

Gradient-based Self-organisation Patterns of Anticipative Adaptation

Sara Montagna, Danilo Pianini and Mirko Viroli
sara.montagna@unibo.it

ALMA MATER STUDIORUM—Università di Bologna a Cesena

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Outline

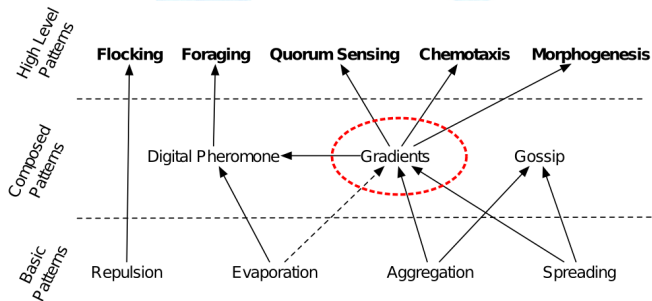
Goal and result

- Start from a catalogue of design patterns for spatial self-organisation
- Aim at extending the **gradient** pattern with temporal aspects
- Design the **antipative gradient** pattern (“proacting” to known future!)
- Build it by combination of simpler patterns
- Qualitative evaluation by simulation



Self-organisation Patterns: reusable design elements

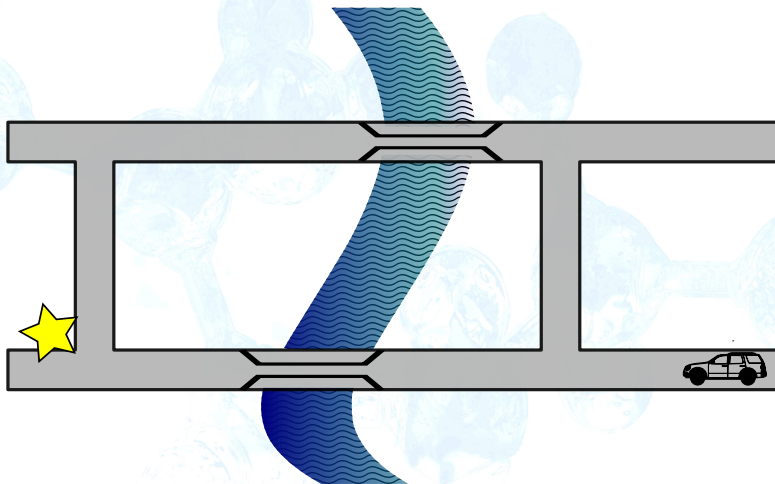
⇒ Start from the layered catalogue in [FMDMSM⁺12]



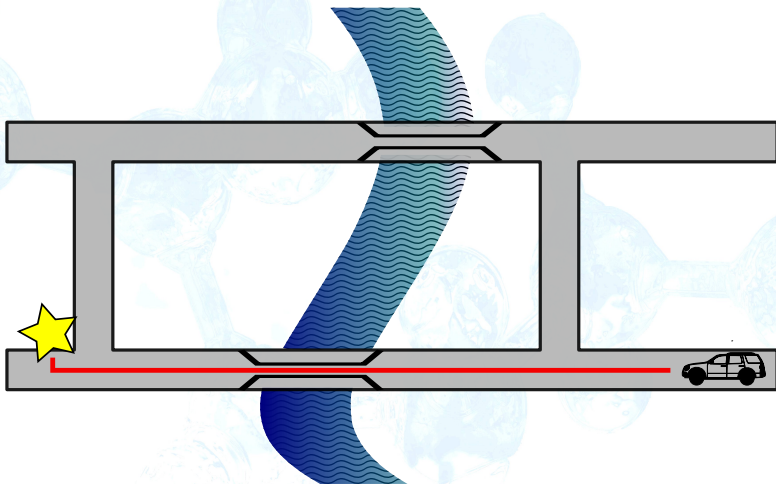
The gradient pattern case

- Information about a *source* node becomes global knowledge
- Information to reach the source is propagated hop-by-hop
- Self-heal to changes, but tackling only “present-awareness”

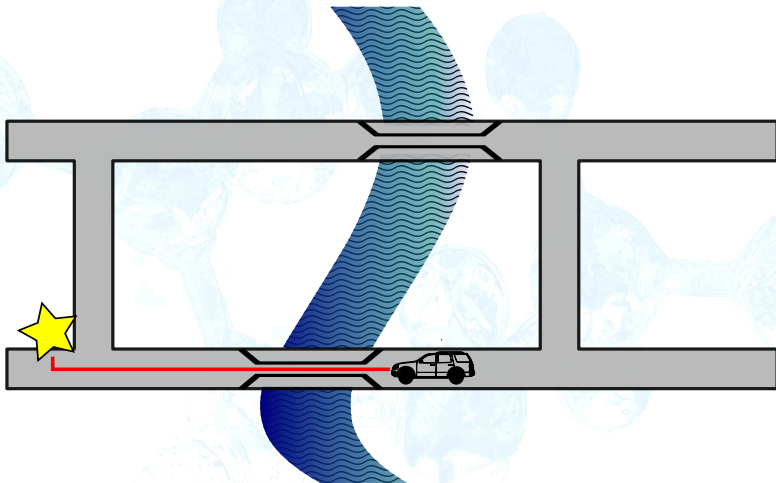
When spatial gradient is not enough



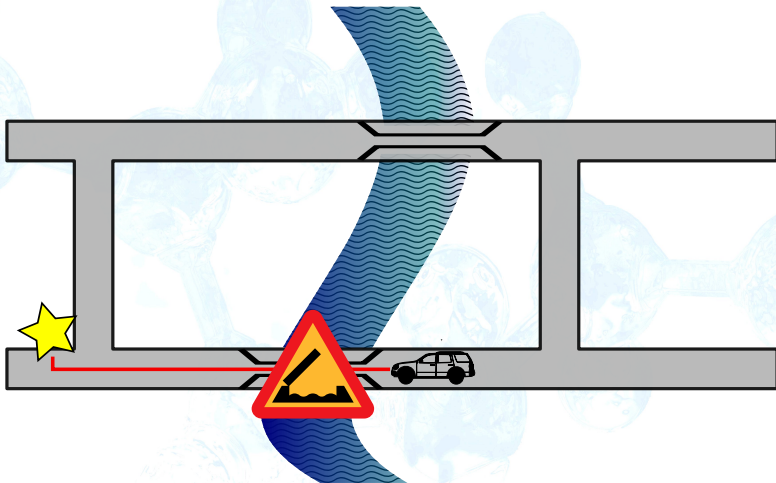
When spatial gradient is not enough



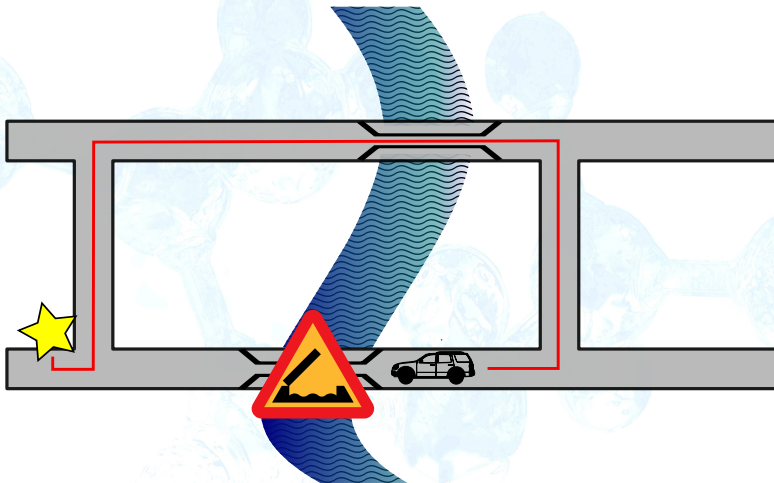
When spatial gradient is not enough



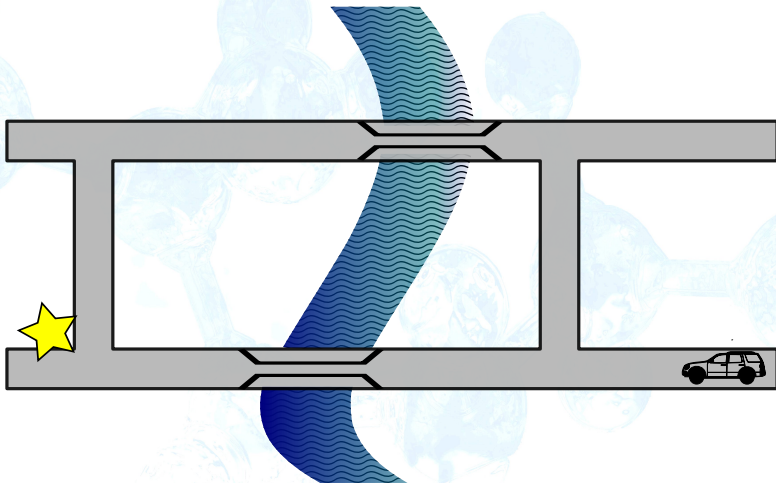
When spatial gradient is not enough



When spatial gradient is not enough



When spatial gradient is not enough



From Gradient to Anticipative Gradient

From space to space-time: anticipative gradient

- The Gradient should deviate now to anticipate known later events

Some design guidelines

- Design anticipative gradient by combining more elementary patterns
- Assume estimated node-to-node average travelling time is available



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Spatial Structure: Horizon Wave

Horizon Wave

Advertises a future event

- Creates a shrinking crown around the source of the future event points
- It's the set of nodes possibly reaching the source during the event

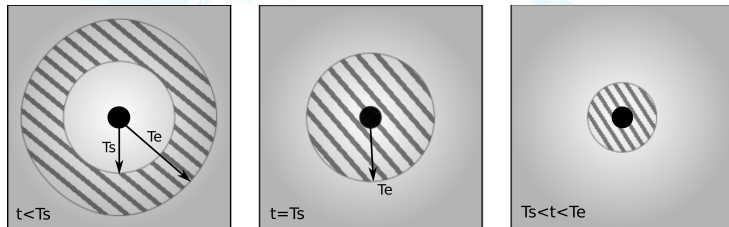


Figure : Horizon Wave pattern, with its shrinking dynamics in evidence.



Spatial Structure: Gradient Shadow

Allows to identify multiple different paths toward the POI

- Tags the gradient paths passing by some future event area
- Nodes store (all) the paths transiting/non-transiting across FEs

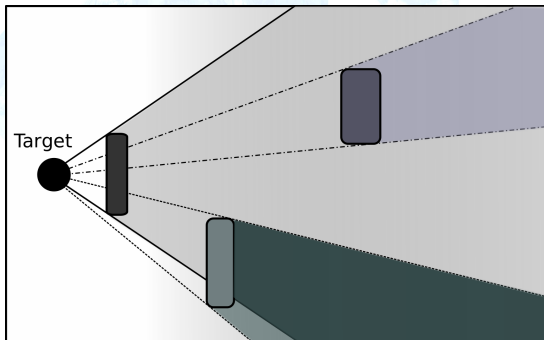


Figure : Shadow spatial structure with overlapping Future Events



Spatial Structure: Future Event Warning

Future Event Warning

Users in this area will reach the event

- Intersection of Gradient Shadow and Horizon Wave.

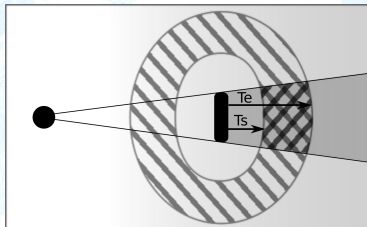


Figure : Warning spatial structure as intersection of Wave and Shadow



Spatial Structure: Anticipative Gradient

Anticipative Gradient

Chooses the time-shortest path

- Penalises those paths passing through the event
- Users travelling those paths must wait for the event to finish

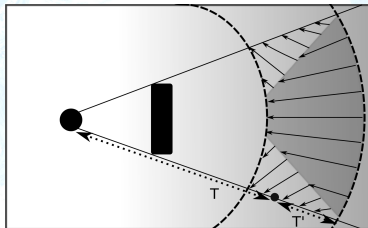


Figure : Anticipative Gradient pattern (and “waiting distance” T').



Early evaluation

- “Implementation” as chemical-like reactions (SAPERE [ZCF⁺11])
- Used *ALCHEMIST* simulator (<http://alchemist.apice.unibo.it>)

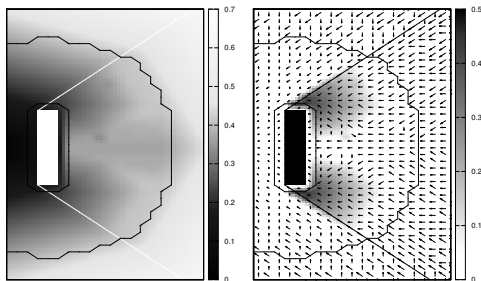


Figure : An Anticipative Gradient case: (Left) estimated distance normalised by the maximum value; (Right) time-to-destination improvement factor and steering direction.



Conclusions

- 1 Added proactive adaptation to the Gradient pattern
- 2 By identification and composition of simpler patterns
 - Wave, Shadow, Warning, Anticipative Gradient

Future works

- 1 Dealing with a wider set of future events
- 2 Deep analysis of performance achievements
- 3 Application of the approach to real scenarios of traffic/crowd routing
- 4 Prototype implementation in the SAPERE framework [ZCF⁺11];



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