Module 2

SELES Modelling Paradigm

Landscape Events to Navigate Space and Time

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Module 2 Objectives

What you can expect to learn from this module:

- Spatio-temporal state-space and spatio-temporal contexts in SELES
- Landscape events as a meta-model of landscape process
  - Landscape properties: declarative behaviour to navigate through the spatio-temporal state-space to identify contexts in which state is changed

➢ See SELES User Documentation: Part 1

Spatio-temporal contexts

- landscape change arises as the result of feedback between system state and definable *processes* or *entities*
- as agents of landscape change, processes react to and modify the landscape state in *spatio-temporal contexts*
- a spatio-temporal context is the set of information (i.e. state variables) available at a *particular time* and *place*
- contexts provide a general hierarchical framework for describing landscape dynamics

Spatio-temporal contexts

SELES is a language for:

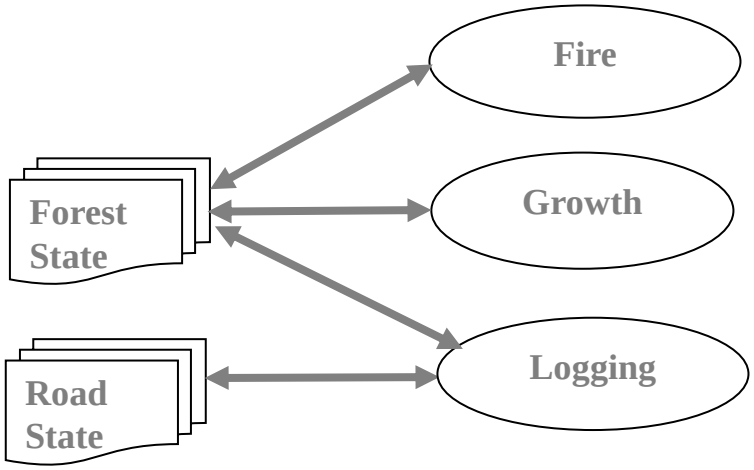
- creating a spatio-temporal state-space
- defining behaviours to navigate through contexts in this state-space, and
- specifying state changes in those contexts

Structure of SELES Dynamic Models

- Feedback between pattern and process

  pattern: state of system
  - Variables

  process: agents of change
  - landscape events
  - no direct interaction



- State-space
  - set of variables and processes *and direct causal links*

Defining a Spatio-temporal State-space

Spatial dimension

- **extent, resolution (grain)**

Temporal dimension

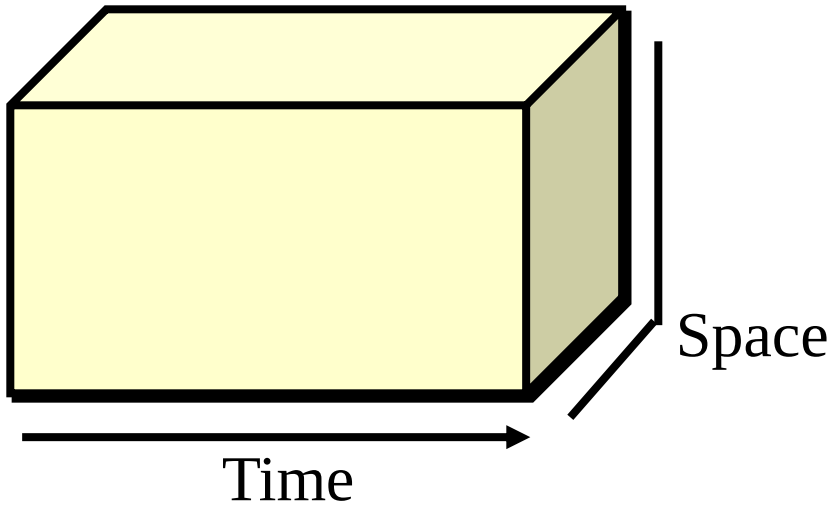
- **horizon, resolution**

State

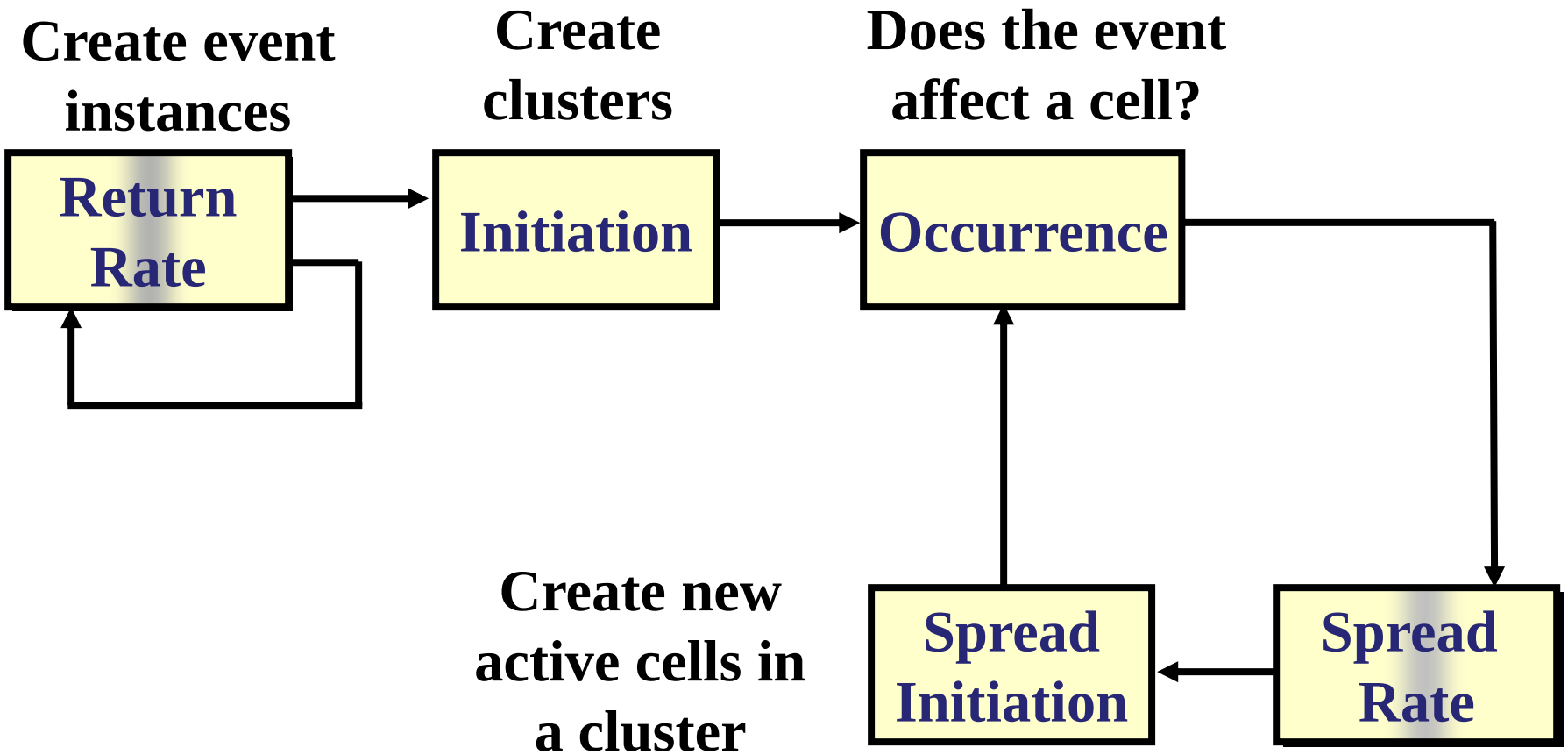
- **variables and constants**
- **spatial and global**

Agents of change

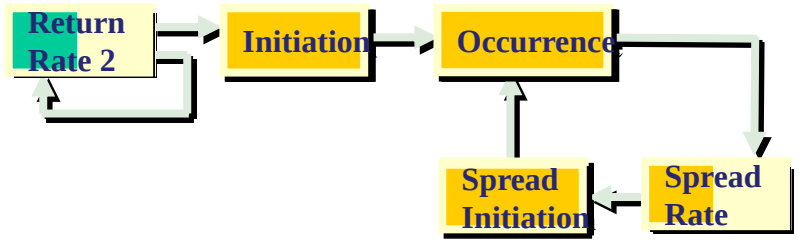
- **landscape events, landscape agents**

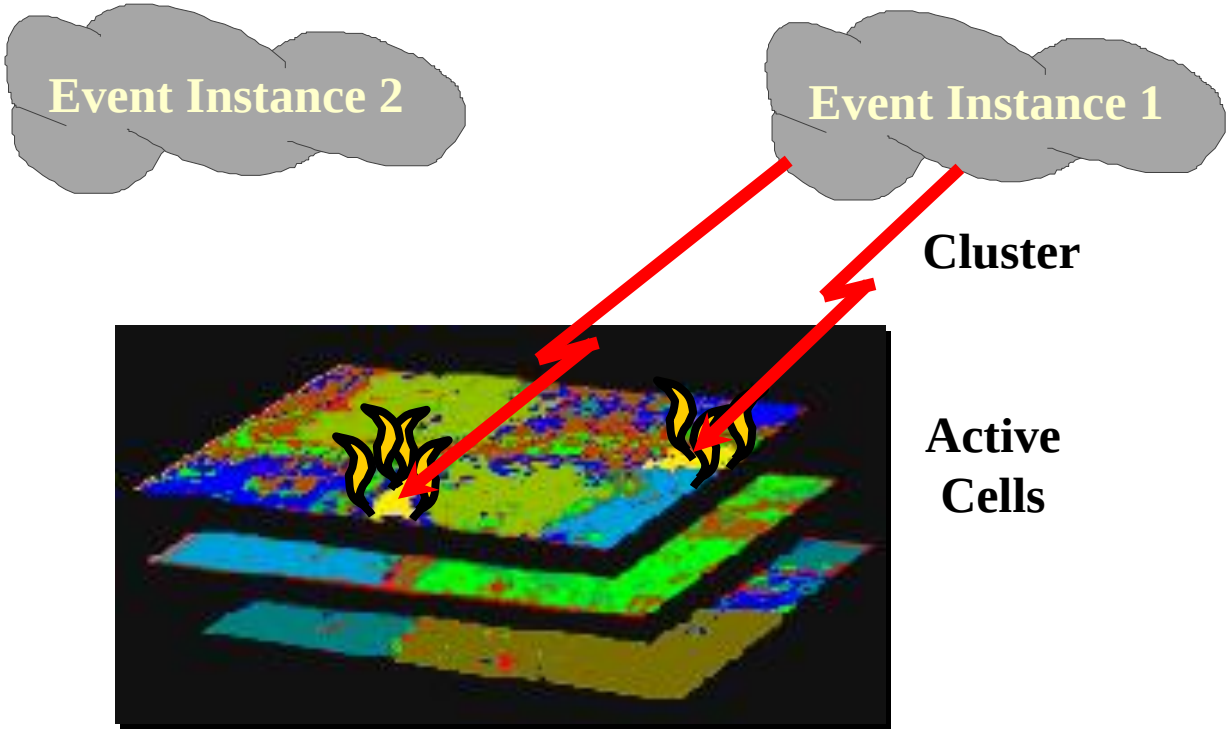


Navigating Contexts via Landscape Events

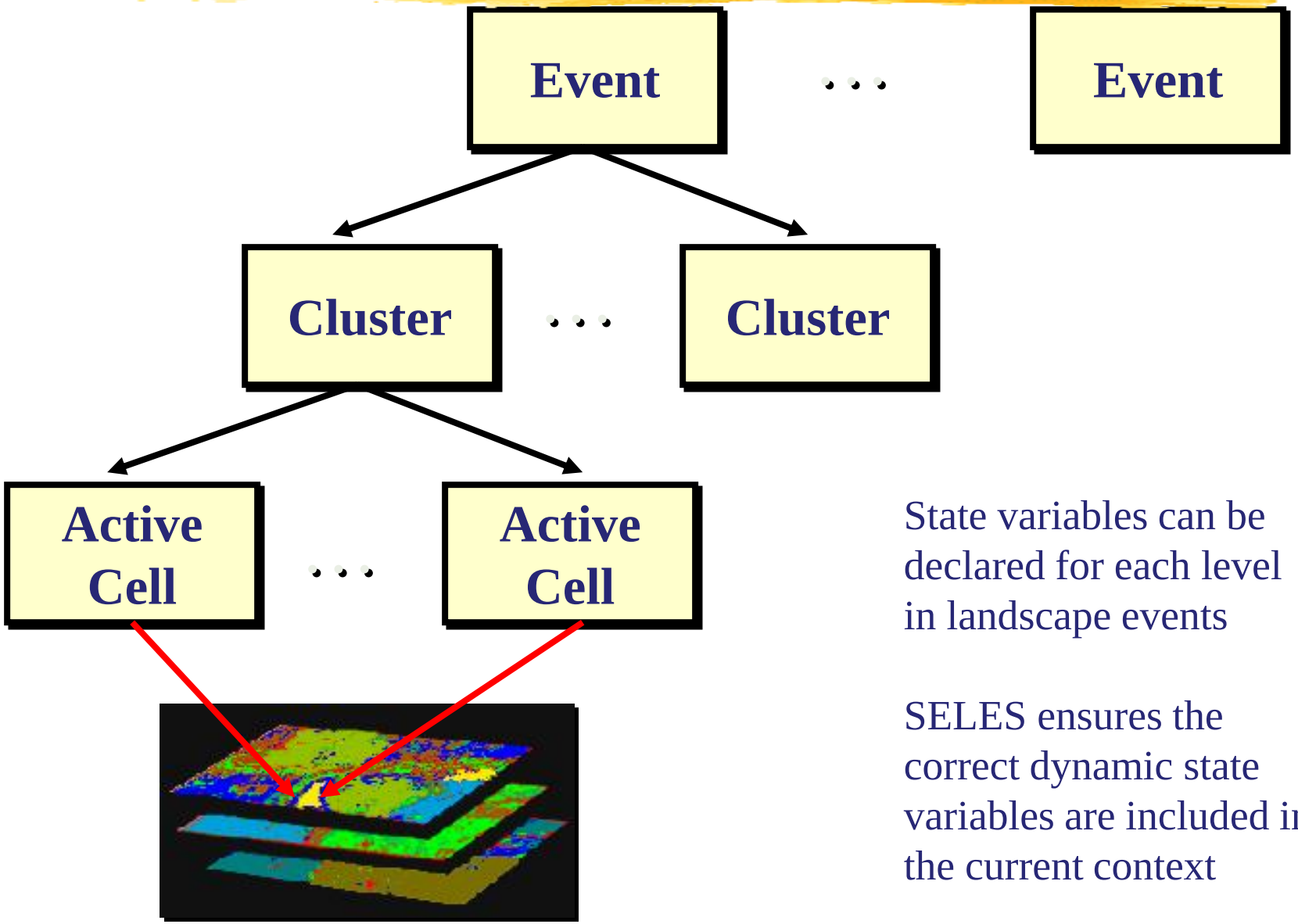


Event Behaviour





Hierarchical Dynamic State



State variables can be declared for each level in landscape events

SELES ensures the correct dynamic state variables are included in the current context

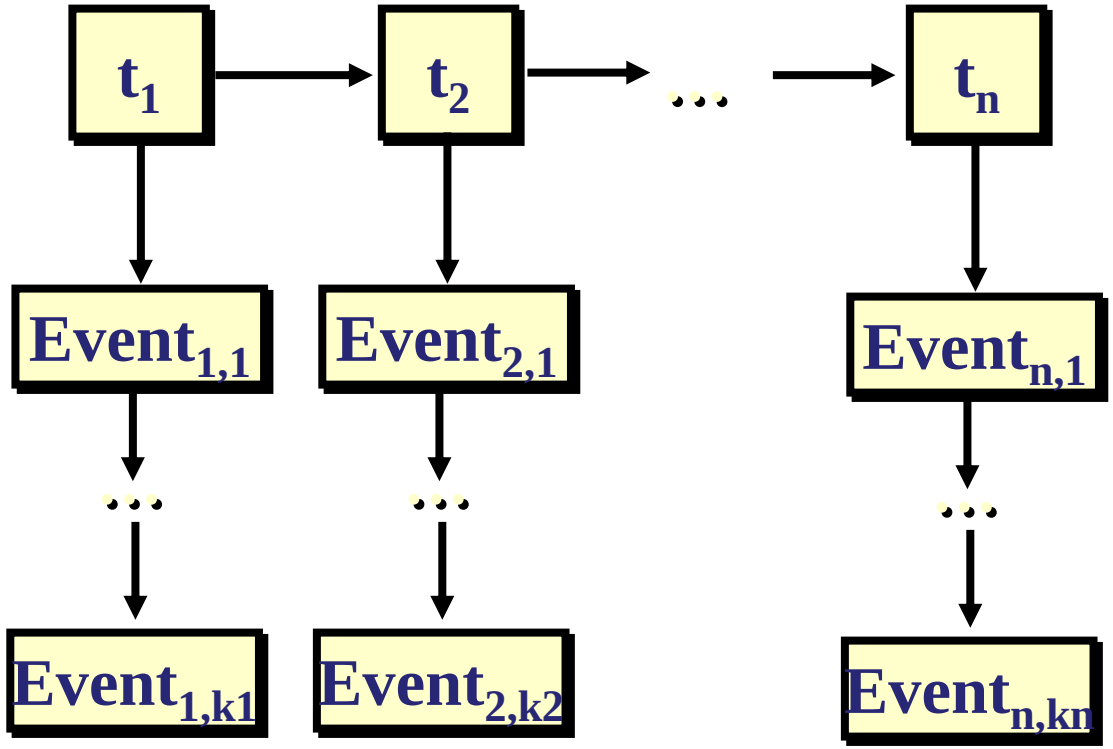
Event Queue

Time at which to process events

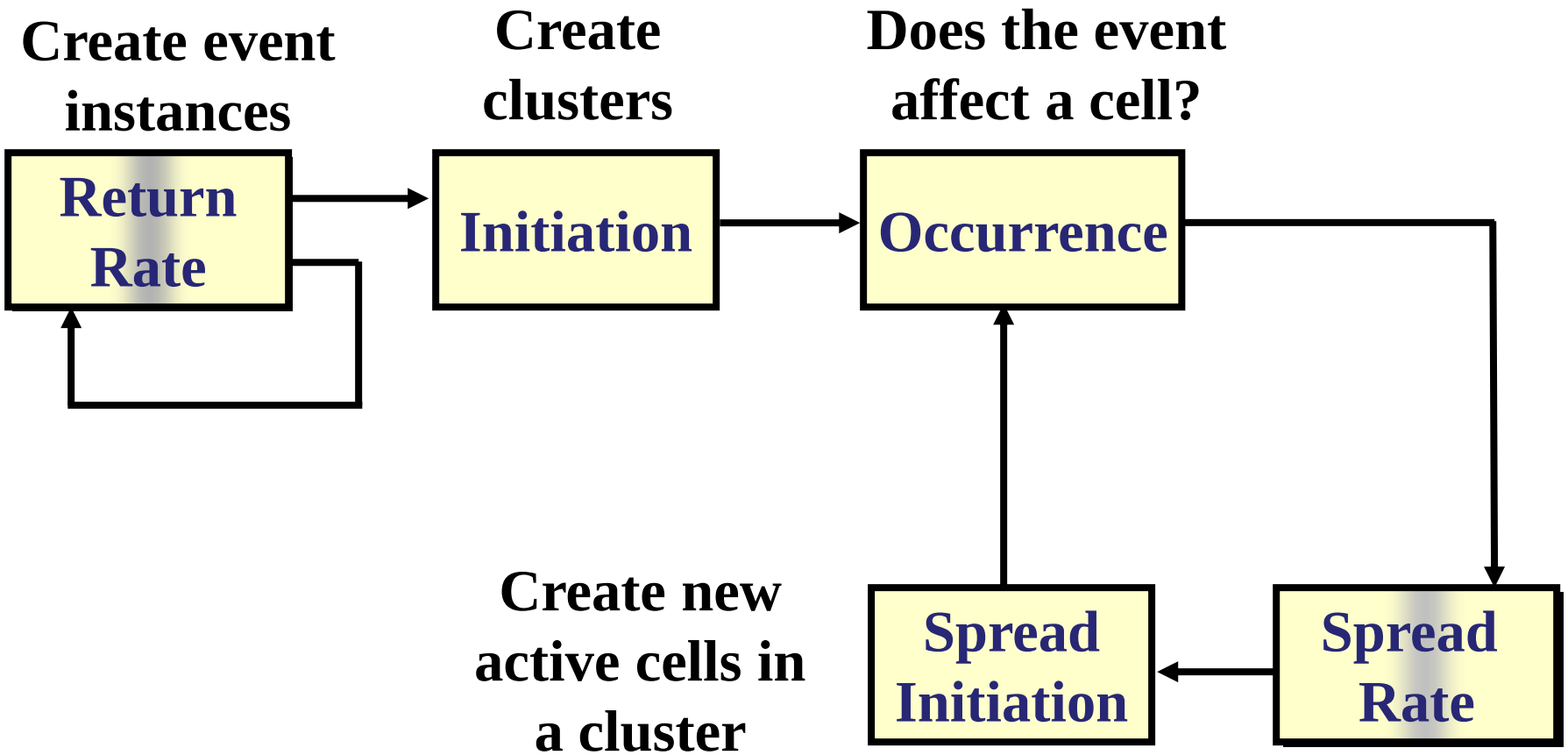
- New events are inserted by time

Event list

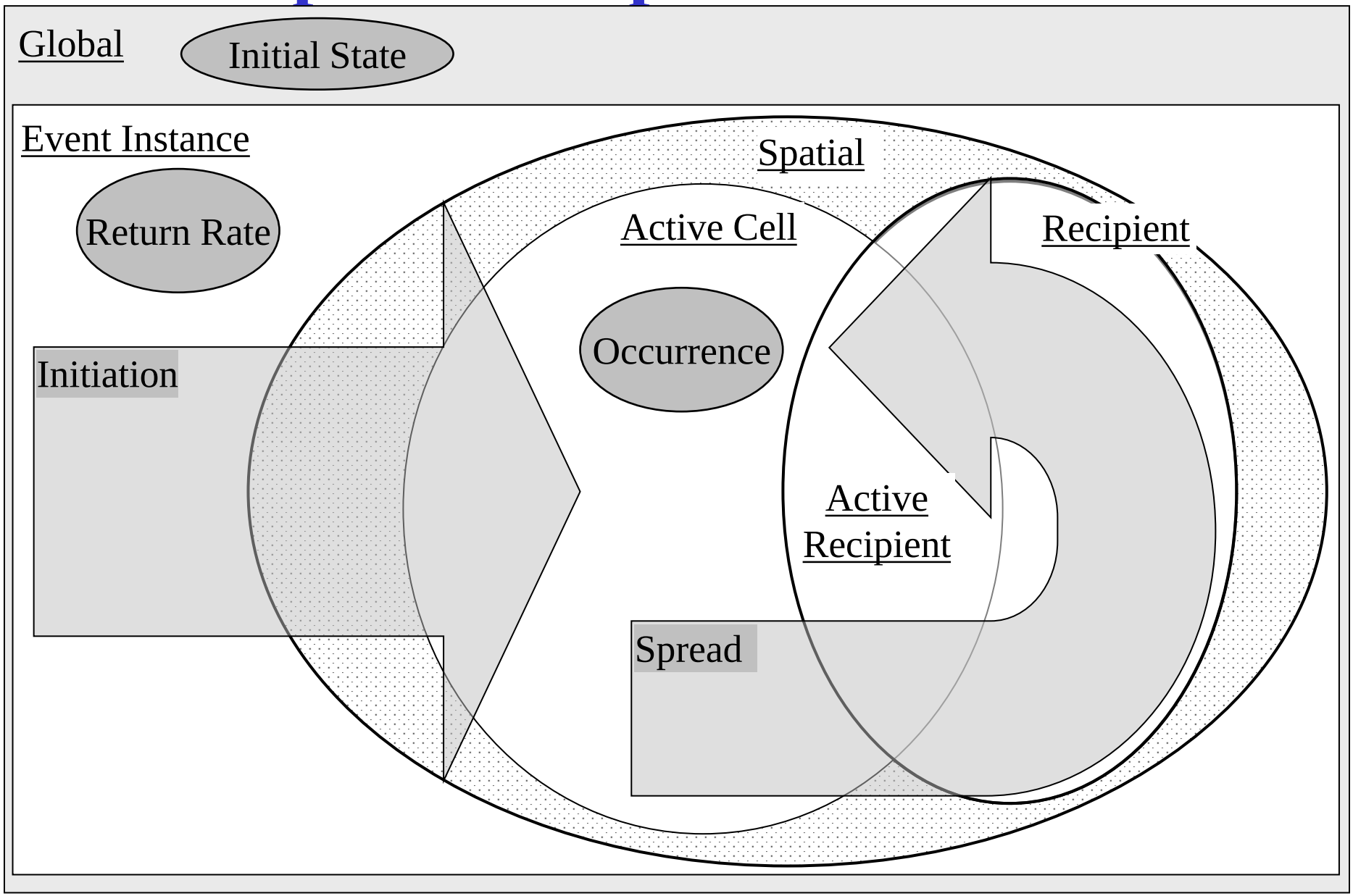
- Events may include landscape events, spreading active cells, schedule output, etc.



Navigating Contexts via Landscape Events



Spatio-Temporal Contexts



Types of Spatio-temporal Contexts

Global: not in a spatial location, no events started

- variables: global, spatial (as entire rasters)

Event Instance: not in a spatial location, event started

- variables: subset of global + event variables

Spatial: in a spatial location

- variables: subset of event instance, except spatial in a grid cell

Active Cell: in an activated cell

- variables: subset of spatial + cluster and active cell variables

Recipient: *potential* recipient of spread from an active cell

- variables: subset of spatial + cluster + location and active cell variables of spreading cell

Active Recipient: cell activated via spread

- variables: subset of active cell (for newly activated recipient) and recipient (location and active cell variables of spreading cell)

Types of Spatio-temporal Contexts

How do I know which context the model is in at any given point?

- SELES will always be in the *current* context (i.e. at the current time, in the current cell, if spatial, and in the current event and cluster if active)
- SELES makes the correct variables available for each context
- To understand SELES, it is important let go of linear, step-by-step procedural thinking and to think declaratively.

Landscape events are defined declaratively by their properties:

- each property is evaluated in the *operating context* (which depends on when and where a landscape reached the property)
- The result of the property, called its *consequence*, may lead to one or more other contexts that may be later in time or in different spatial locations) – the *consequent* contexts

Landscape Event Properties

Properties of landscape events are defined using a common template:

Preliminary expressions

Main Expression

Consequent expressions

- The main Expression: value drives property behaviour (i.e. defines how the property may change contexts)
- Expression are used to specify state changes, such as:

  variable = expression

  - The preliminary expressions and main expression are evaluated in the same context (*operating context*)
  - The consequent expressions are evaluated in zero or more different contexts arising from the property (*consequent context)*
  - Preliminary and consequent expressions are optional

Landscape Event Properties

startup and initiation of active cells

Initial State	Number of initial instances of the event
Return Time	Interval of time between successive instances of the event
Event Location	The set of cells in which the event can potentially initiate
Number of Clusters	The number of cells in which the event will initiate
Probability of Initiation	The relative or absolute probability that the event will initiate in a particular cell
Transitions	Whether the event occurs in a cell or not

Initial State

- Default: 1
- Operating context: global
  - Evaluated once at simulation startup
- Result:
  - Number of instances to create
- Consequent context: event instance
  - For each instance created

Spatio-Temporal Contexts

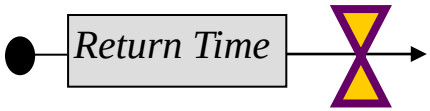
Return Time

- Default: 0 (once at time 0)
- Operating context: event instance
  - at time when instance is created
- Result:
  - time step before instance is processed
- Consequent context: event instance
  - at time when instance is processed

Spatio-Temporal Contexts

Global

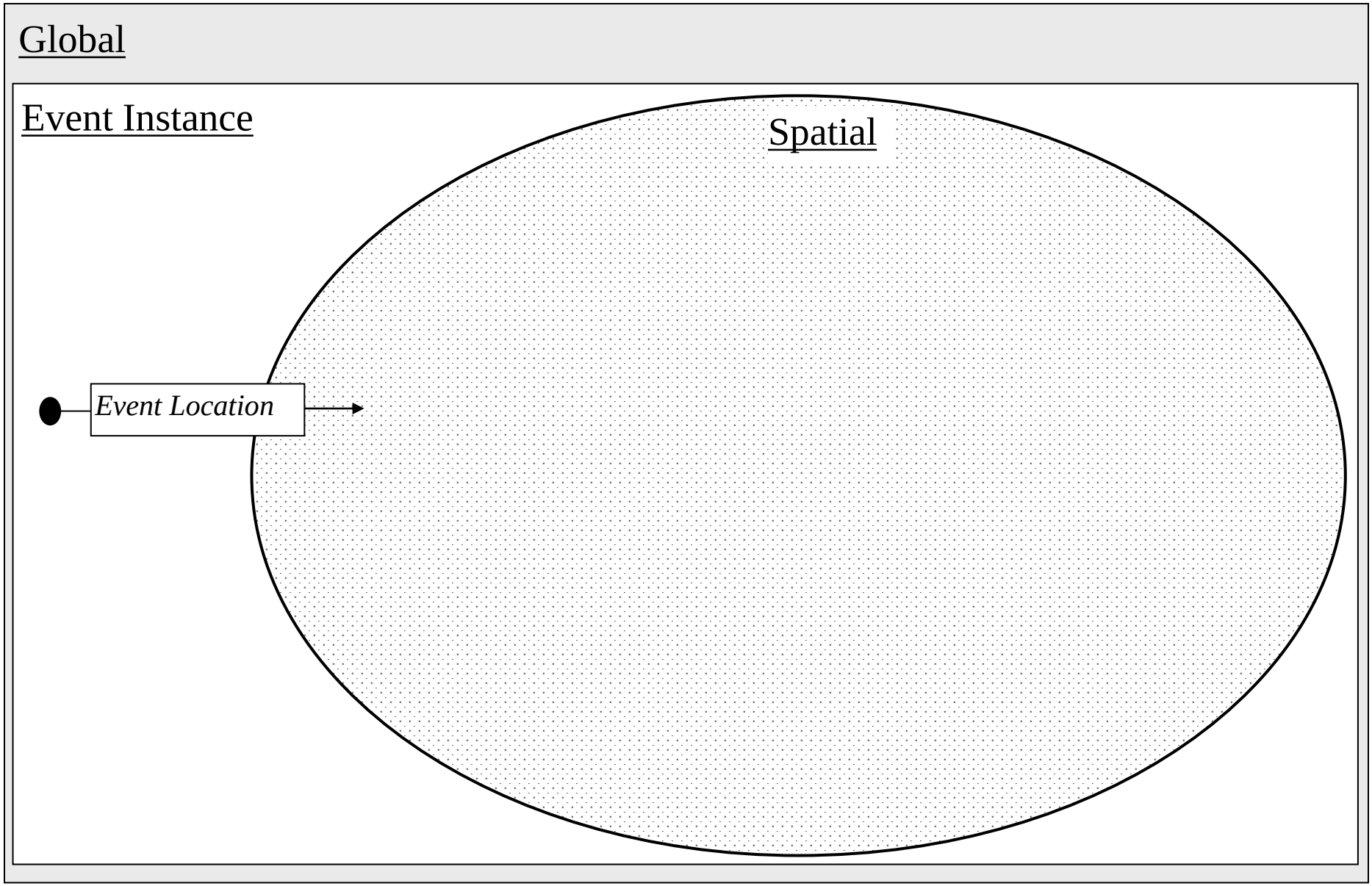
Event Instance



Event Location

- Default: whole map
- Operating context: event instance
  - same as consequence of Return Time
- Result:
  - region in which event can *potentially* initiate
- Consequent context: spatial
  - each cell in the region

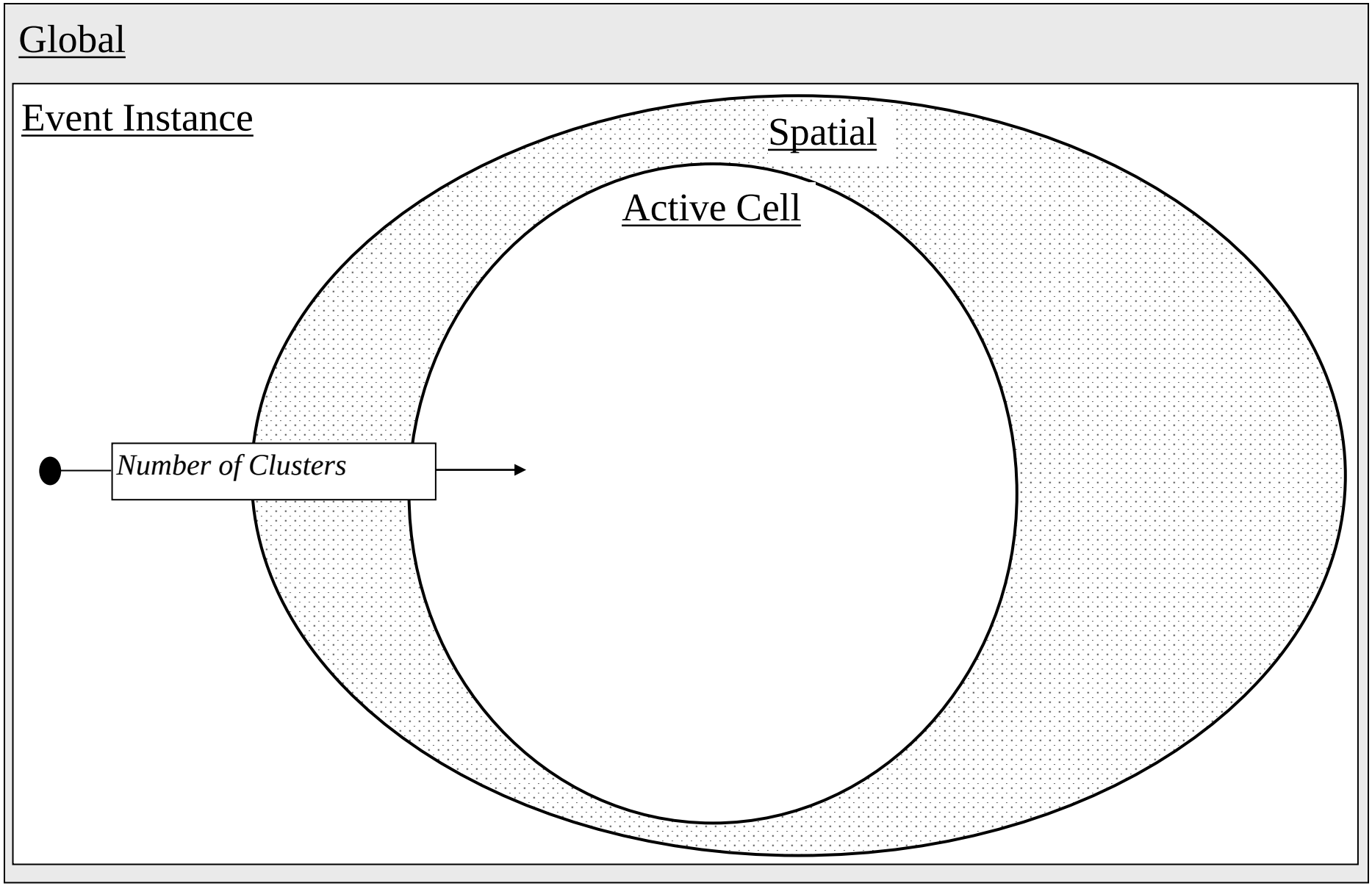
Spatio-Temporal Contexts



Number of Clusters

- Default: undefined (-1)
- Operating context: event instance
  - same as consequence of Return Time
- Result:
  - Number of clusters to initiate
- Consequent context: active cell
  - each cluster, in location of first active cell

Spatio-Temporal Contexts



Number of Clusters

unknown, but limited number of clusters

- Default: predetermined or undefined (emergent)
- Option:

```
NUMCLUSTERS = WHILE condition
```

  - initiate new clusters as long as *condition* holds
  - works best with sequenced clusters

Number of Clusters

with replacement

- Default: pick unique cells (without replacement)
- Option:

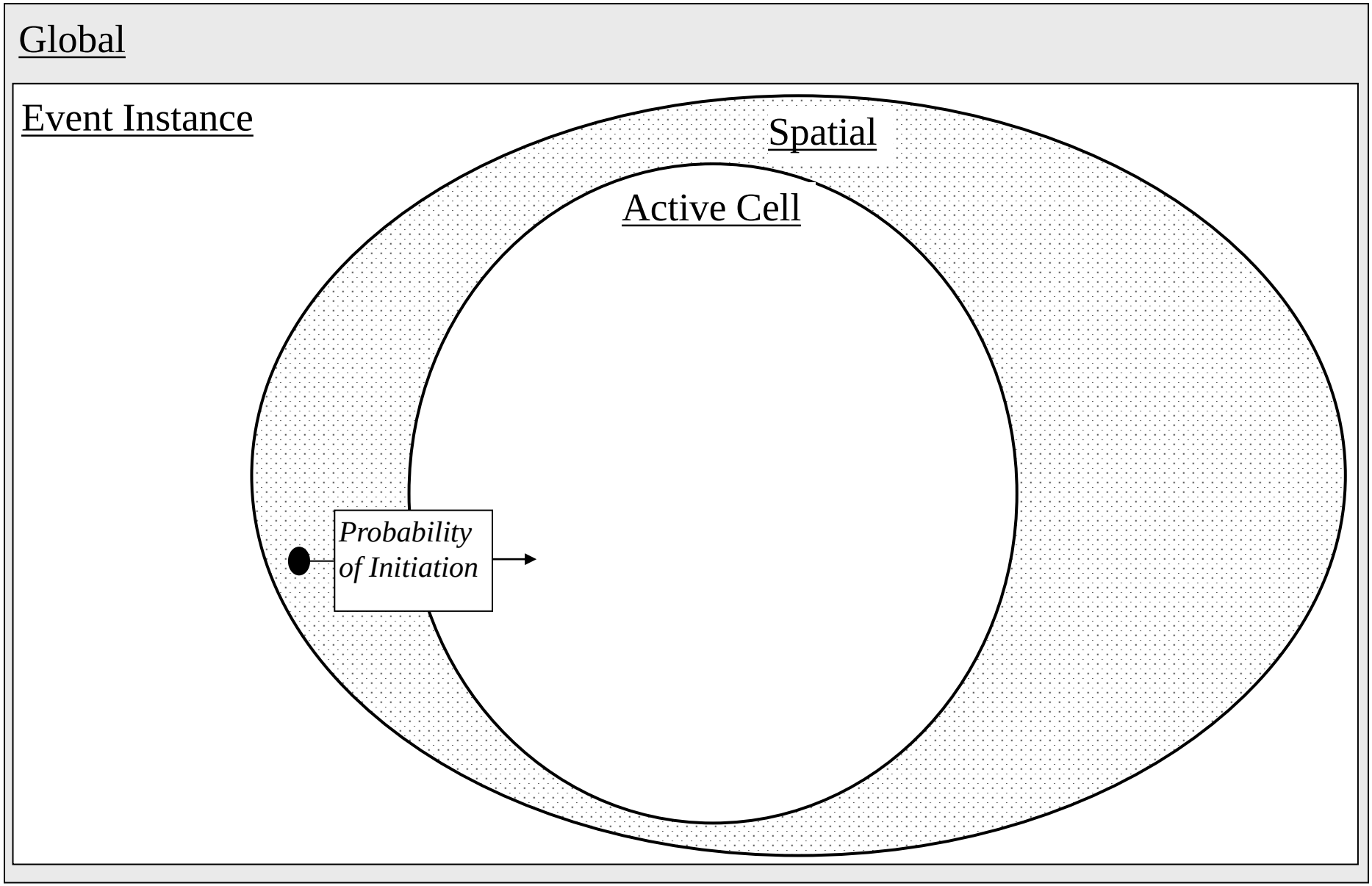
```
NUMCLUSTERS WITH REPLACEMENT
    NUMCLUSTERS = …
ENDNC
```

  - Allows the more than once cluster to initiate in a given cell

Probability of Initiation

- Default: 1 (100%)
- Operating context: spatial
  - each cell in Event Location region
- Result:
  - probability for event to select cell for initiation
- Consequent context: active cell
  - each cluster, in location of first active cell

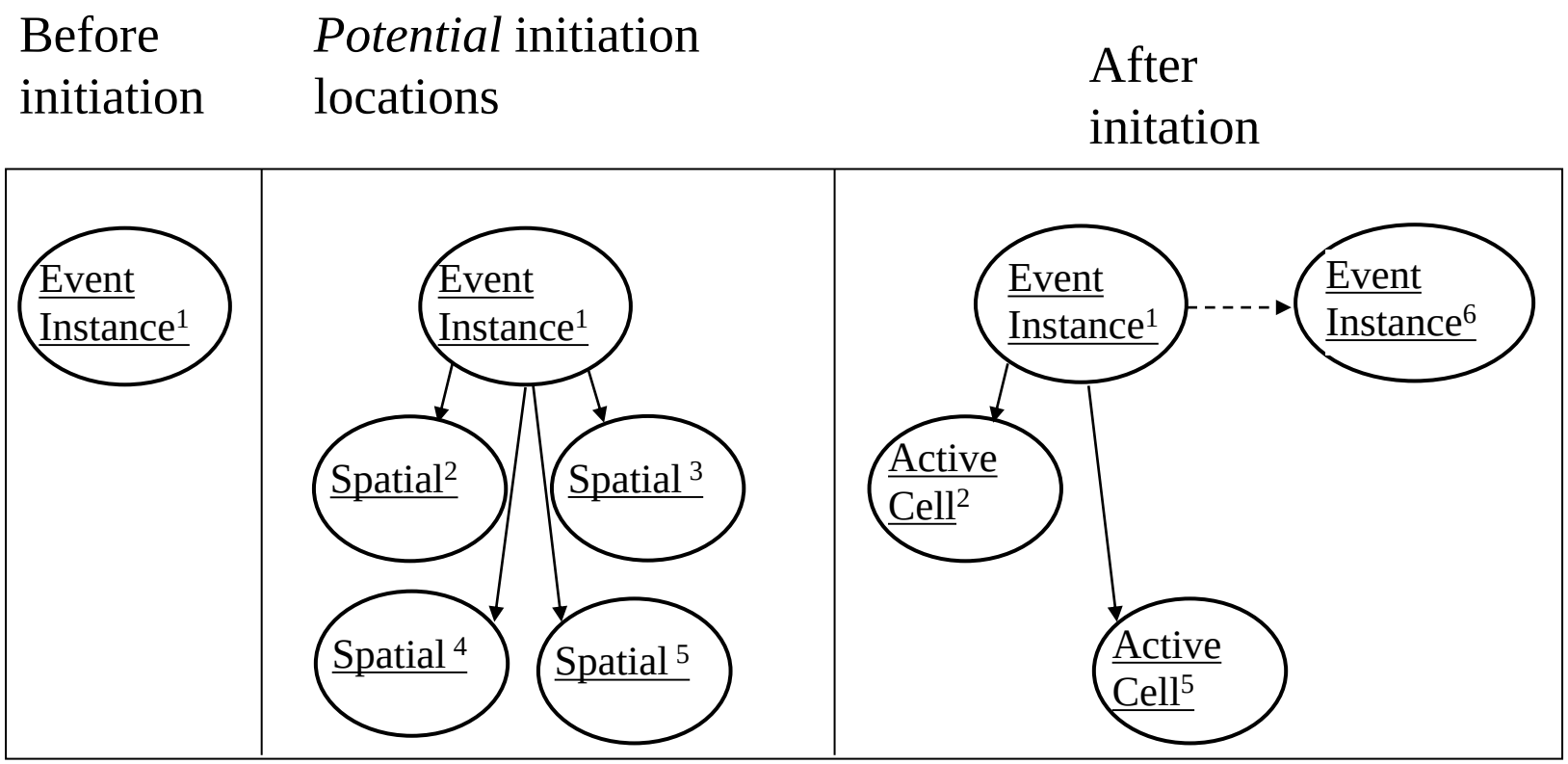
Spatio-Temporal Contexts



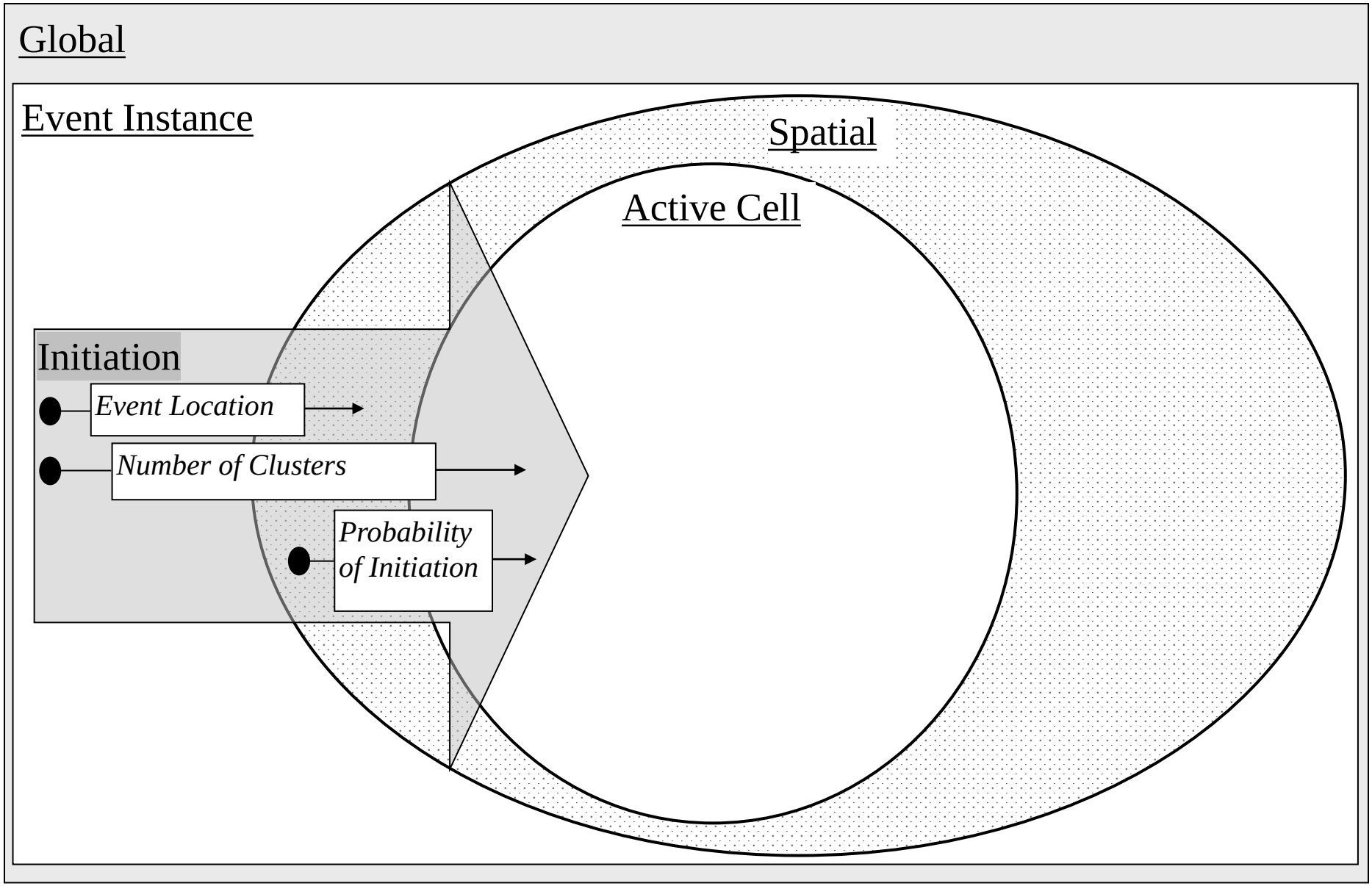
Event Initiation

	ProbInit NOT specified	*ProbInit* specified
NumClusters NOT specified	Initiate in every cell defined by *Event Location*	*ProbInit* is an absolute probability
NumClusters specified	Initiate in *NumClusters* randomly selected cells	Initiate in *NumClusters* cells selected using *ProbInit* as a relative probability

Event Initiation



Spatio-Temporal Contexts



Probability of Initiation

process in sorted order

- Default: probabilistic
- Option:

```
PROBINIT ORDERED
   PROBINIT = …
ENDPI
```

  - Process cells in decreasing order according to value of PROBINIT

Probability of Initiation

process in random order

- Default: evaluate from bottom left to top right (but don't count on it if order matters)
- Option:

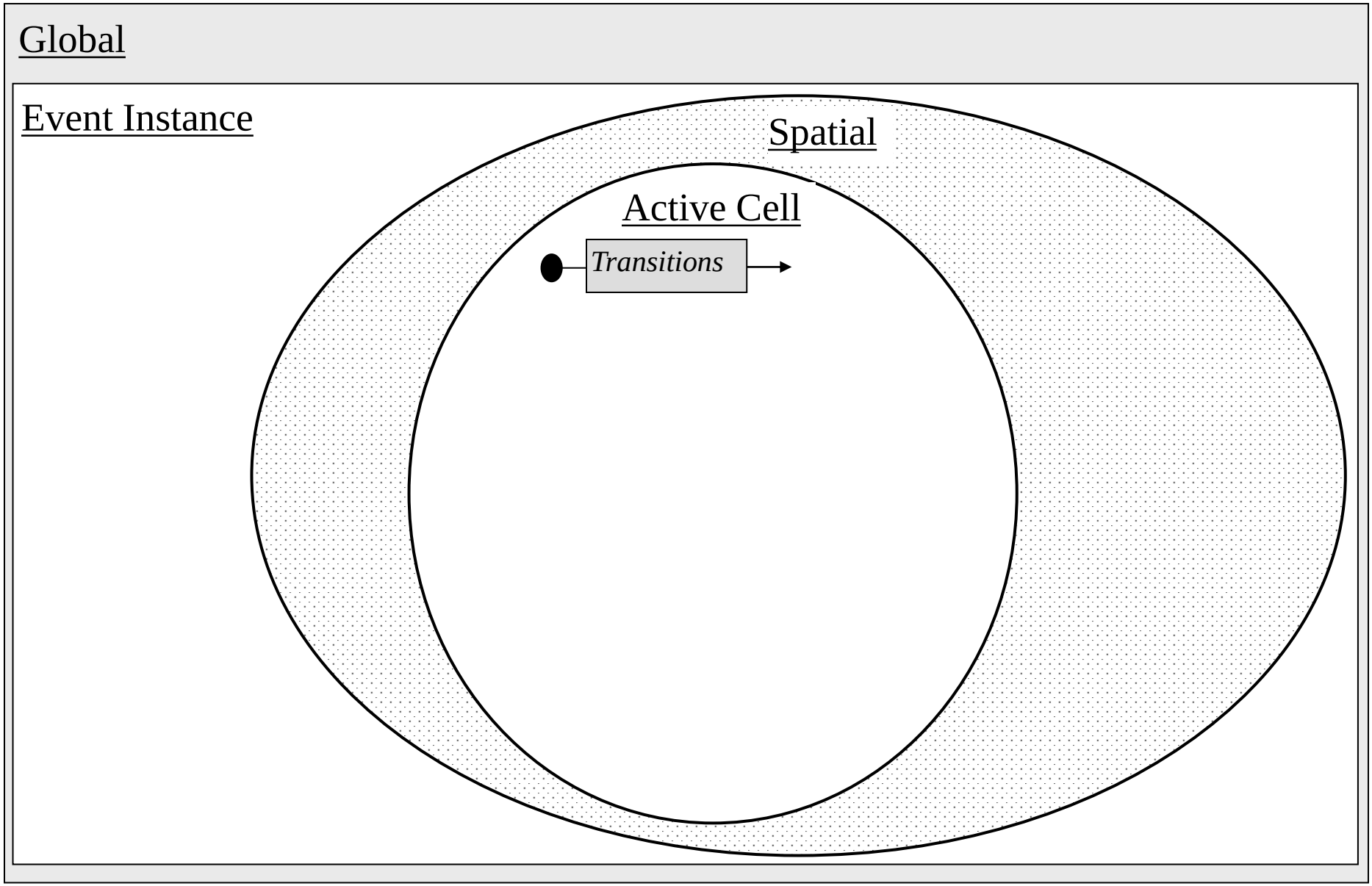
```
PROBINIT RANDOM
    PROBINIT = …
ENDPI
```

  - Process cells in random order

Transitions

- Default: TRUE
- Operating context: active cell
  - an active cell where event hasn't yet *occurred*
- Result:
  - whether or not event occurs
- Consequent context: active cell
  - an active cell for which event *occurred*

Spatio-Temporal Contexts



Landscape Event Properties

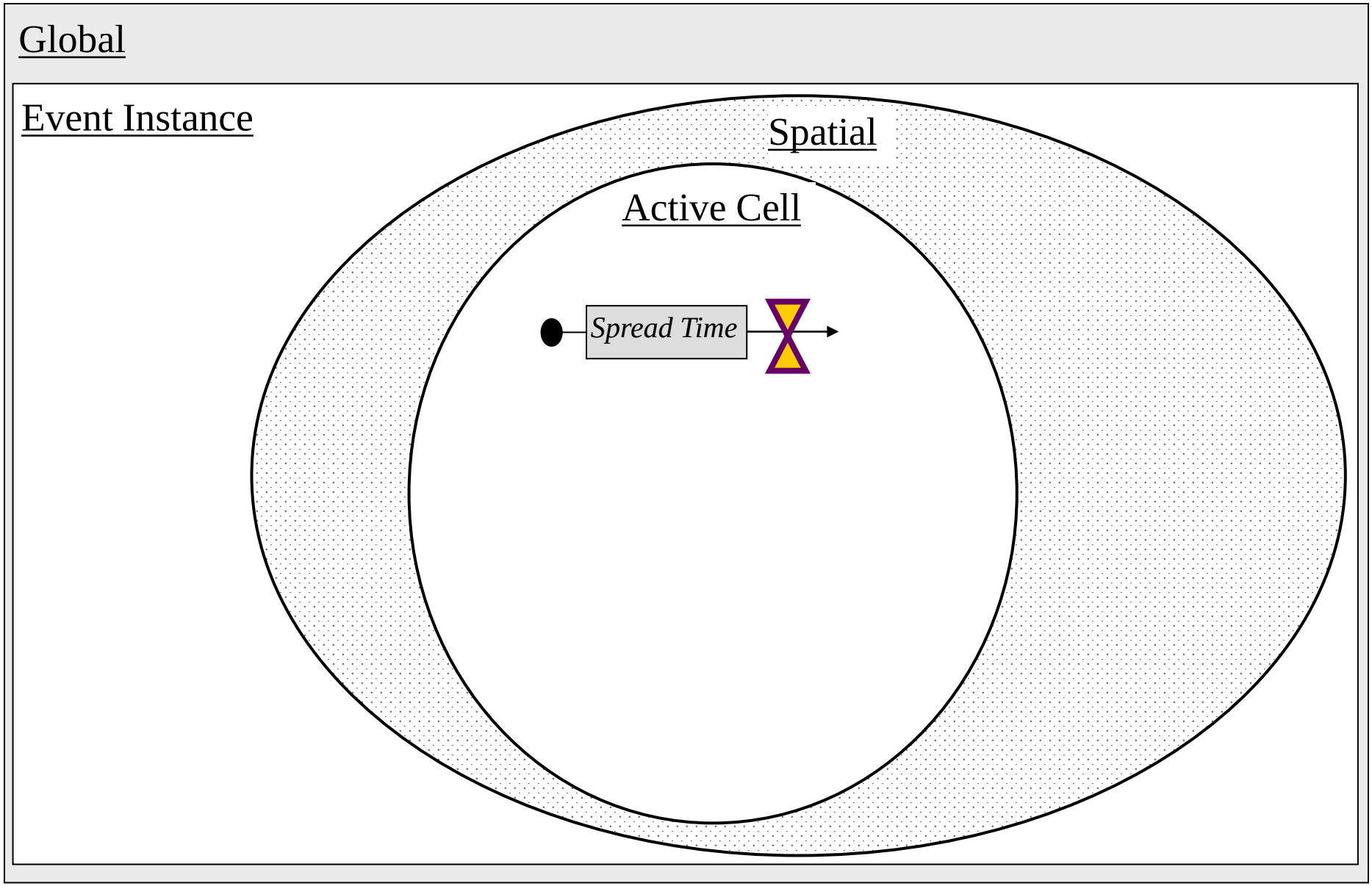
spread from an active cell

Spread Time	Interval of time required for an event to spread from the current cell to its neighbours.
Spread Location	The set of cells to which an event can potentially spread from a cell
Number of Spread Recipients	The number of cells to which the event will spread from an affected cell
Probability of Spread	The absolute or relative probability that the event will spread to a particular cell

Spread Time

- Default: no spread
- Operating context: active cell
  - at time of an active cell for which event just *occurred*
- Result:
  - time step before spread from cell is processed
- Consequent context: active cell
  - at time of spreading, *after* spreading has been processed (just prior to termination)

Spatio-Temporal Contexts



Sequenced Clusters

- Default: simultaneous spread
- Option:
  - spread a cluster completely before initiating subsequent cluster

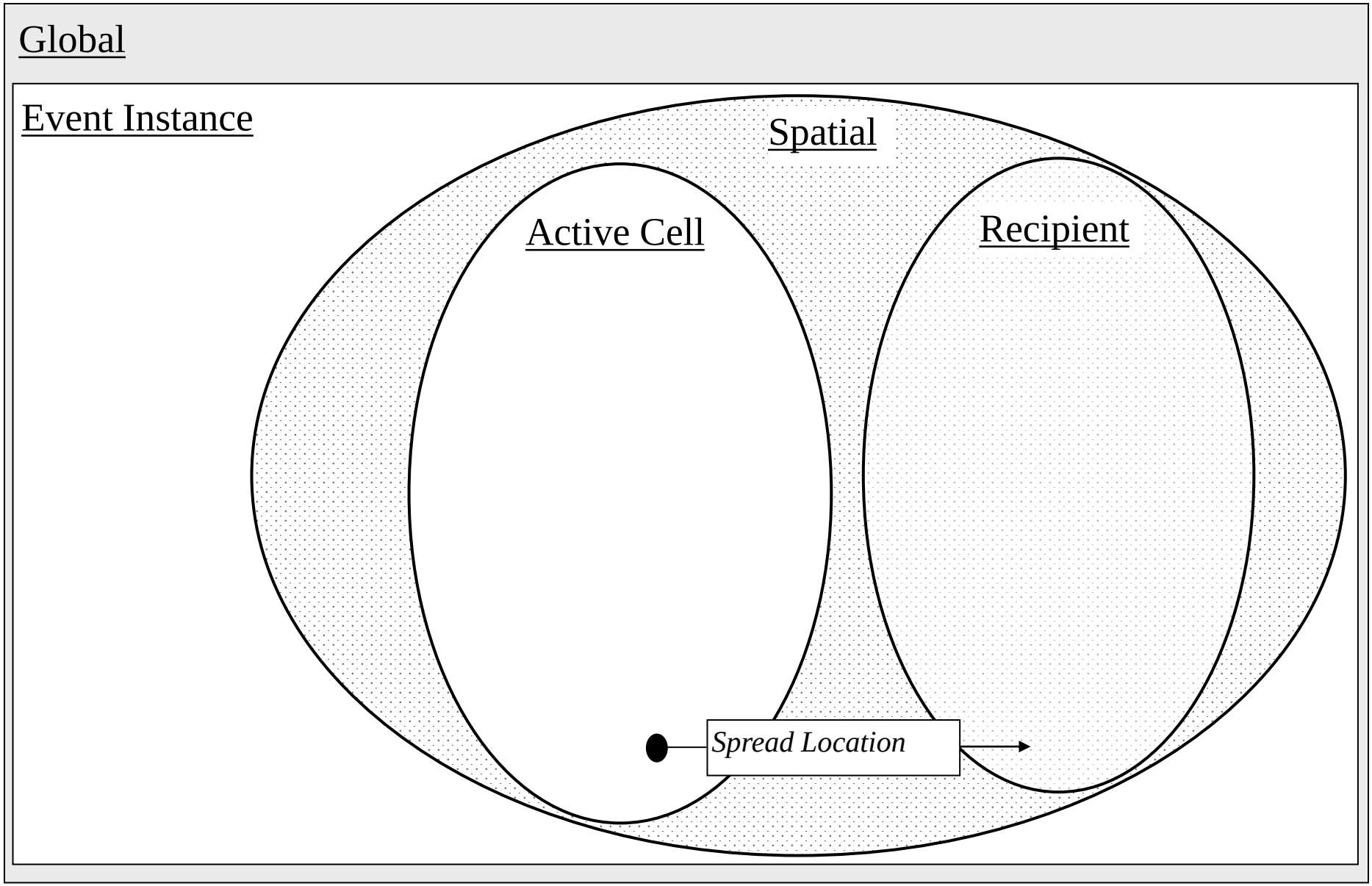
```
SPREADTIME = -x
```

  - same ordering of cells within cluster (but no passage of time)

Spread Location

- Default: 4 cardinal neighbours
- Operating context: active cell
  - an active cell at time when spread is processed
- Result:
  - region to which active cell can *potentially* spread
- Consequent context: recipient
  - each cell in region

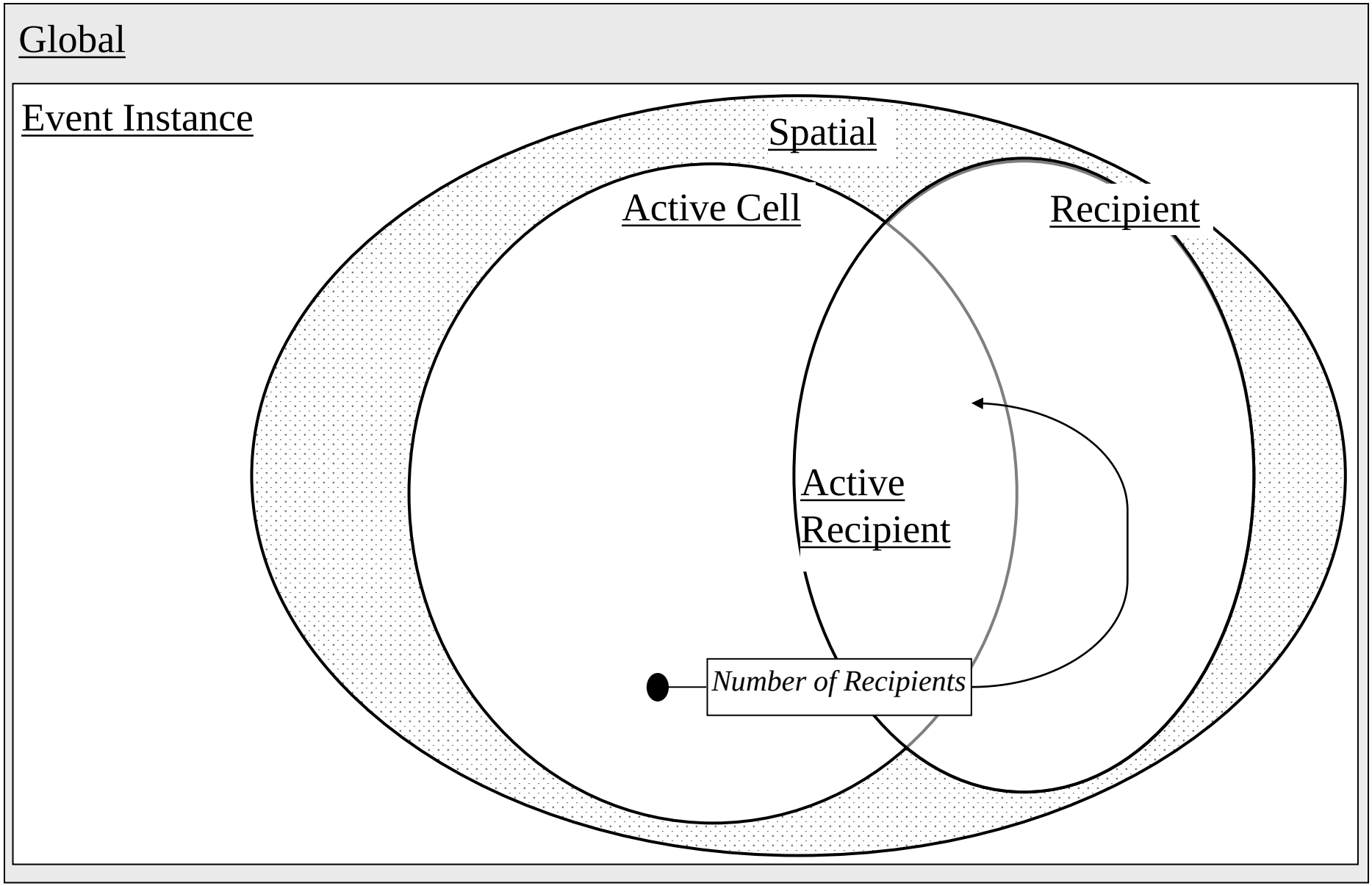
Spatio-Temporal Contexts



Number of Recipients

- Default: undefined (-1)
- Operating context: active cell
  - same as consequence of Spread Location
- Result:
  - Number of cells to select for spread
- Consequent context: active recipient
  - each new active cell selected for spread (recipient)

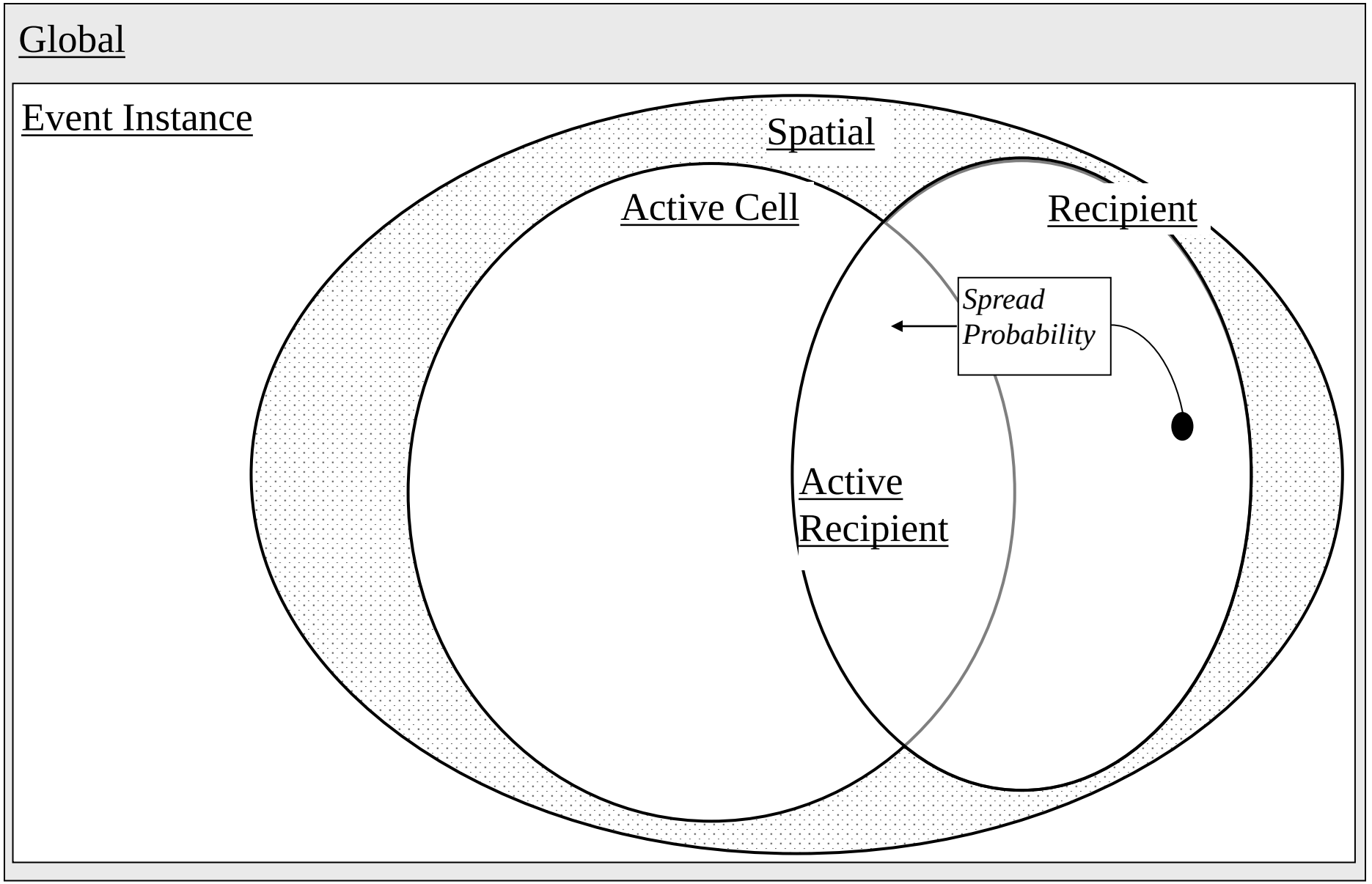
Spatio-Temporal Contexts



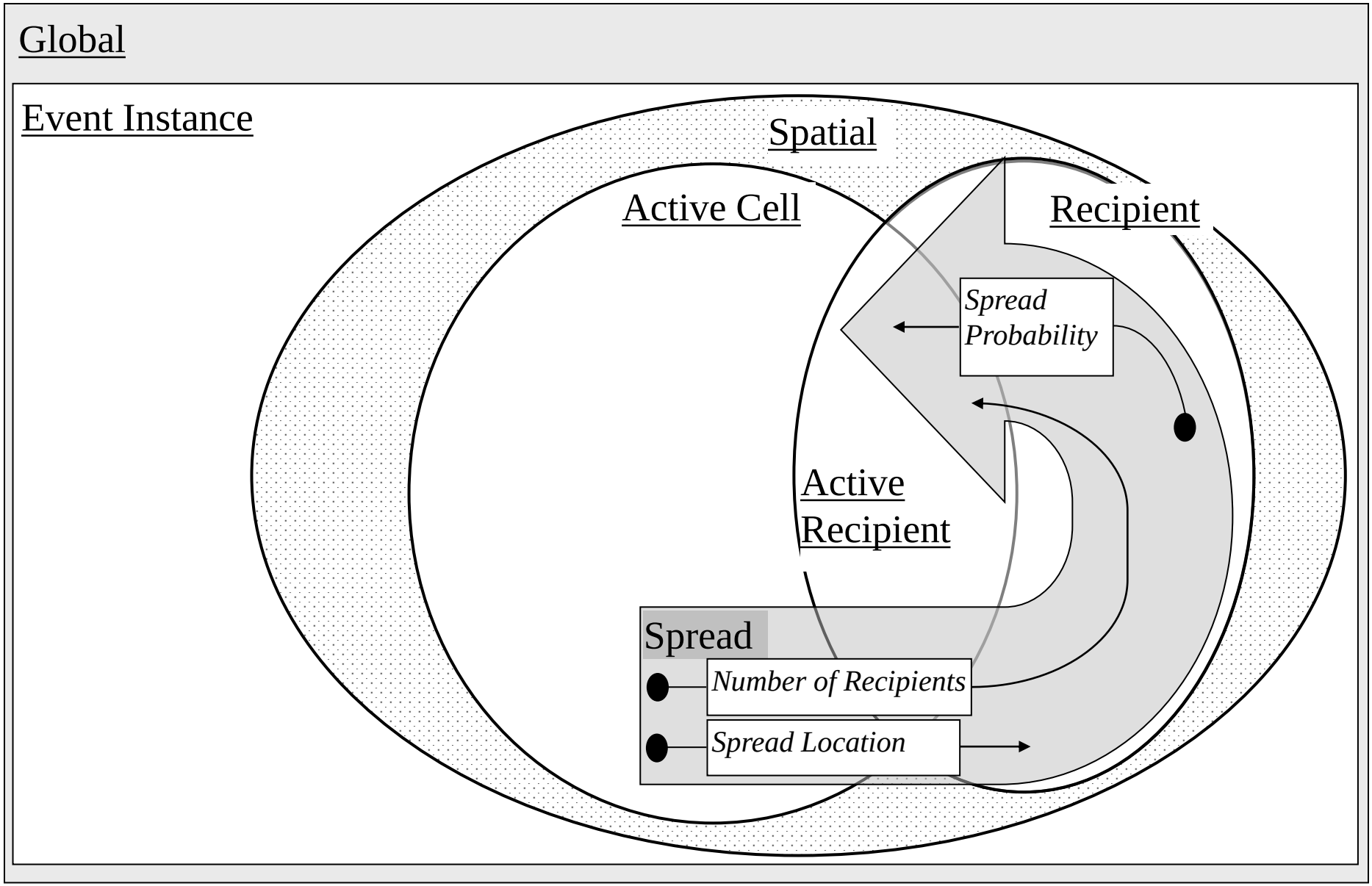
Spread Probability

- Default: 1
- Operating context: recipient
  - each cell in Spread Location region
- Result:
  - probability for event to select cell for spread
- Consequent context: active recipient
  - each new active cell selected for spread (recipient)

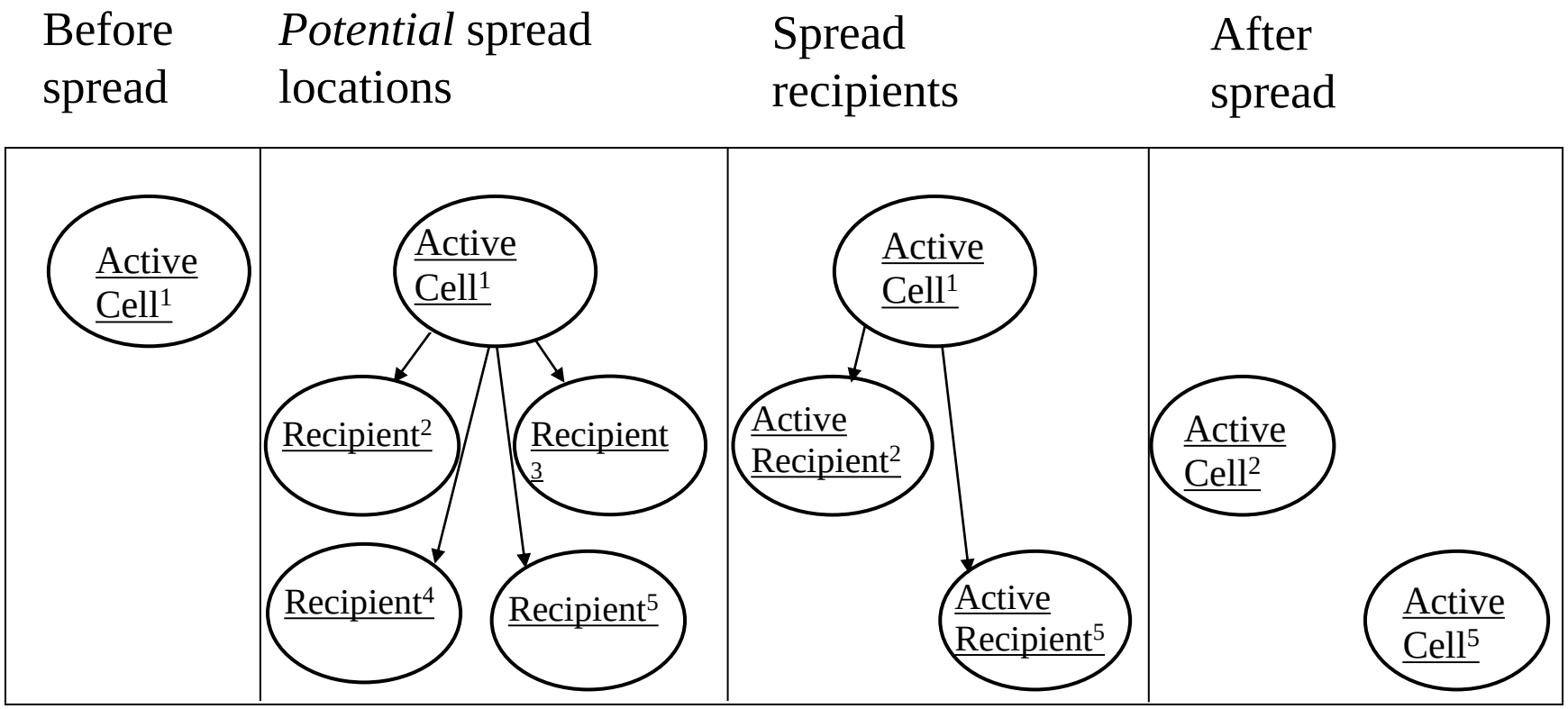
Spatio-Temporal Contexts



Spatio-Temporal Contexts



Event Spread



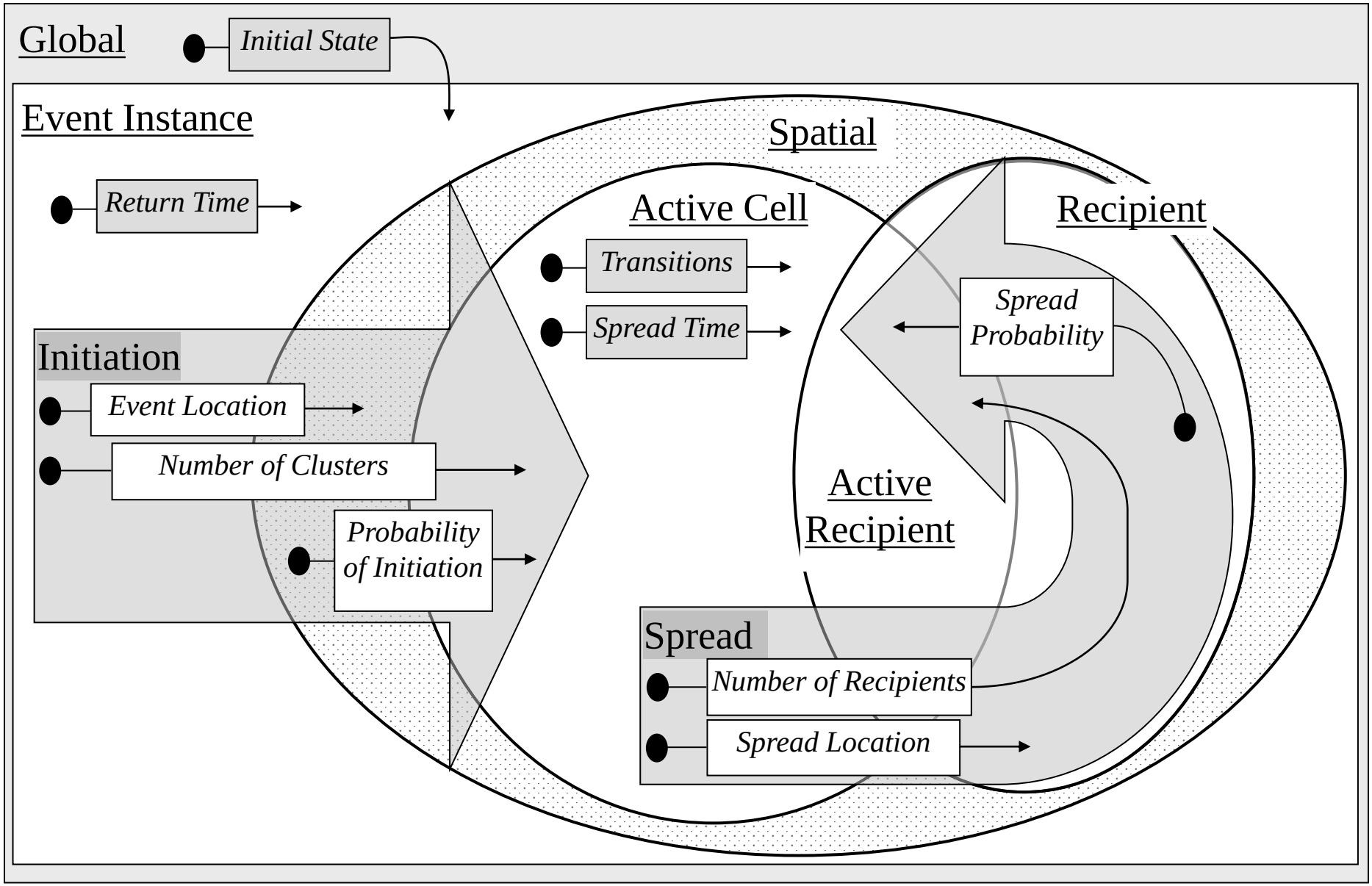
End Cluster

- Default: TRUE
- Operating context: active cell
  - time and place when last active cell of a cluster terminates
- Result: n/a
- Consequent context: n/a

End Event

- Default: TRUE
- Operating context: active cell
  - time and place when last active cell of last cluster of an event instance terminates
- Result: n/a
- Consequent context: n/a

Spatio-Temporal Contexts



What do you need to understand?

Model drivers: basic understanding of the concepts

Model designers: sufficient understanding of the concepts to know if SELES is an appropriate tool

Model mechanics: sufficient understanding to read, and possibly modify, landscape event files

Constructors: mastering modelling in SELES is synonymous with understanding this non-linear conceptual process