Activity-Based Modelling and Activity-Enhanced Simulation

"the activity-enhanced working group"
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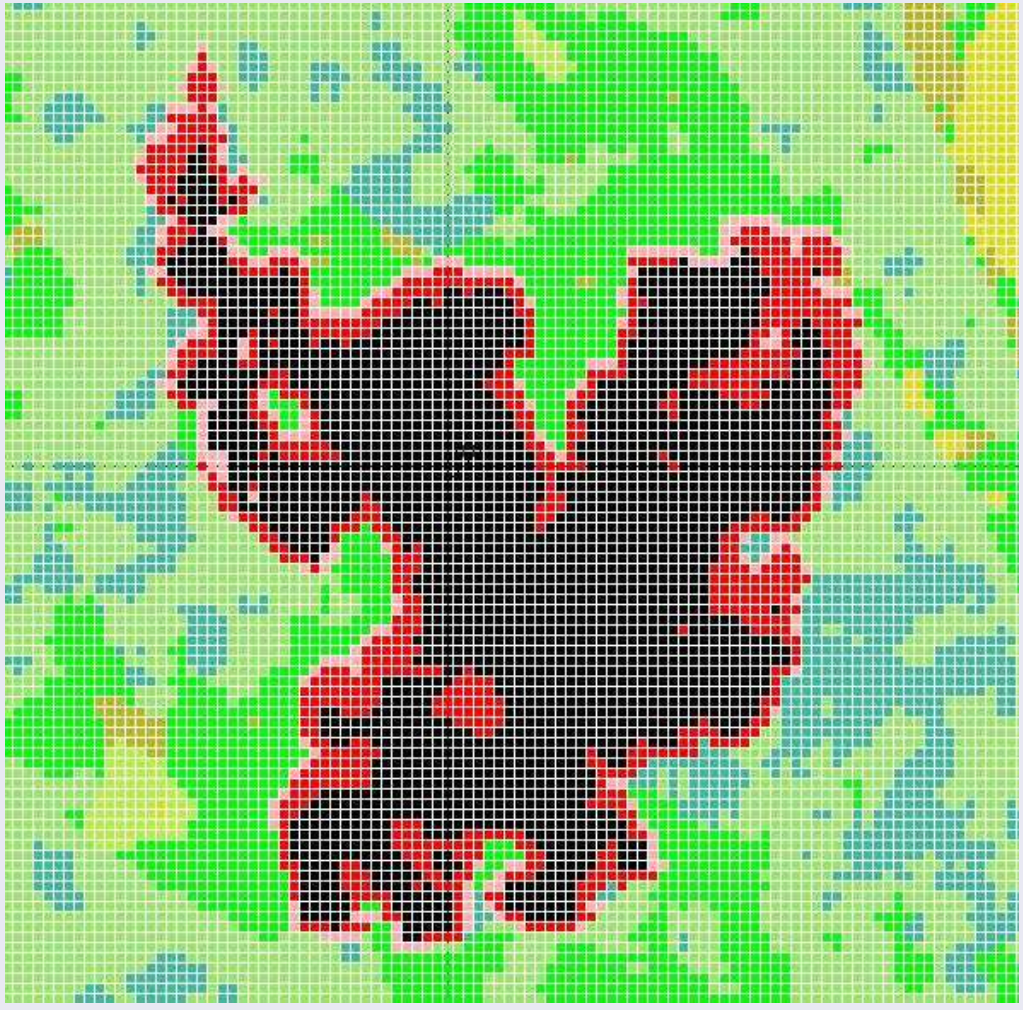
1. notion of locality in space and time: “activity”
2. “activity” seems to be an emergent “abstraction”
   philosophical question: inherent or perceived?
3. currently used in “activity tracking” simulators
   to better allocate computational resources

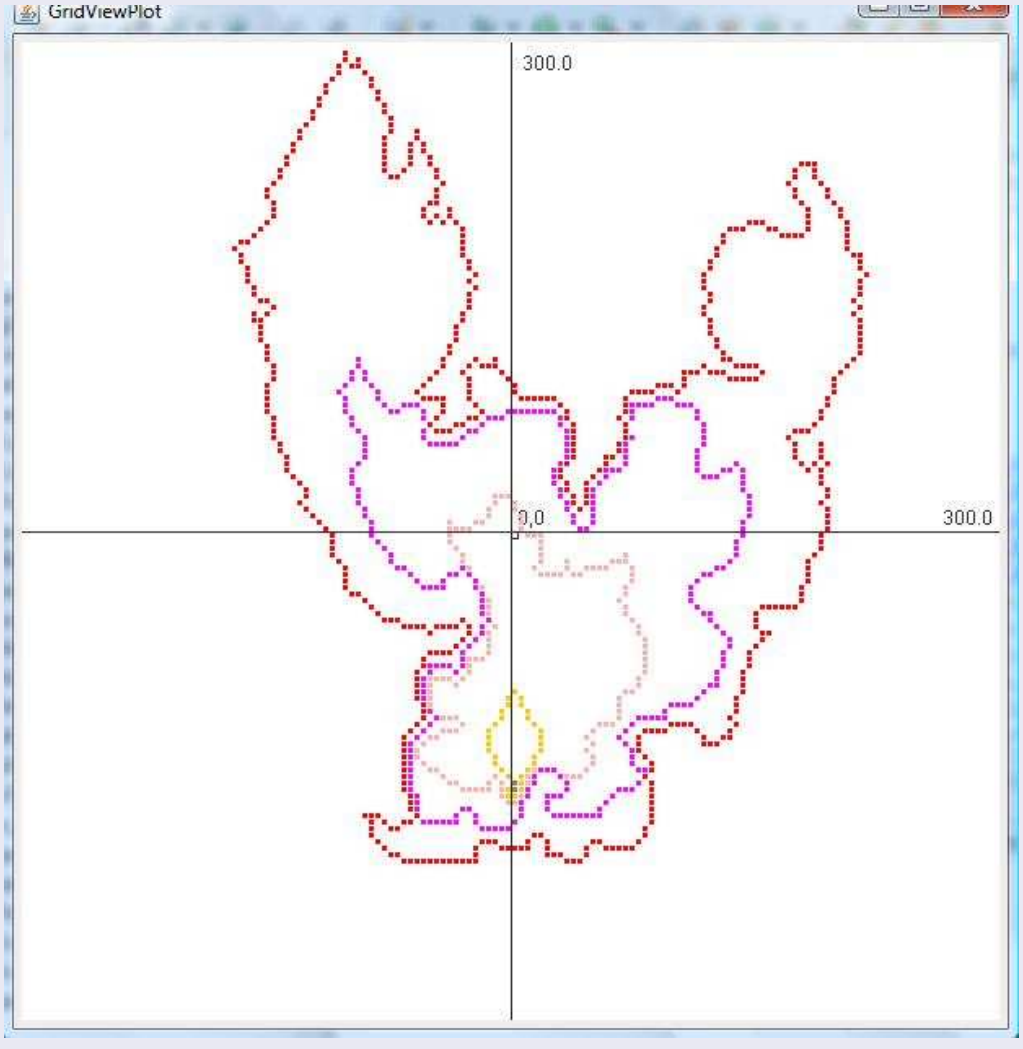
Example: Fire Spread

fire “front” is the only region of activity

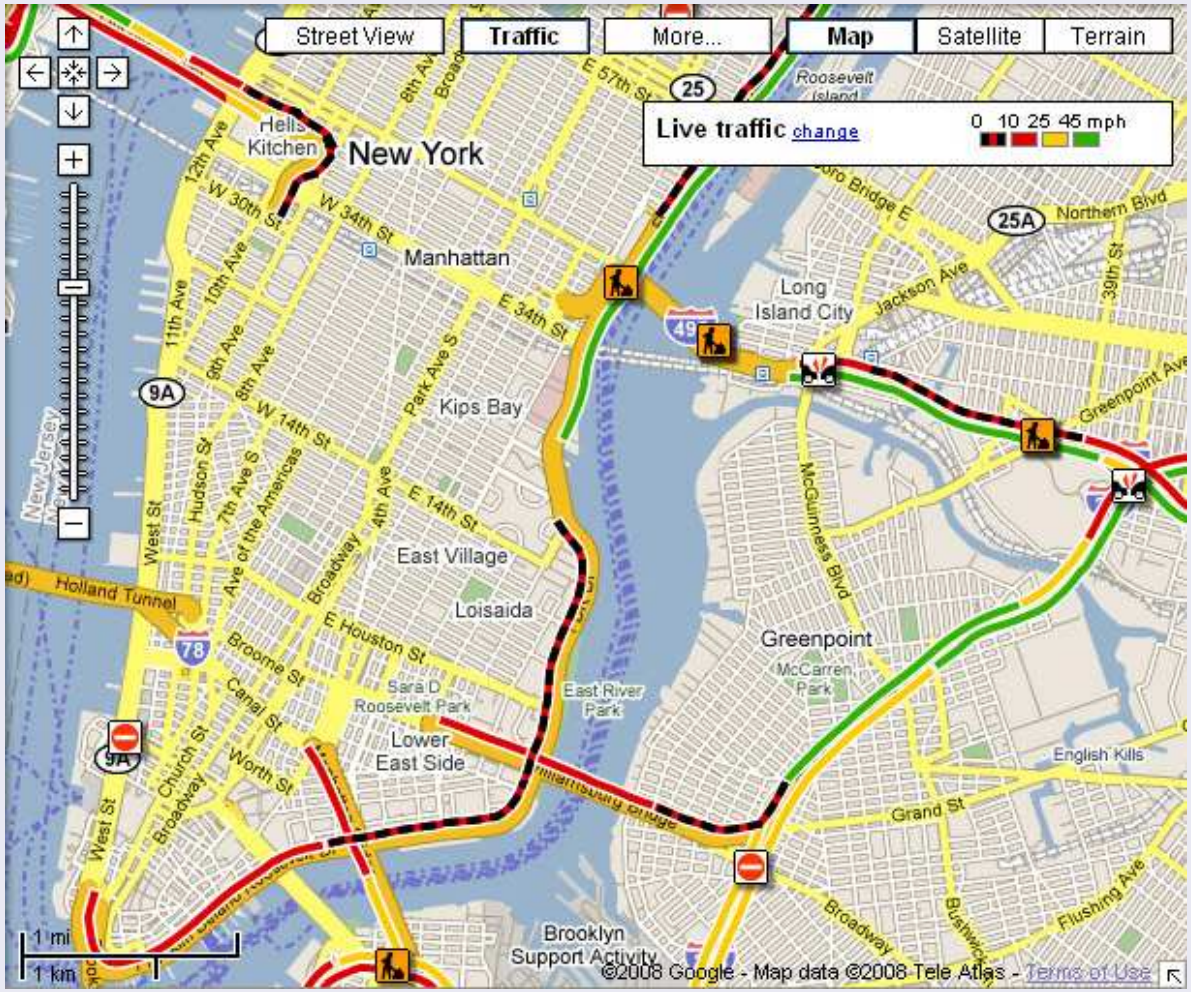
Activity intensity distribution, (non-)Activity Region



Activity Region moves over time

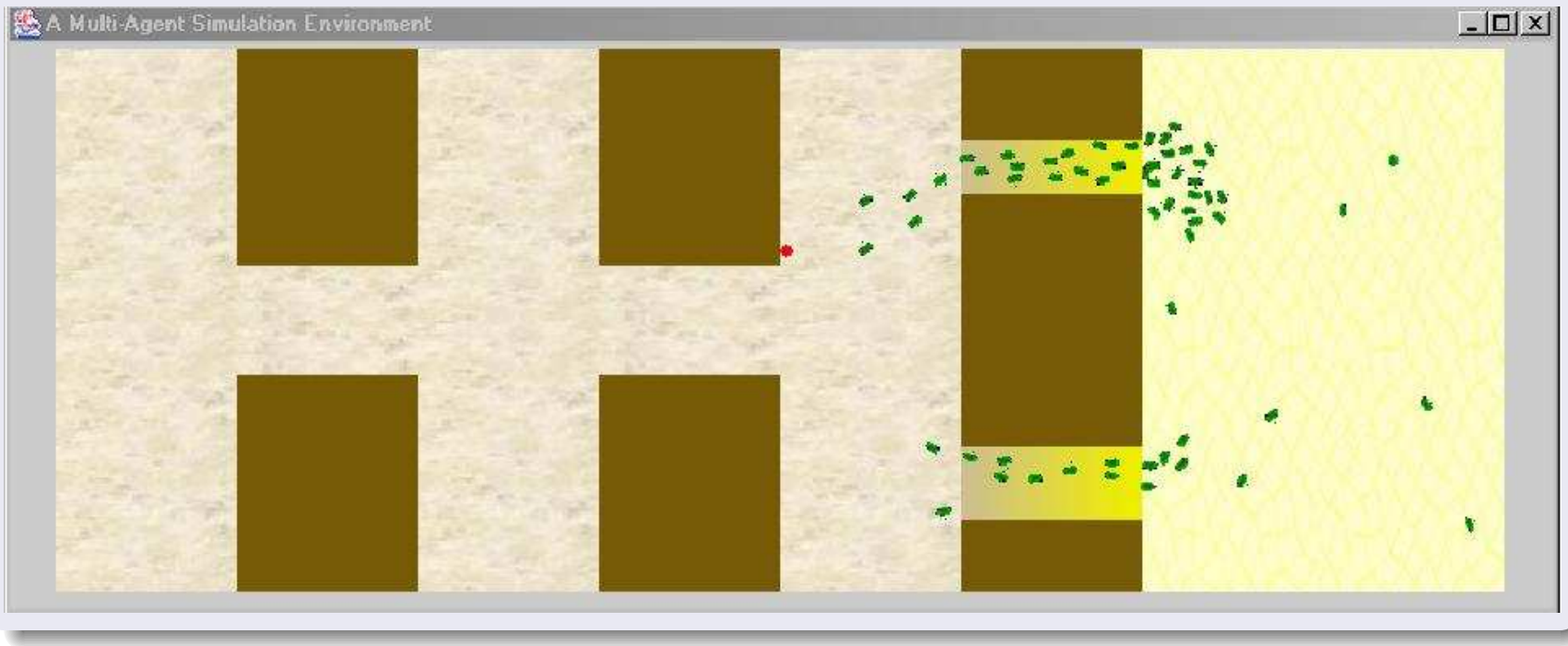


Example: dynamics of groups of “agents”

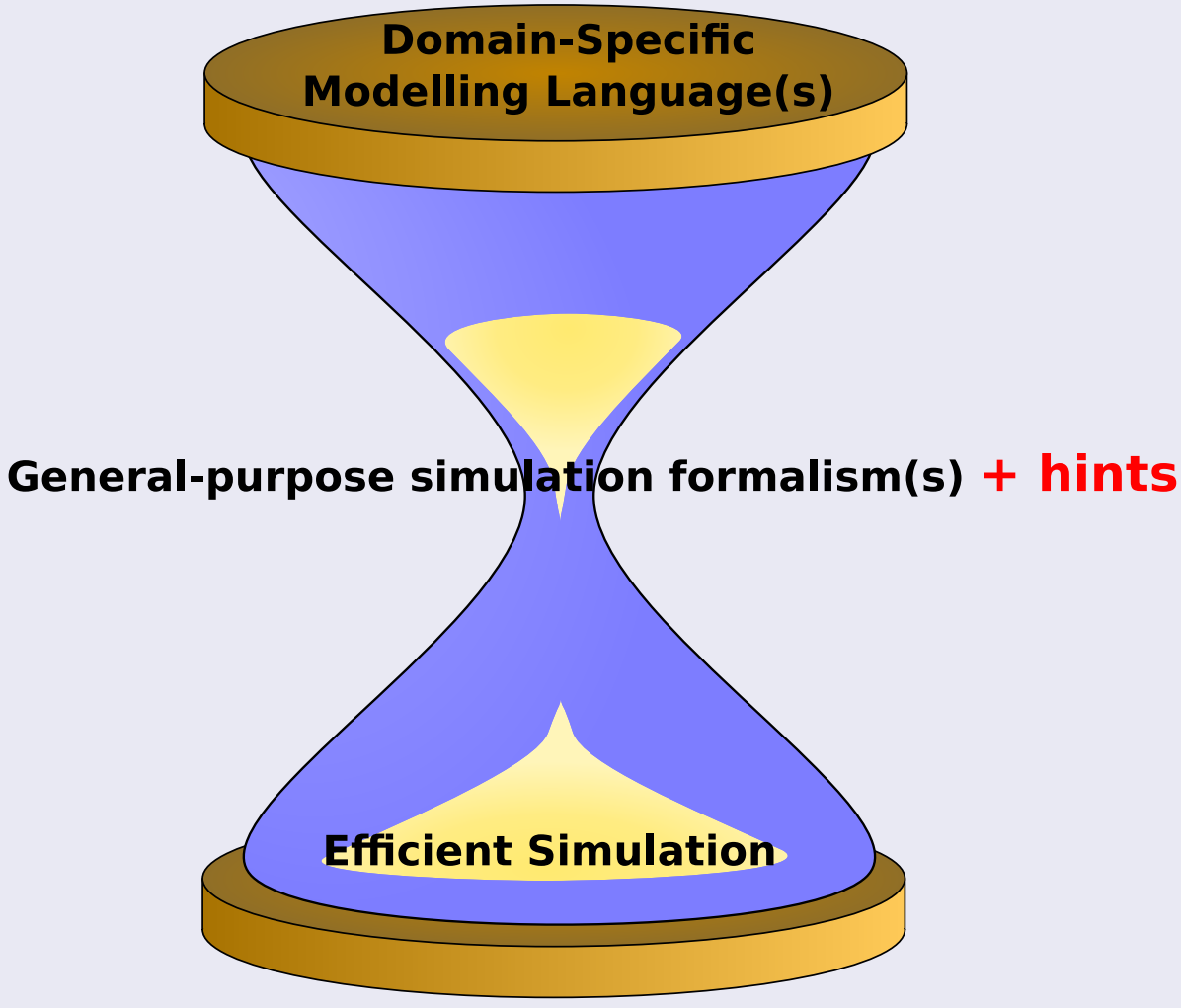


locality of activity in space and time

Crowds: locality of activity in space and time



Activity-Based Modelling vs. Activity Enhanced Simulation



Goals

- formalization of
  1. Activity Tracking simulation (computation view)
  2. Activity-Based modelling (modelling view)
  3. Activity-Enhanced simulation (computation view, from modelling)
  4. Relationships between 1 – 3 + validation
- explore examples (limits)

Notation

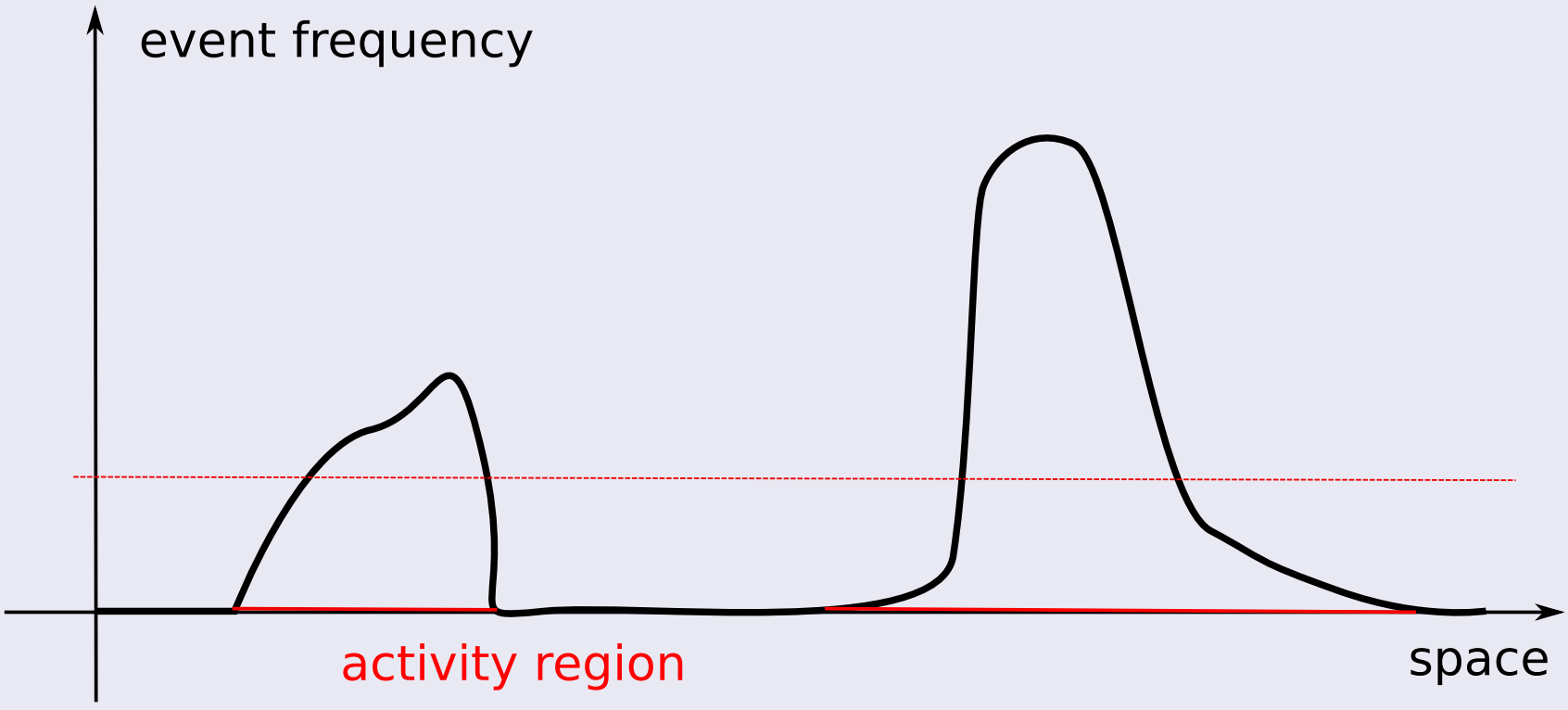
- time base T, time $t \in T$
- spatial "coordinates" used to index space S, $\boldsymbol{s} \in S$
- the "state space" Q of the system
  state $q(\boldsymbol{s}, t)$ is a function of independent variables space and time

  note: we may wish to use "generalized coordinates" which includes part of the state as this helps identify/encode regions of activity at the modelling level.
  Example: "liveness" coordinate $= \{alive, dead\}$
- A "model", in the form of some transition function, concisely describes how q evolves.
  A "simulator" takes a model and a specification of initial state and computes the "trajectory" $q(\boldsymbol{s}, t)$.

Measure of activity intensity

- assume Discrete Event abstraction (without loss of generality)
- Event Frequency $\nu_H(t)$
- need H lookahead horizon

Activity Region



$$AR_H(t) \subseteq S$$

Activity Tracking Simulation

$q(\mathbf{s}, t) \Rightarrow \nu_H(t) \Rightarrow AR_H(t) \Rightarrow$ (re-)allocate computational resources

Note

more fine-grained if (weighted) resource allocation is done based on $\nu_H(t)$

Activity-Based introduction of modularity in models

- δ_{AR_H} model $AR_H(t)$, the evolution of activity region over time
- model the evolution of state over time
  - $\delta = \hat{I}$ for $s \notin AR_H(t)$
  - $\delta = \delta_{ACT}$ for $s \in AR_H(t)$

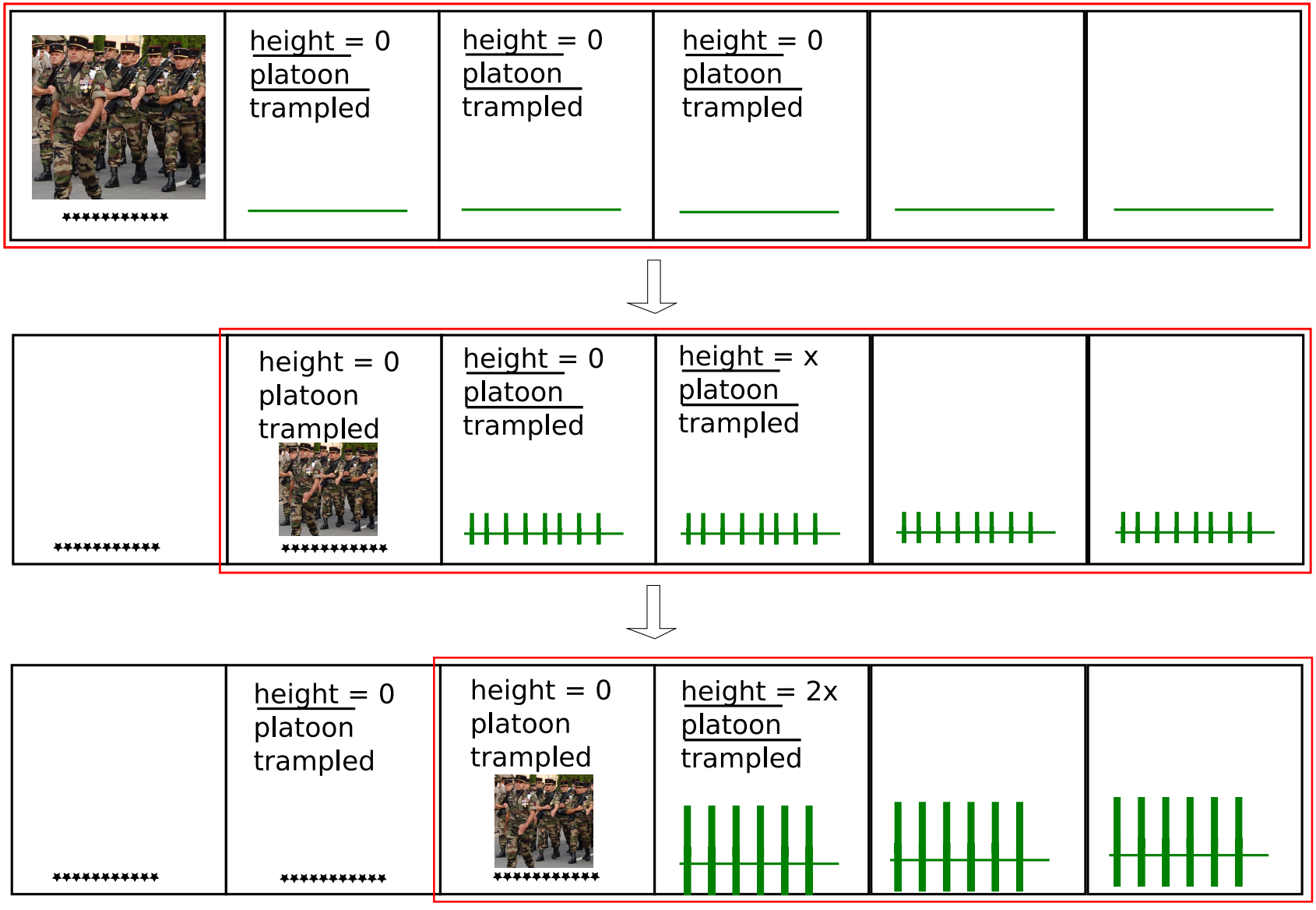
Note: may start from δ and provide $AR_H(t)$

- in the best case, this allows for concise (from the point of view of modelling, and/or from the point of view of computation) description based on domain insights of the modeller.
- in the worst case, this is just an encoding of the activity tracking machinery.

$(\delta, AR_H) \Rightarrow q(\boldsymbol{s}, t)+$ (re-)allocate computational resources
Implemented using appropriate model/solver interface

Validation

- track activity in simulator $\rightarrow$ compute $AR_H(t)$
- AR_H model describing activity region evolution
- comparison $+$ interpretation (conservative/optimistic)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provided formalization of:

1. Activity Tracking simulation
2. Activity-Based modelling
3. Activity-Enhanced simulation

accuracy

- Activity-Enhanced simulation has **same accuracy** as traditional or Activity Tracking
- Different $AR_H(t)$ do however influence performance

future:

- generalized coordinates
- look into $AR_H(t)$ described in different formalism
- model ν_H to describe activity "levels" (no longer on/off)
- hierarchy of activity region/behaviour modelling