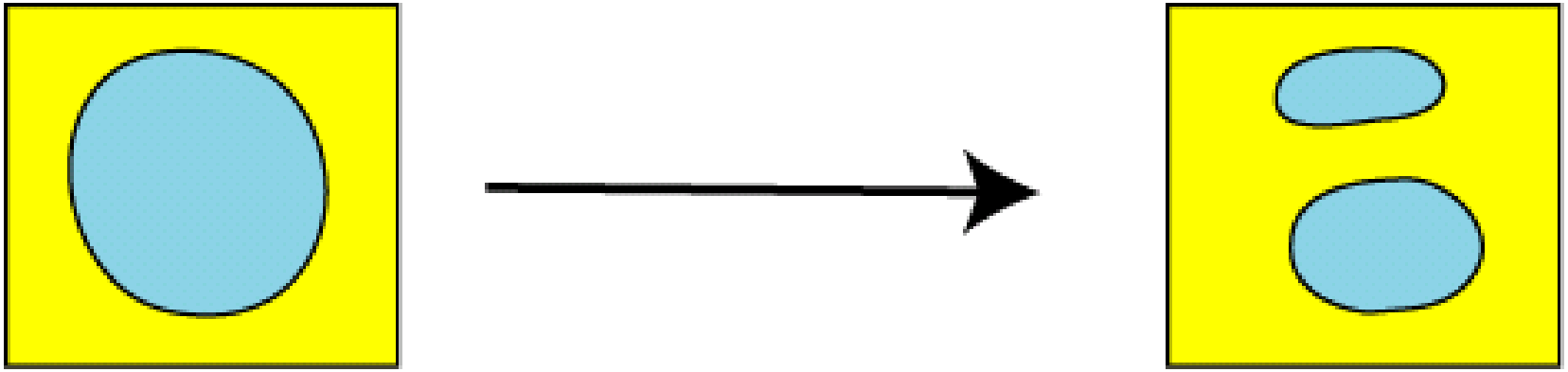
$$E = \text{Continuants} \cup \text{Occurrents}$$

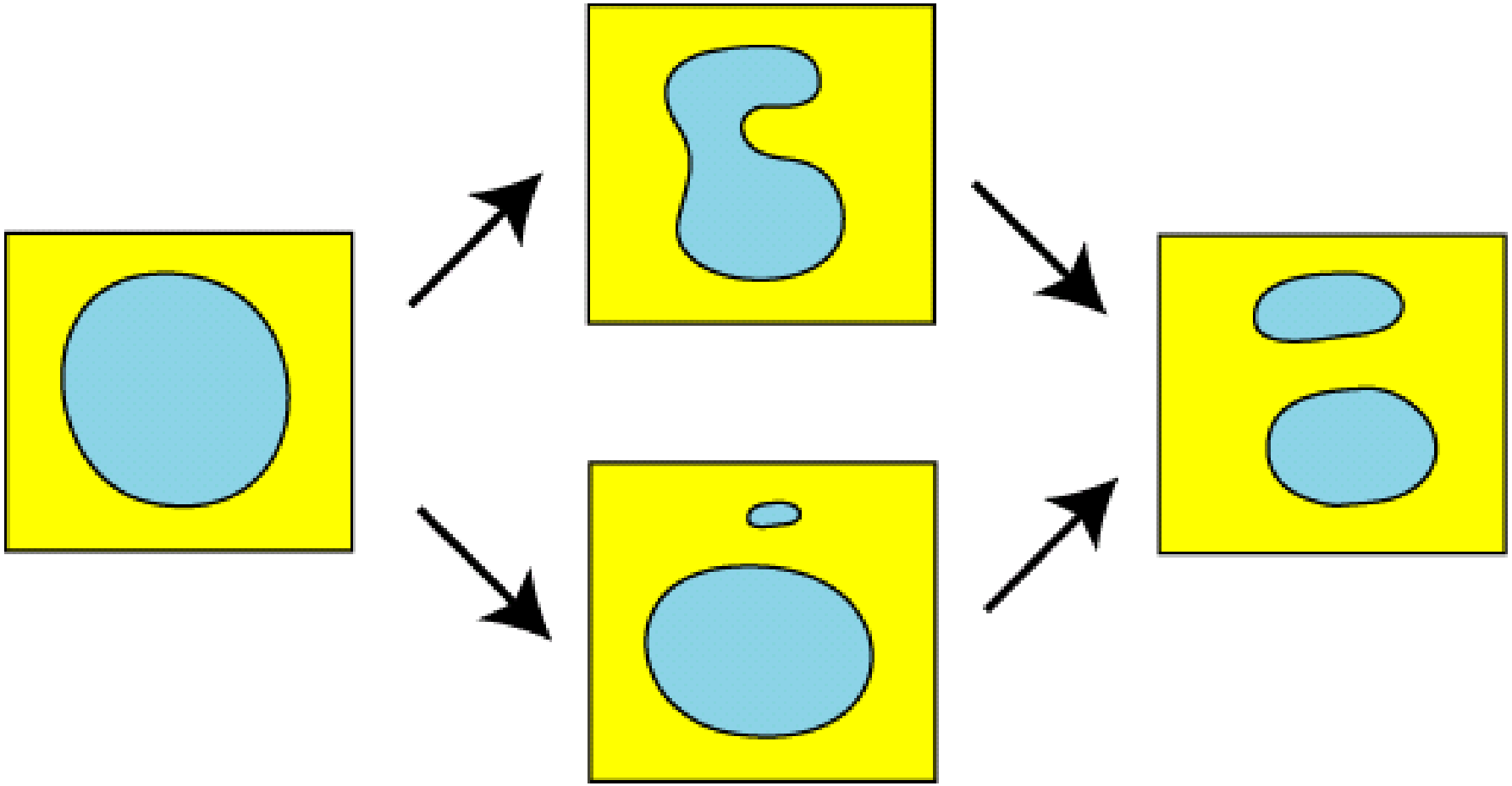
SWAP AND SPAN

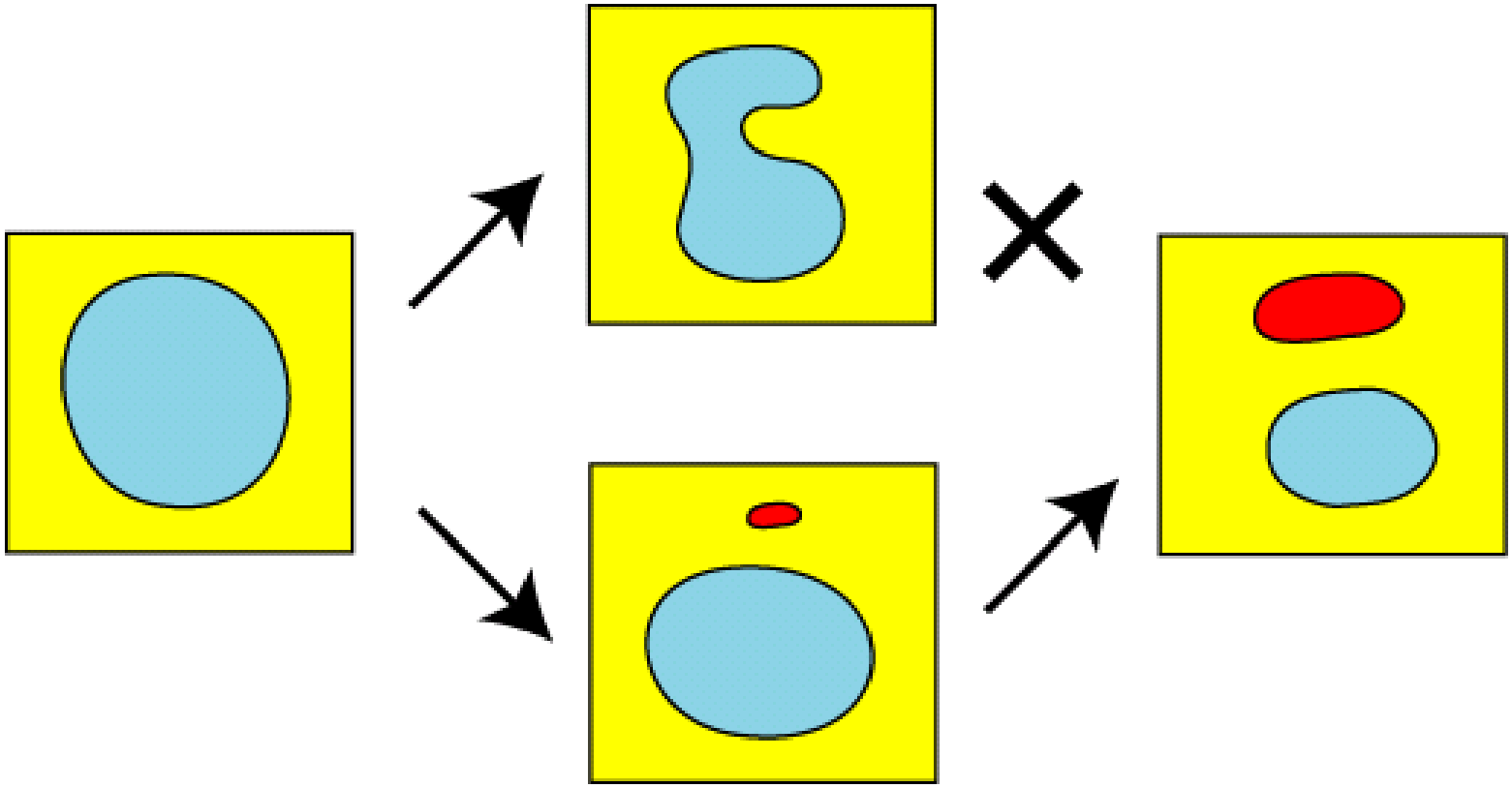


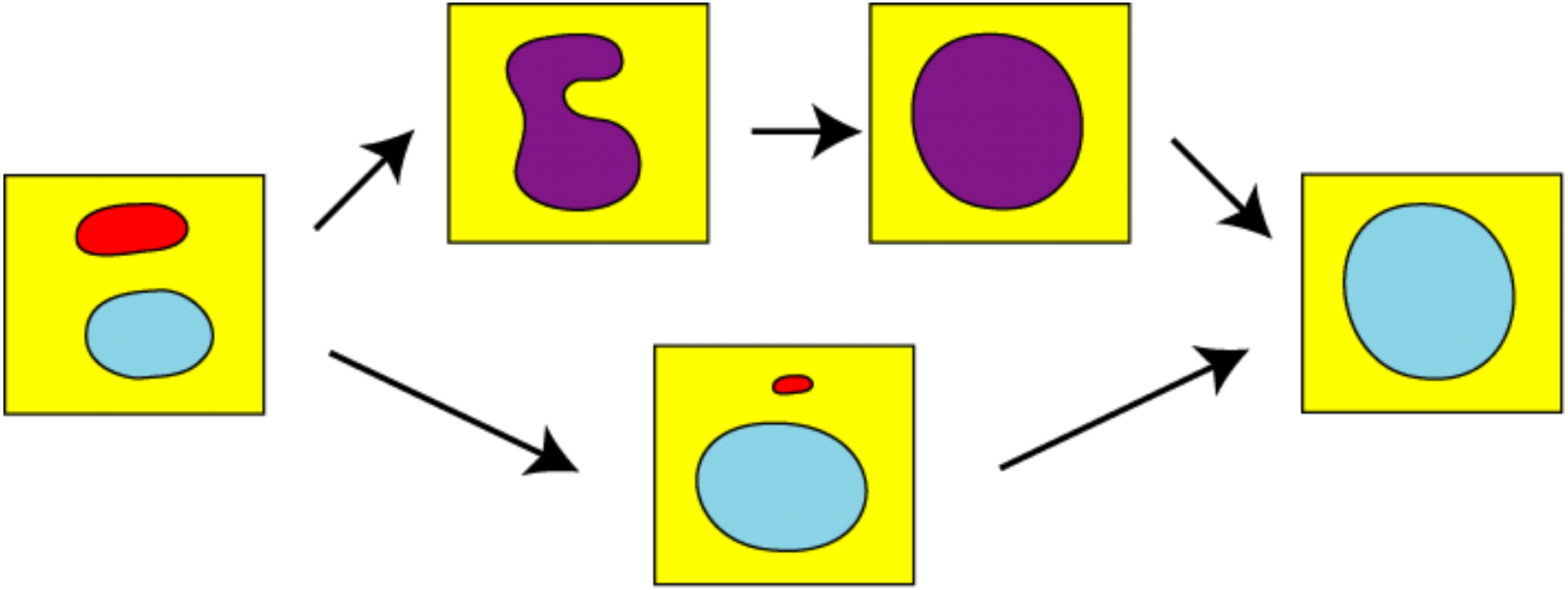


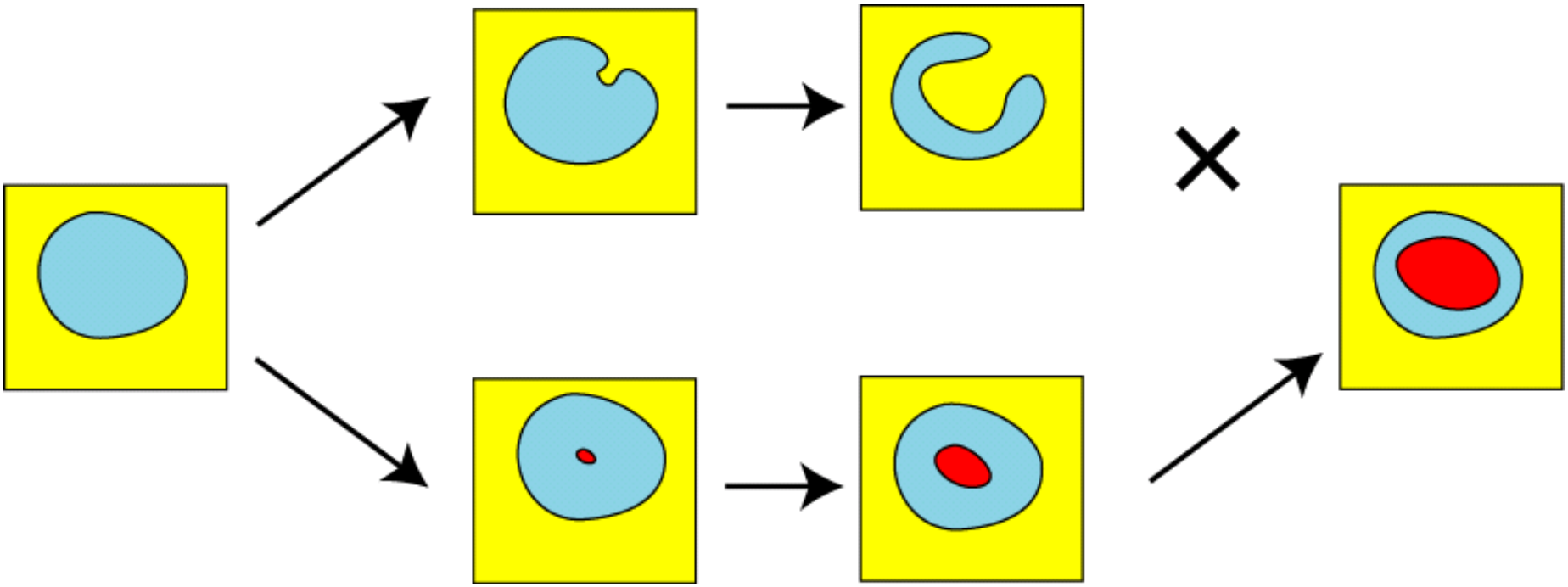


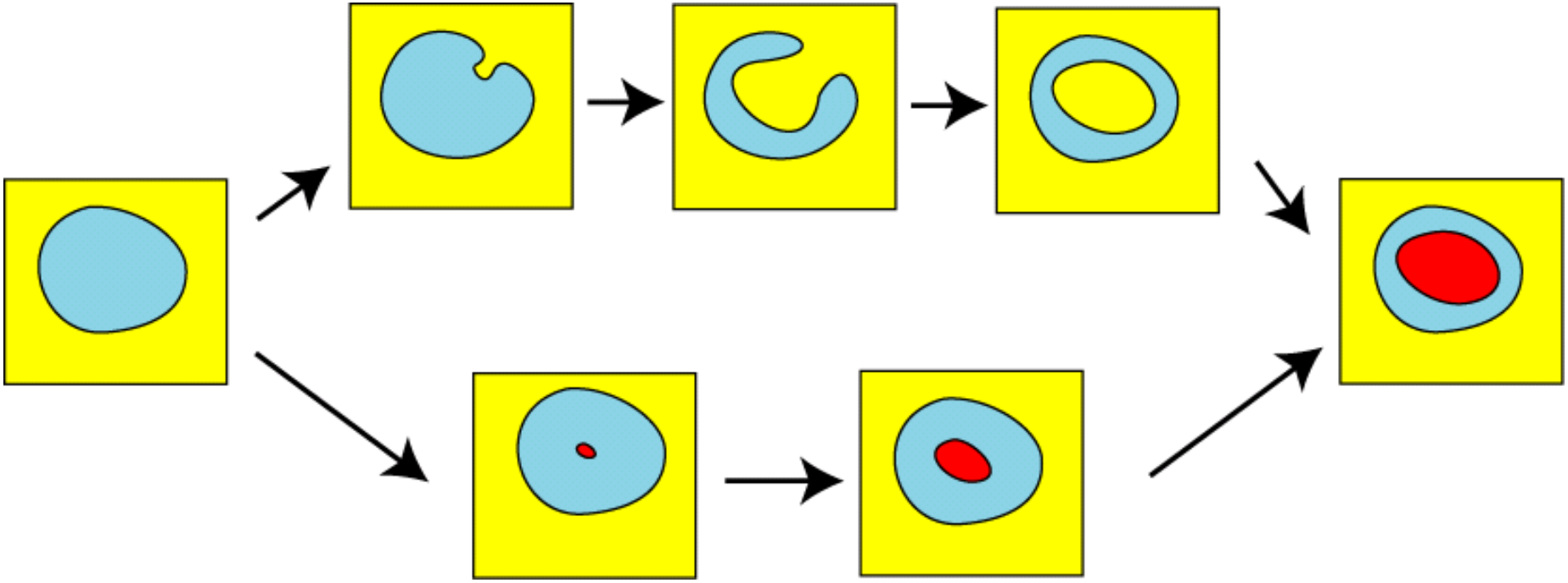






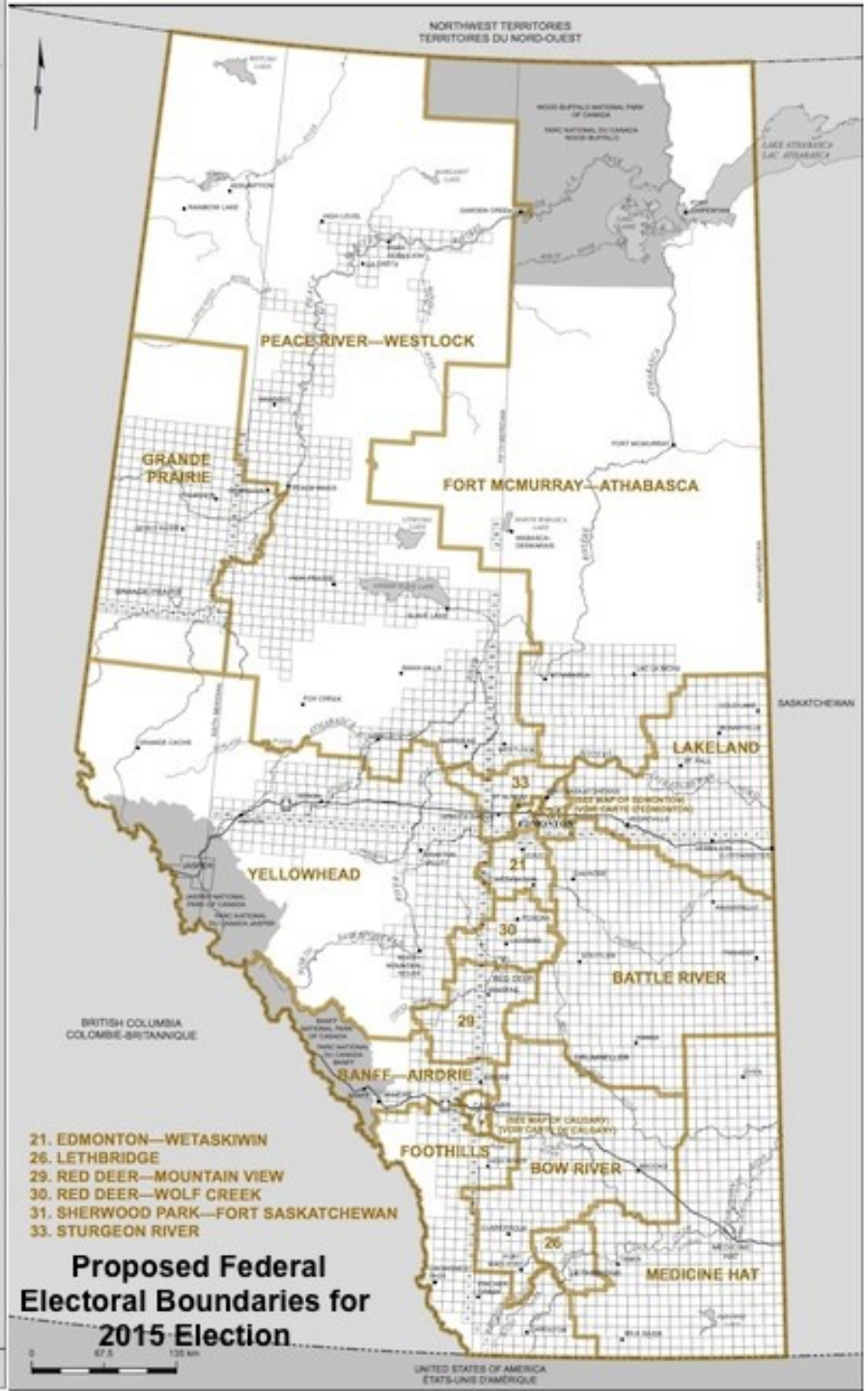


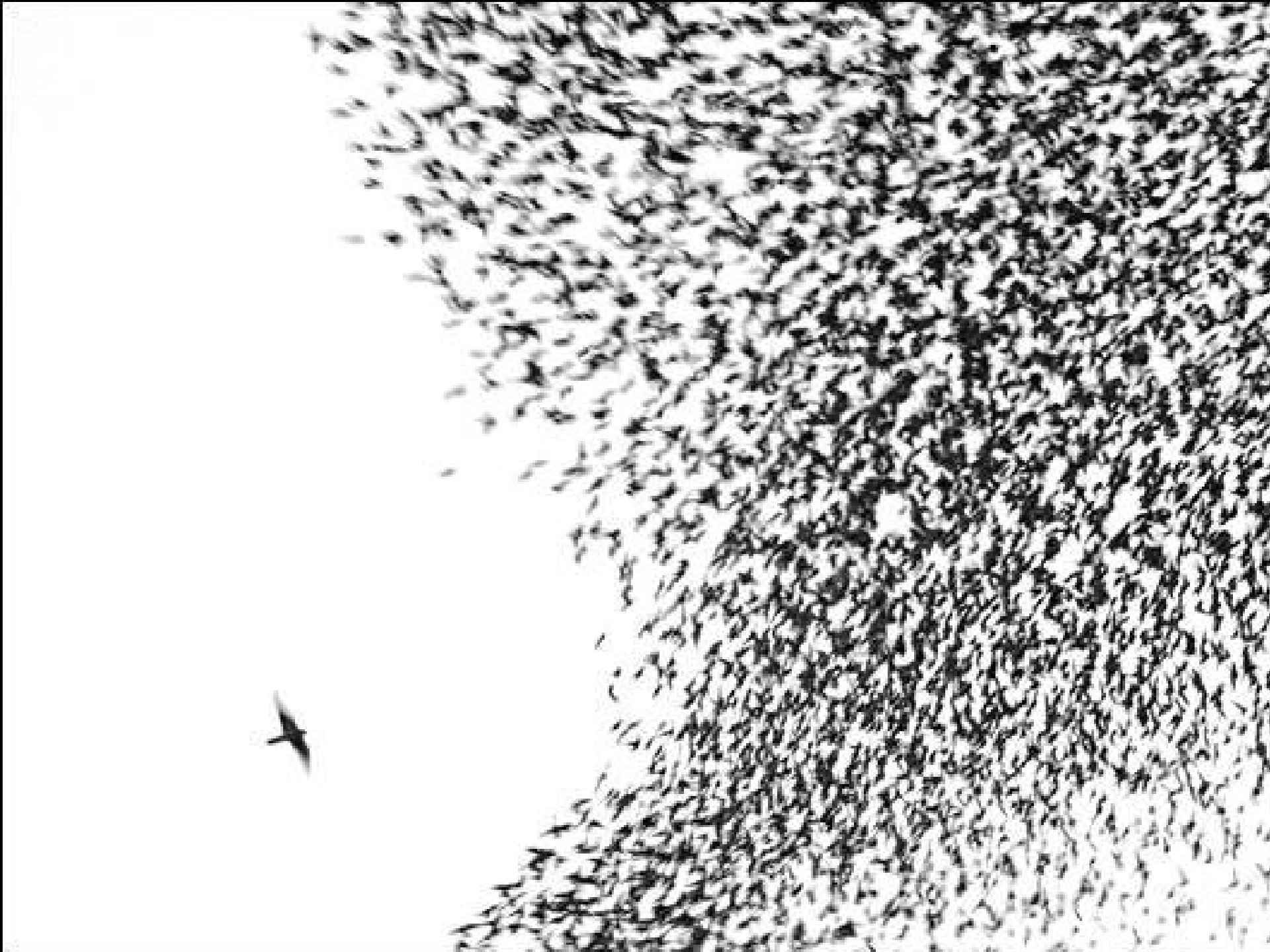




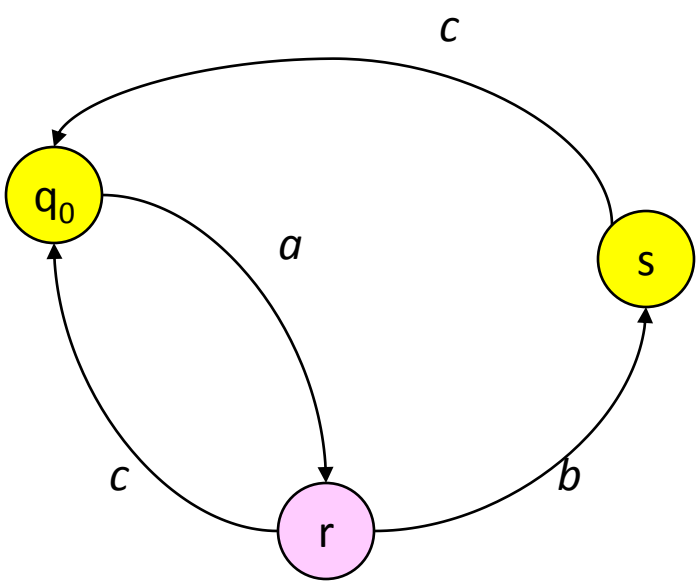
Event $\Rightarrow$ State change


PEACE RIVER
ATHABASCA
YELLOWHEAD
WESTLOCK—ST. PAUL
VEGREVILLE—WAINWRIGHT
WETASKIWIN
RED DEER
WILD ROSE
CROWFOOT
MACLEOD
MEDICINE HAT
LETHBRIDGE
BRITISH COLUMBIA
COLOMBIE-BRITANNIQUE
SASKATCHEWAN
14. EDMONTON—LEDUC
16. EDMONTON—SHERWOOD PARK
17. EDMONTON—SPRUCE GROVE
Federal Electoral Boundaries after 2002/2003


NORTHWEST TERRITORIES
TERRITOIRES DU NORD-OUEST
PEACE RIVER—WESTLOCK
GRANDE PRAIRIE
FORT MCMURRAY—ATHABASCA
LAKELAND
YELLOWHEAD
BATTLE RIVER
BANFF—AIRDRIE
FOOTHILLS
BOW RIVER
MEDICINE HAT
BRITISH COLUMBIA
COLOMBIE-BRITANNIQUE
SASKATCHEWAN
21. EDMONTON—WETASKIWIN
26. LETHBRIDGE
29. RED DEER—MOUNTAIN VIEW
30. RED DEER—WOLF CREEK
31. SHERWOOD PARK—FORT SASKATCHEWAN
33. STURGEON RIVER
Proposed Federal Electoral Boundaries for 2015 Election
UNITED STATES OF AMERICA
ÉTATS-UNIS D'AMÉRIQUE



Process model



This process is deterministic, as there
is at most one transition (q, a, q'), for each pair (q, a).

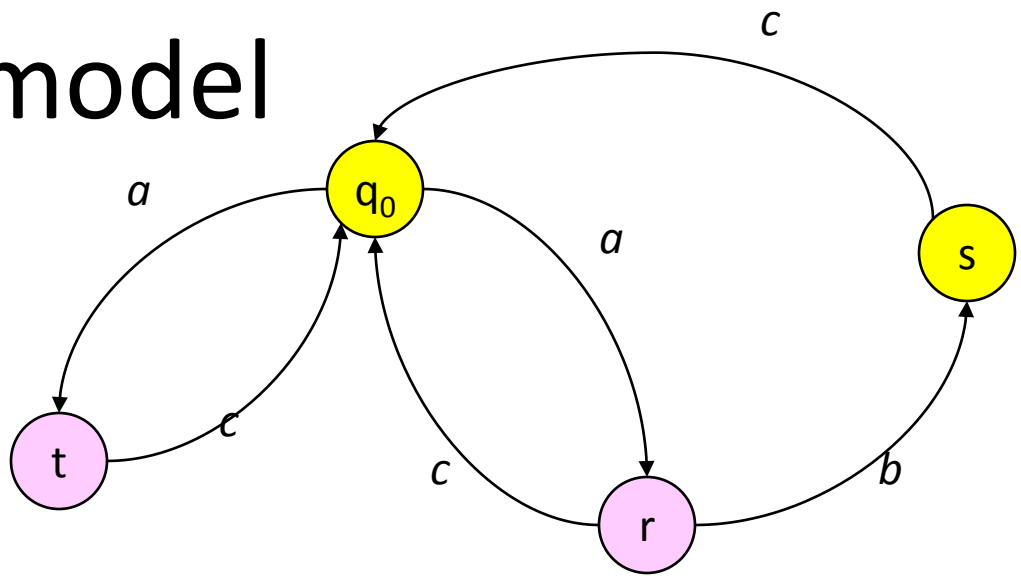
Process notation:

$Q_0 \;==\; aR$

$R \;==\; bS + cQ_0$

$S \;==\; cQ_0$

Process model



This process is nondeterministic, as there is more than one transition *a* with start state q_0.

Process notation:

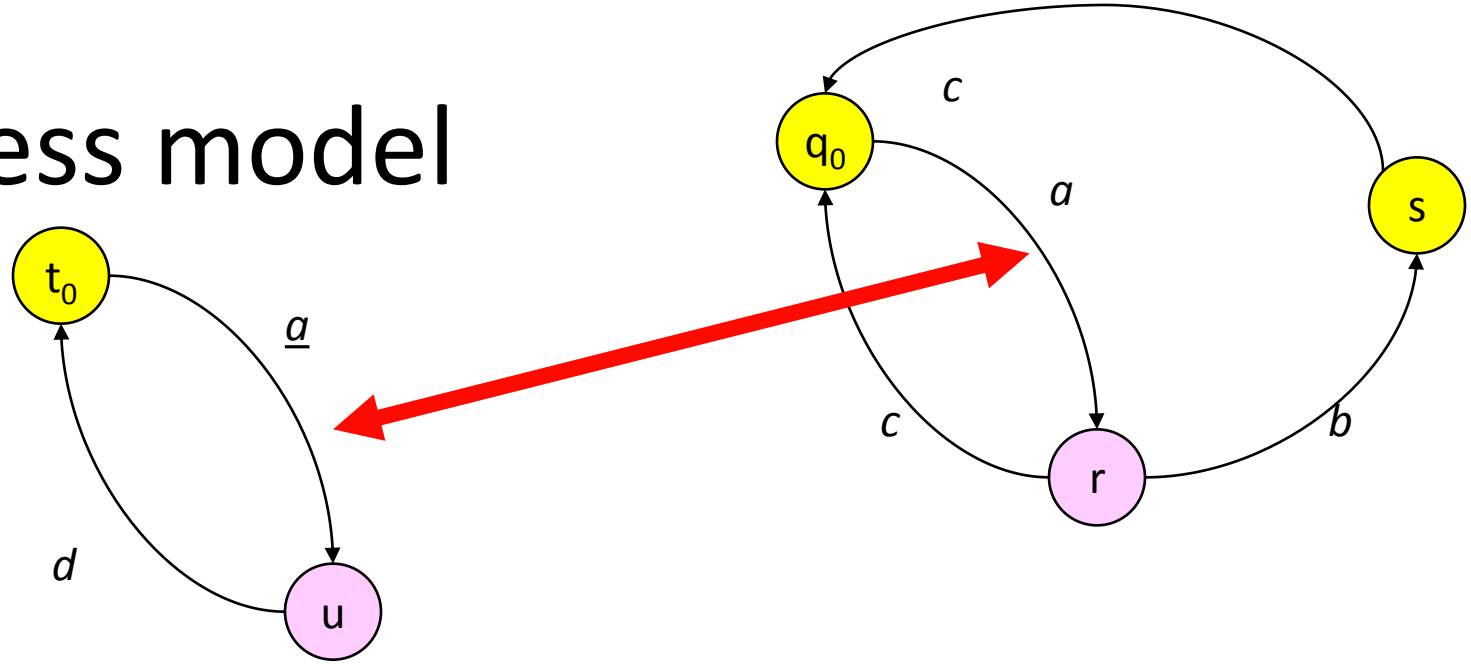
$Q_0 \;==\; aR + aT = a(R+T)$

$R \;==\; bS + cQ_0$

$S \;==\; cQ_0$

$T \;==\; cQ_0$

Process model



These processes communicate via input action a and output action $\underline{a}$. The combined process is $Q_0 \mid T_0$

Process notation:

$Q_0 \;==\; aR$

$R \;==\; bS + cQ_0$

$S \;==\; cQ_0$

$T_0 \;==\; \underline{a}U$

$U \;==\; dT_0$

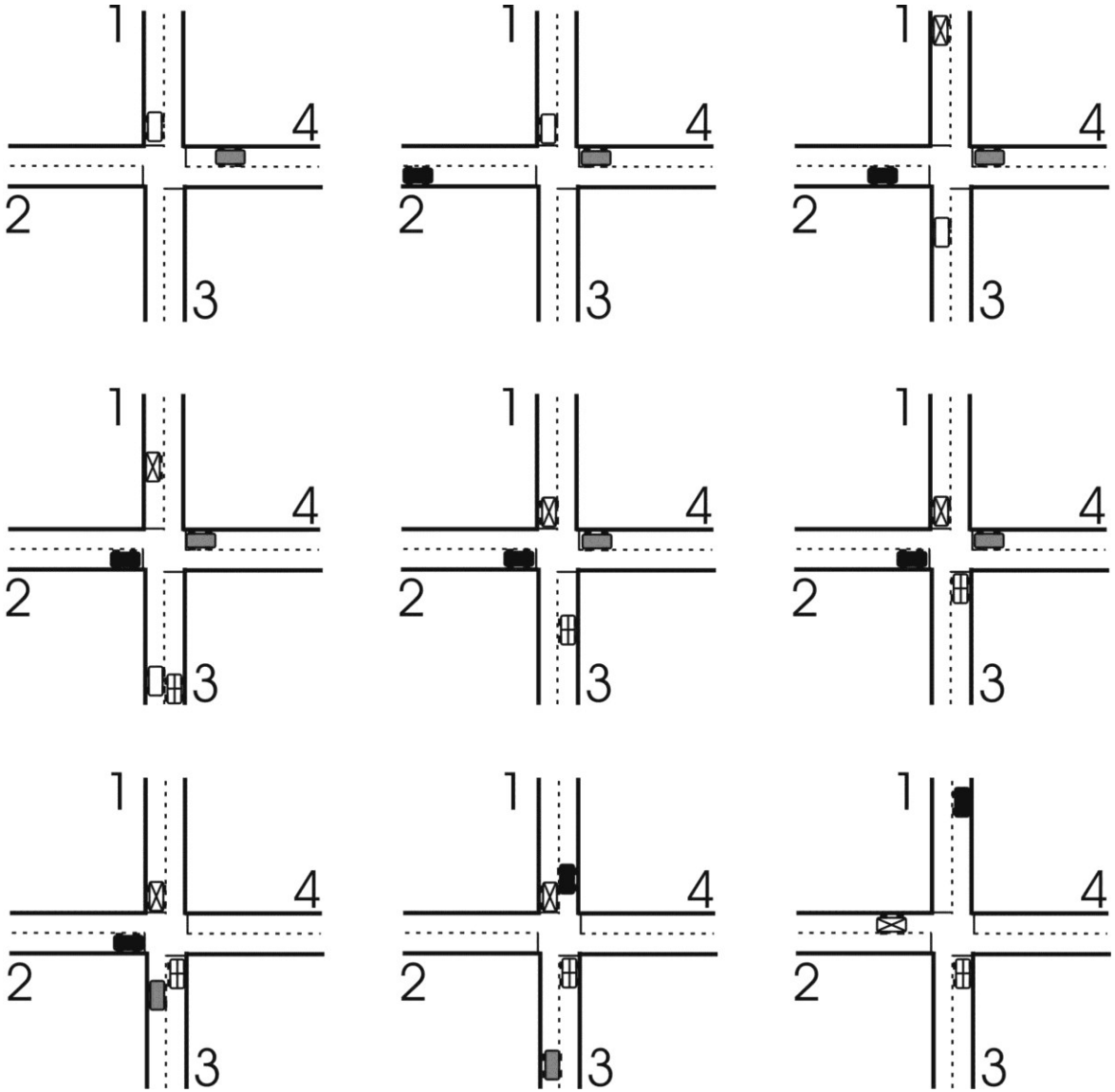
$Q_0 \mid T_0$

$\downarrow$

$U \mid R$

$\downarrow$

Fourway stop



Fourway stop processes

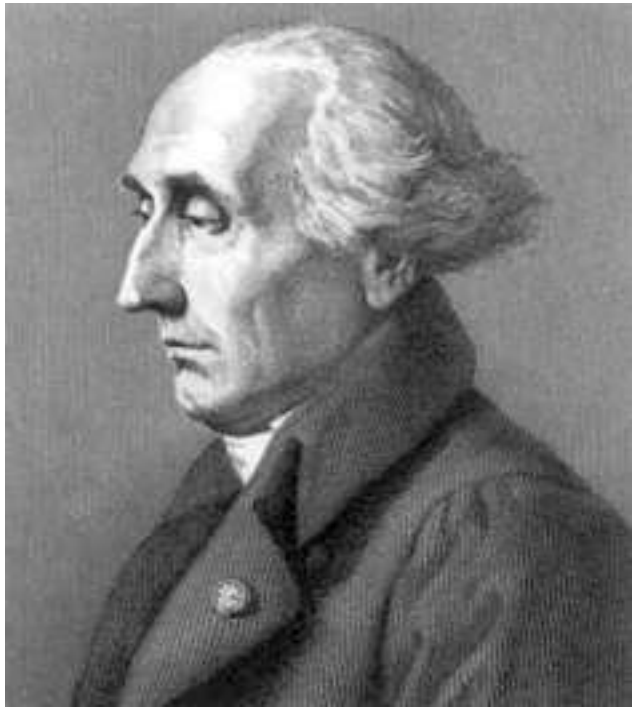
$$X = \sum_i a_i X_i$$

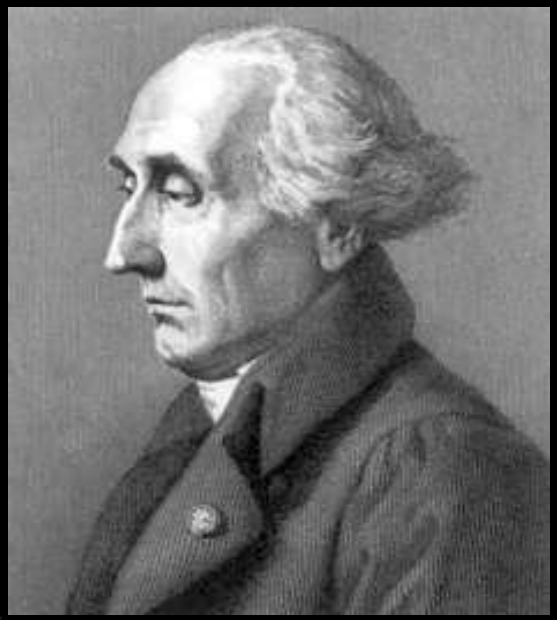
$$X_i = \overline{b_i} X + \sum_{j \neq i} a_j X_{ij}$$

$$X_{ij} = \overline{b_i} X_j + \sum_{k \neq i,j} a_k X_{ijk}$$

$$X_{ijk} = \overline{b_i} X_{jk} + \sum_{l \neq i,j,k} a_l X_{ijkl}$$

$$X_{ijkl} = \overline{b_i} X_{jkl}$$





Leonhard Euler

1707 – 1783

Joseph-Louis Lagrange

1736 – 1813

EULER $\quad S \times T \longrightarrow V$

LAGRANGE $\quad E \times T \longrightarrow V$

includes S

EULER

$$\left\{\begin{array}{l} S \to (T \to V) \\ T \to (S \to V) \end{array}\right\}$$ PURE FIELD

LAGRANGE

$$\left\{\begin{array}{l} T \to (E \to V^*) \\ E \to (T \to V^*) \end{array}\right.$$

- MIXED

- PURE OBJECT

EULER $\quad S \times T \longrightarrow V$

$S \longrightarrow (T \longrightarrow V)$ time series

$T \longrightarrow (S \longrightarrow V)$ snapshots of spatial patterns

LAGRANGE $\quad E \times T \longrightarrow V$

$E \longrightarrow (T \longrightarrow V)$ trajectories

$T \longrightarrow (E \longrightarrow V)$ snapshots of entity patterns

EULER

$$\left\{\begin{array}{l} S \to (T \to V) \\ T \to (S \to V) \end{array}\right\}$$ PURE FIELD

LAGRANGE

$$\left\{\begin{array}{l} T \to (E \to V^*) \\ E \to (T \to V^*) \end{array}\right.$$

- MIXED

- PURE OBJECT

CASE STUDY

PEDESTRIAN MOVEMENT

CHECKPOINT

Eulerian approach

S – position (pt., road seg., area)

T – linear time

V – #people, flow velocity, congestion coeff., ...

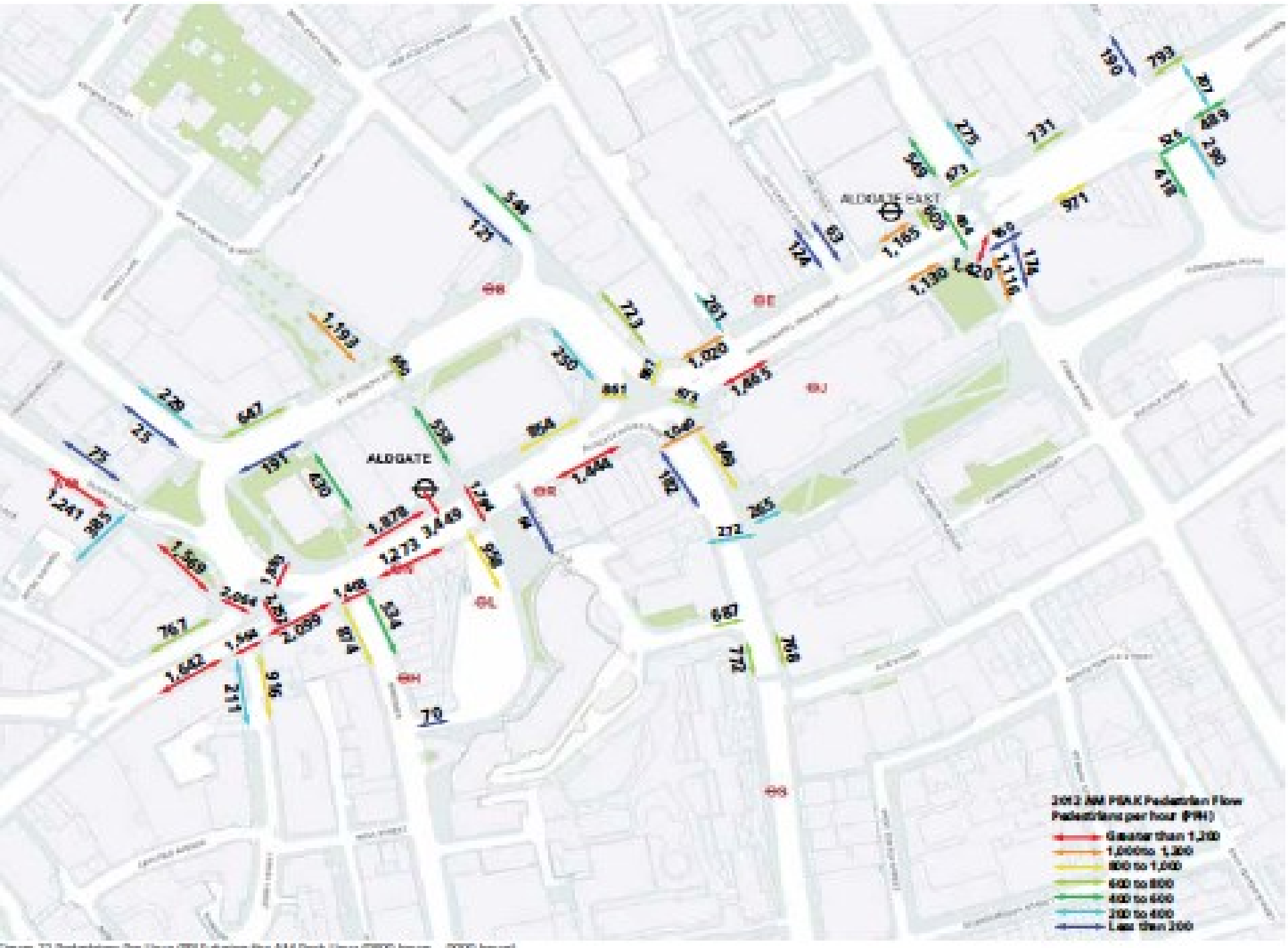


Figure 32 Pedestrians Per Hour (PPH) during the AM Peak Hour (0800 hours - 0900 hours)

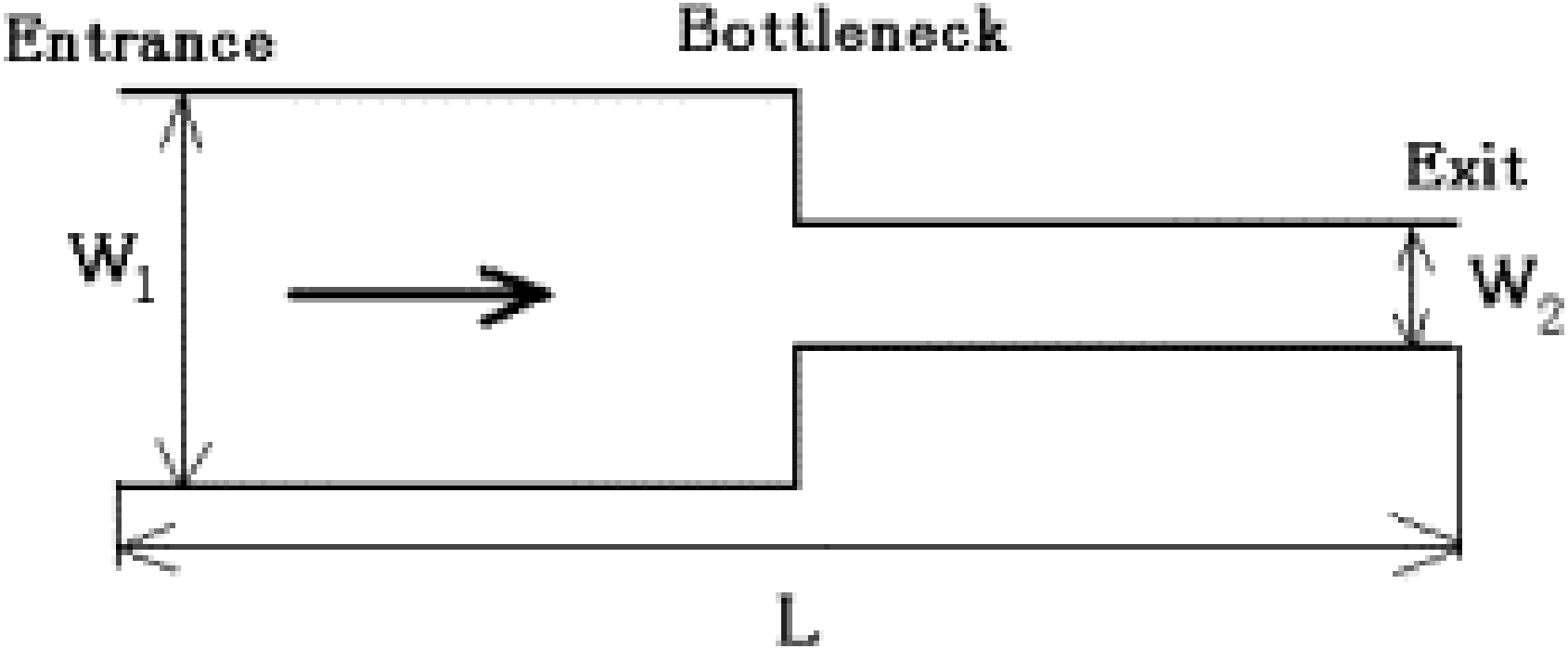


Fig. 1 Schematic illustration of the pedestrian channel flow from the entrance, through a bottleneck, and to the exit. The widths of the left and right parts are W 1 and W 2 . The length is L .

Takashi Nagatani

Dynamical transition and scaling in a mean-field model of pedestrian flow at a bottleneck

Physica A: Statistical Mechanics and its Applications, Volume 300, Issues 3–4, 2001, 558 - 566

http://dx.doi.org/10.1016/S0378-4371(01)00366-1

Flow equation example

ρ density

(u, v) x & y components of velocity

} at point (x, y)

Conservation of pedestrians implies

$$\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial x}(\rho u) + \frac{\partial}{\partial y}(\rho v) = 0$$

Lagrangian approach

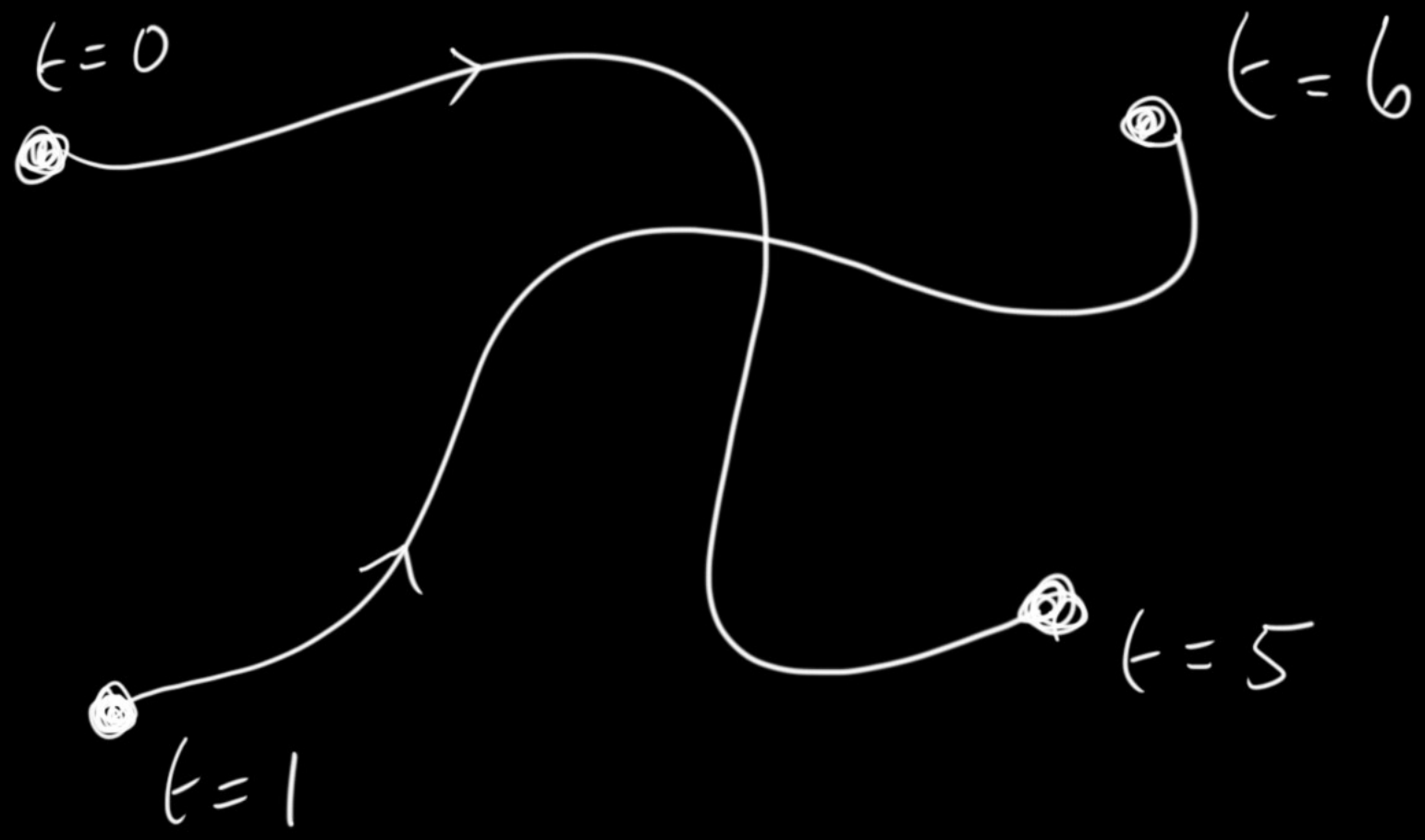
TRAJECTORY

E pedestrians

V^* position

other attributes
e.g. velocity, gender, type

T linear time


t=0
t=6
t=5
t=1

Properties

S-length
T-length
circularity
sinuosity
T-variability
⋮

Binary relations

equality
path equality
similarity

meet
inclusion

leading
⋮

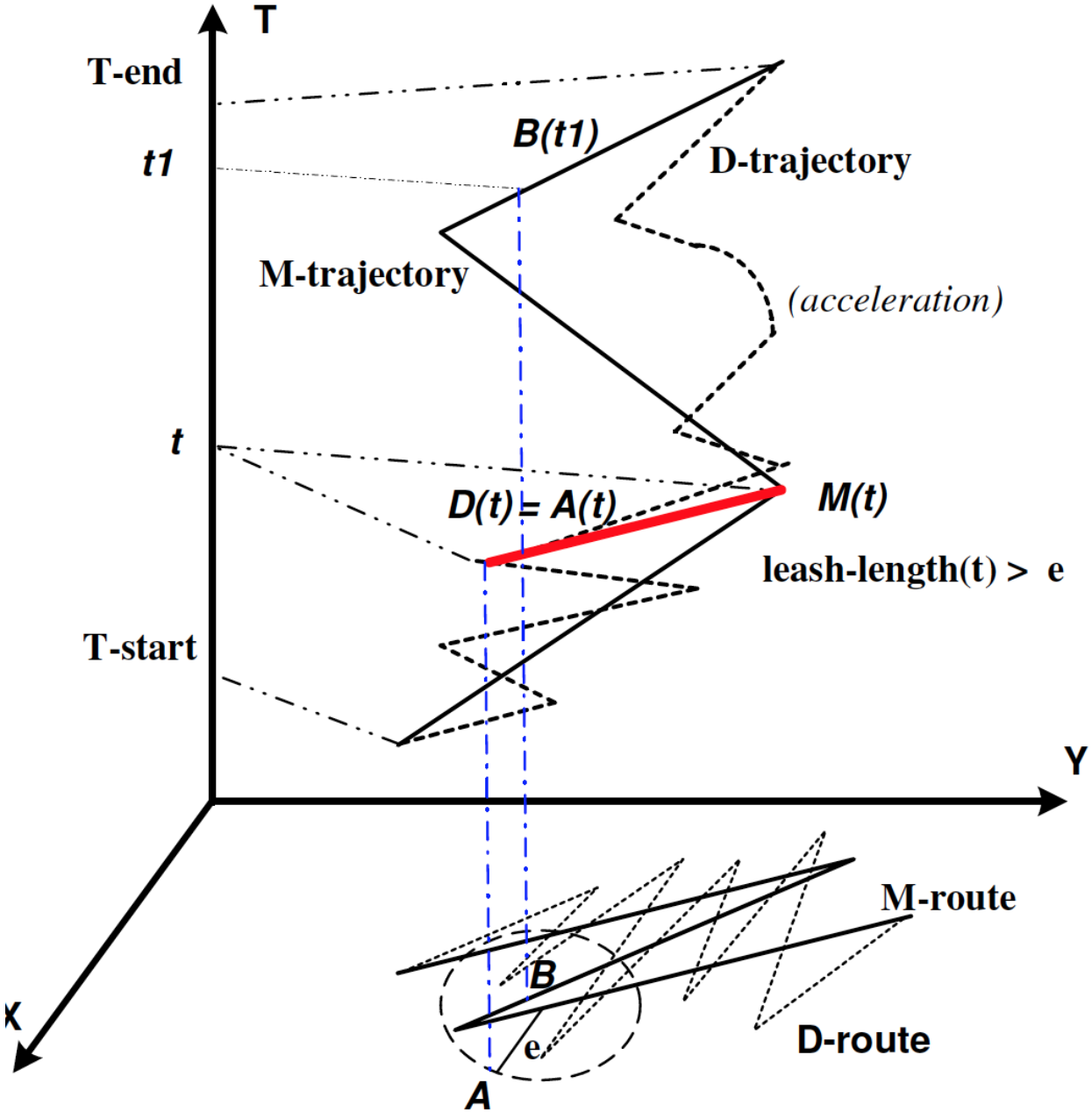


Figure 2: Hausdorff vs. Fréchet distance

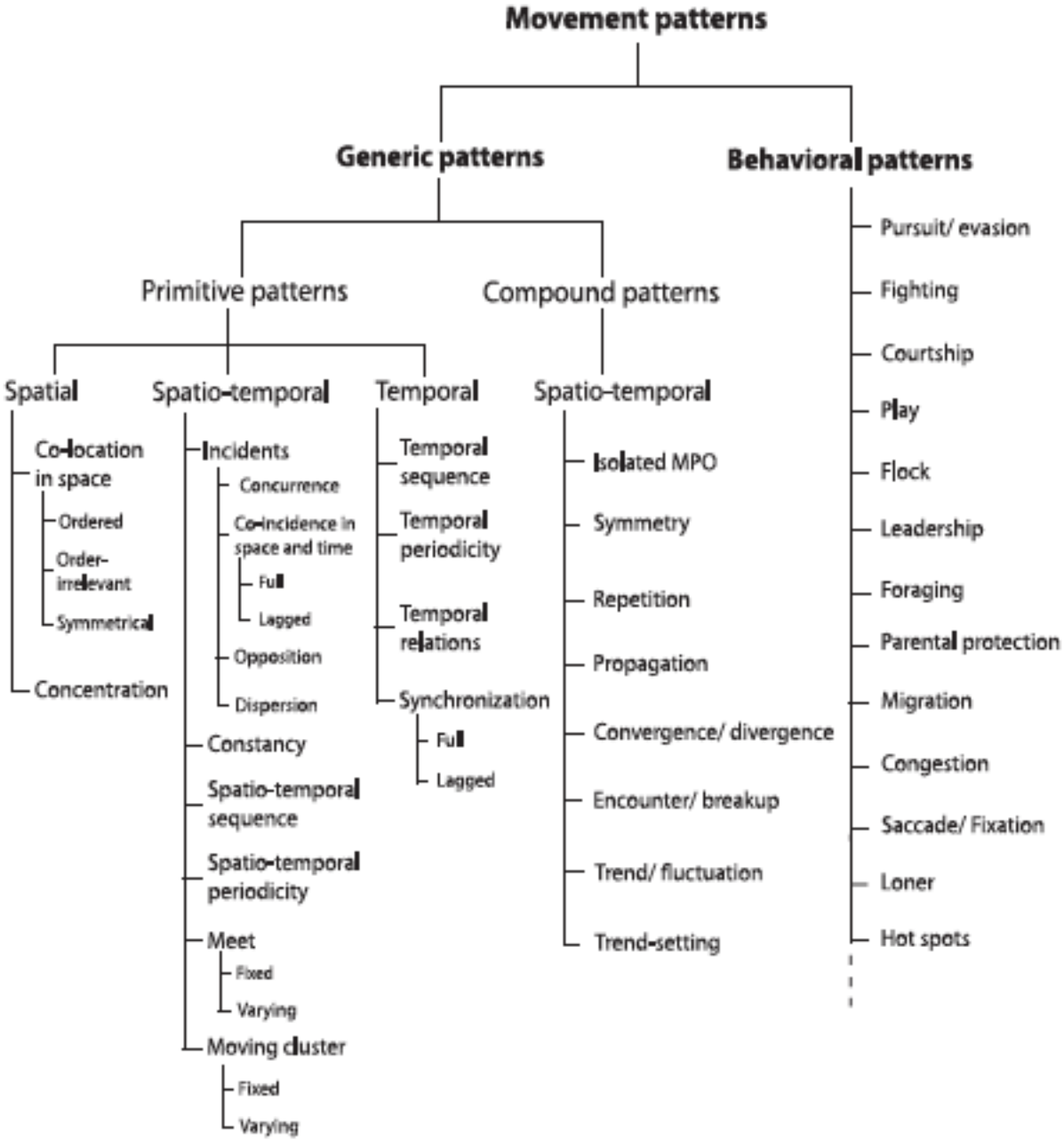


Figure 1 Classification of movement patterns.

$$\text{LAGRANGE} \xleftrightarrow{\;?\;} \text{EULER}$$

EULER

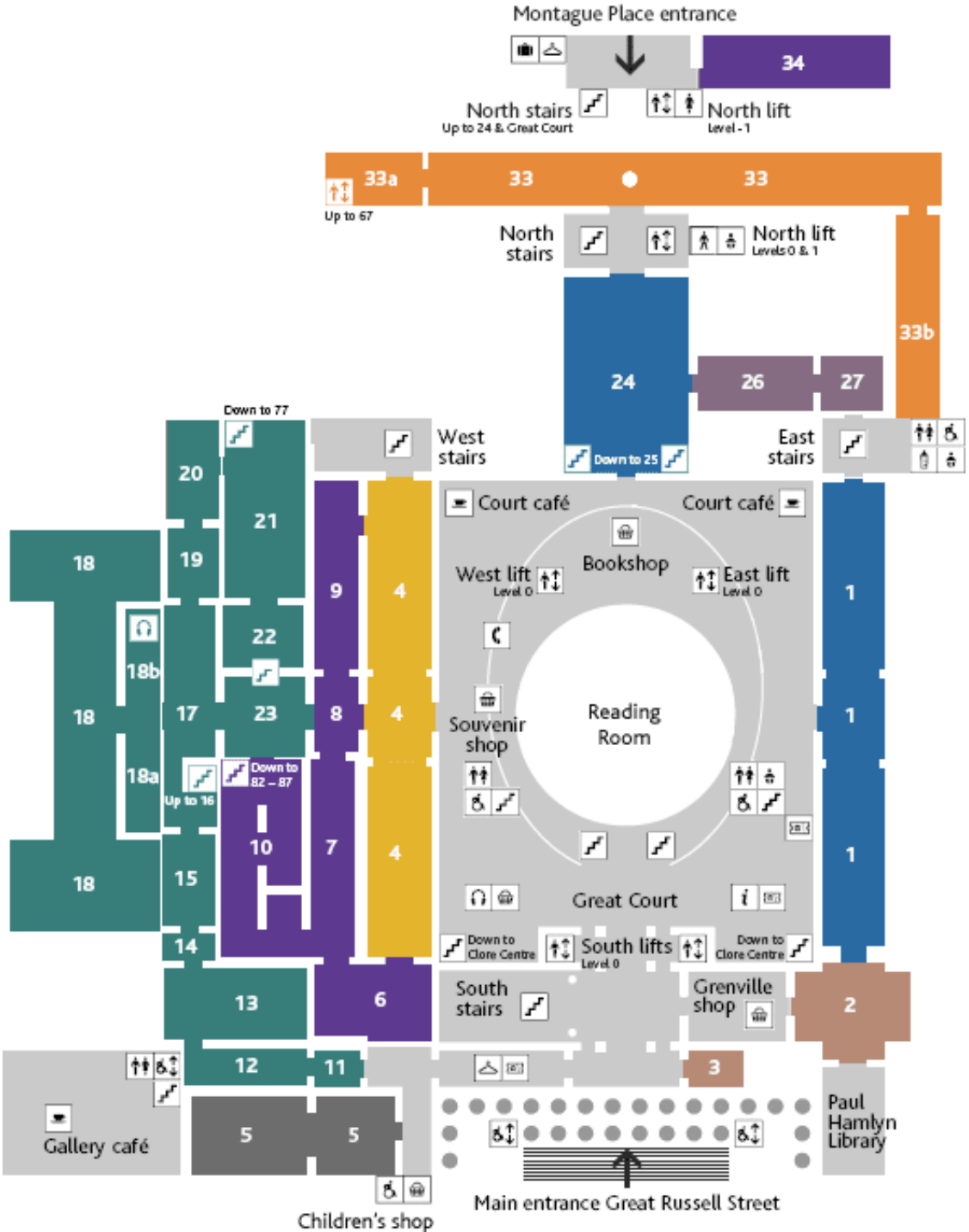
$$\left\{\begin{array}{l} S \to (T \to V) \\ T \to (S \to V) \end{array}\right\}$$ PURE FIELD

LAGRANGE

$$\left\{\begin{array}{l} T \to (E \to V^*) \\ E \to (T \to V^*) \end{array}\right.$$

- MIXED

- PURE OBJECT


Montague Place entrance
34
North stairs
Up to 24 & Great Court
North lift
Level - 1
33a
33
33
Up to 67
North stairs
North lift
Levels 0 & 1
33b
24
26
27
Down to 25
Down to 77
West stairs
East stairs
20
21
18
19
9
4
Court café
Court café
Bookshop
West lift
Level 0
East lift
Level 0
1
18b
22
18
17
23
8
4
Souvenir shop
Reading Room
1
18a
Up to 16
Down to 82 – 87
10
7
4
1
18
15
Great Court
14
Down to Clore Centre
South lifts
Level 0
Down to Clore Centre
13
6
South stairs
Grenville shop
2
12
11
3
Gallery café
5
5
Paul Hamlyn Library
Children's shop
Main entrance Great Russell Street


ATCHO
22
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THANK YOU!